



Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Kumukumu 1, a hilltop site in the Aird Hills: Implications for occupational trends and dynamics in the Kikori River delta, south coast of Papua New Guinea

Bruno David ^{a, *}, Ken Aplin ^b, Fiona Petchey ^c, Robert Skelly ^a, Jerome Mialanes ^a, Holly Jones-Amin ^a, John Stanistic ^d, Bryce Barker ^e, Lara Lamb ^e

^a Monash Indigenous Centre, Monash University, Clayton, Victoria 3800, Australia

^b Division of Mammals, National Museum of Natural History, Smithsonian Institution, Washington D.C. 20013-7012, USA

^c Radiocarbon Dating Laboratory, University of Waikato, Hamilton 3240, New Zealand

^d Queensland Museum, P.O. Box 3300, South Brisbane, Queensland 4101, Australia

^e School of Humanities and Communication, Public Memory Centre, University of Southern Queensland, Toowoomba, Queensland 4350, Australia

ARTICLE INFO

Article history:

Available online xxx

Keywords:

Headhunting

Defensive site

Aird Hills

Papua New Guinea

Archaeology

Porome

ABSTRACT

We report on archaeological excavations undertaken at Kumukumu 1 atop the dense rainforest-clad Aird Hills of the Kikori river delta islands, south coast of Papua New Guinea. Results indicate exploitation of the nearby environment, including the gathering of some 200 million shellfish from riverine habitats at the base of the hill some 600 years ago, and deposition of shell remains onto hilltop middens. We ask what the implications of such a site in a defensive location on the upper, steep hillslope of Kumukumu hill are for regional occupation and dynamics. We conclude that the hinterland-marine fringe islands of the river deltas that include the site of Kumukumu 1 were especially sensitive to heightened cross-cultural influences and inter-group raids and competition, leading to accelerated processes of centralisation and aggrandisement among some groups, and the subjugation, fragmentation and dispersal of less powerful neighbouring groups.

© 2014 Elsevier Ltd and INQUA. All rights reserved.

1. Introduction

Along the south coast of mainland Papua New Guinea (PNG) and mid reaches of the Kikori River, the culture, organisation and infrastructure of village life at the time of first European contact in the 1800s was steeped in politics of inter-village alliances, raiding of non-allied villages and landscapes for human bodies and heads, defence from raids, and long-distance trade, each of these being mediated by communion with a rich spirit-world. Those engagements with the spirit-world included headhunting towards the consumption of human body parts for the consumption of power (cf. Knauff, 1993; see below).

This broad region covering the mid to lower reaches of the major rivers of PNG's Gulf Province is dominated by dense rainforest and vast swamplands largely devoid of rock. For more inland regions, much has been made of the paucity of villages along major waterways and the presence of smaller hamlets in more secluded locations during the early ethnohistoric period of the late 1800s (see Rhoads, 1980 for a detailed study). This has been explained as a local settlement-subsistence response to headhunting raids by powerful polities, in particular the Kerewo and other peoples of the Turama to Purari Rivers delta islands who had, over the past 400 years or more, aggrandised into large permanent coastal stilt-settlements numbering over 2000 inhabitants, often on low-lying river delta mud islands, largely controlling long-distance *hiri* maritime trade partnerships into the region (Frankel and Rhoads, 1994; David et al., 2010; Barker et al., 2012; Skelly and David, in press). Here coastal and near-coastal tribes, all non-Austronesian language speakers, practiced headhunting until its cessation in the early 1900s following regular government patrols from the turn of the nineteenth century, missionisation (e.g. Aird Hill mission,

* Corresponding author.

E-mail addresses: bruno.david@monash.edu (B. David), aplink@si.edu (K. Aplin), fpetchey@waikato.ac.nz (F. Petchey), robert.skelly@monash.edu (R. Skelly), jerome.mialanes@monash.edu (J. Mialanes), hjjon2@student.monash.edu (H. Jones-Amin), john.stanistic@qm.qld.gov.au (J. Stanistic), bryce.barker@usq.edu.au (B. Barker), lara.lamb@usq.edu.au (L. Lamb).

<http://dx.doi.org/10.1016/j.quaint.2014.06.058>

1040-6182/© 2014 Elsevier Ltd and INQUA. All rights reserved.

established 1913) and the establishment of colonial administrative outposts (e.g. Kikori, established 1913) (cf. Butcher, 1963).

2. Headhunting along the south coast of mainland PNG

Headhunting was prominent among all the tribes of the geographically and culturally interconnected Turama-Purari river delta region of the south coast of mainland PNG, as illustrated by an example dating to the first year following the establishment of the colonial outpost at Kikori:

Last May, the natives of Morigio Island, Turama River, came across to the east bank of the Turama River, and murdered eleven natives belonging to the village of Yawobi, on the Paibuna River. On word reaching the station, the Assistant Resident Magistrate proceeded to the scene of the massacre, and from thence to Morigio Island. This island is a huge swamp, with hardly an acre of dry ground on it. Before leaving for Morigio, 22 canoes from Goari-Bari [a Kerewo island], with fighting men all painted and well armed with a large supply of bows and arrows, appeared on the scene. They were most anxious to go to Morigio and avenge the deaths of the eleven murdered men, which meant that they would kill men, women, and children. [T]he Assistant Resident Magistrate, knowing full well what would happen if he allowed those people to accompany him, sent them back, much to their disgust. On the approach of the officer and his party the murderers deserted their villages, and took to the swamps. (Ryan, 1913 cited in; Goldman and Tauka, 1998, p. 60)

For this same region, Barker et al. (2012, p. 162) note the scale of headhunting evident from the number of skulls witnessed in Kerewo villages during colonial naval reprisal attacks on the island of Goaribari following the killing of the missionaries James Chalmers and Oliver Tomkins in 1901:

In a report on the massacre, the Rev. H.M. Dauncey says, 'in one of the dubus [longhouses] were over seven hundred skulls, and at another four hundred. ... I am within the mark in saying that there must have been ten thousand skulls in the twenty dubus burned'. (Haddon, 1918, p. 180, p. 180)

Here headhunting was associated with male growth, well-being, power and prestige. Skull shrines featured the skulls of slain victims of individuals from non-allied groups and concerned the attainment of 'vital strength' (Wirz, 1937). Wirz (1937, p. 410) thus writes for the Purari River delta region that 'human sacrifices were occasionally made to the kaiamunu; raids were made from time to time to a foreign district, in order to kill a man, who was brought home and given to the kaiamunu to "devour." In the Goaribari district [of the Kerewo further to the west] the same practice existed, but here the skulls were preserved for the agibe shrine':

... a somewhat more spectacular form of cultural heritage is found in the form of 'skull shrines' (*agiba* and *marabu*) common amongst the Kerewo and Kairi populations. These skulls were traditionally kept in long-houses (*dubu*) and mounted on a platform with flat decorated oval boards (Haddon, 1918). The skulls are described as having been those of slain enemies and most probably ancestors too ...

Vanderwal (no date, pp. 21–22) writes for the Kerewo and their immediate neighbours:

Underlying headhunting and cannibalism, and the ceremonies that legitimised them in the Delta Country, was the concept of

imunu; the knowledge that all objects are imbued with spirit or animus, some more so than others. *Imunu* 'is synonymous with "vital strength" or "vital principle" and is responsible for the individuality of all things. Strange and unusual things possess this power to a higher degree than ordinary, secular things.' Natural objects have *imunu*, but manufactured objects are imbued with spirit through their creation and use. Thus for example, ancestral boards contain *imunu*, ceremonial masks contain more, and certain mangrove root forms – enhanced by carving and painting – also contain *imunu*. The *imunu* of one class or type of object cannot reside in a separate kind of object, so the *imunu* of a pig, for instance, cannot reside in a man. ...

People have the most *imunu* of all, and they may acquire more than they were born with, though only by obtaining the spirit of another. This is accomplished by cannibalism, by eating those with *imunu*. Even people of the same language group, or close neighbours, were often enemies whose heads were desired for their *imunu*. It was the constant threat of being killed that ultimately led to the establishment of large communities.

Haddon (1918, p. 177) notes that *agibe* shrines, consisting of wooden platforms housing *agibe* boards with their attached human skulls, were during the early 1900s a common feature of the delta region. Such shrines were kept in men's longhouses and did not feature as stand-alone architecture (see Haddon, 1918 for images of *agibe* shrines). The human skulls attached to the *agibe* carved boards were exclusively obtained from enemies during raids. Haddon (1918, p. 180) further writes:

I was informed at Dopima that when a new war canoe (*obi*) is made the warriors go in it to a strange village on the mainland and kill a man ... the body is eaten and the skull attached to an *agiba*. In Ubu, an off-shoot from Kerewa in the Kikori estuary, the beheaded corpse is held over the bow of the new canoe, so that the latter is covered with blood ... In all cases the body of the victim was eaten and the skull kept in the *dubu daima*. The Kerewa folk were in the habit of raiding the bush tribes of the Omati and those of neighbouring rivers, but most raids appear to have been made right up to the hills on the Sirebi River, which flows from the east into the Kikori some thirty miles from its mouth.

As a result of such uses of human bodies and human skulls from groups other than one's own, raids were frequent across the region, with some powerful coastal groups being particularly feared and individuals and village groups on constant alert for raiding parties.

In the lower reaches of the Kikori and Omati Rivers and along the adjacent coastline, village sites were typically positioned in low-lying areas, because here there is only one location where elevated land is present: the Aird Hills. All the largest villages bordered the banks of rivers. This is the case of the Aird Hills also. However, recent archaeological fieldwork has revealed a very large archaeological site on the very steep upper slopes of Kumukumu hill in the Aird Hills, the only upland site yet recorded from the region. Here we investigate the archaeology of this site as a means by which to historicise aspects of cultural practice known from regional ethnography.

3. The Aird Hills

The Kikori River delta of the Gulf Province is a dense network of swamplands and interwoven river channels (Fig. 1) whose configurations rapidly shift, thereby giving shape to more or less 'fluid

islands' as the 5 m–8 m annual rainfall feeds high sediment loads from the highlands and highland foothills into the river, to be redeposited in the delta some 140 km downstream. As decades unfold, new river channels appear and existing channels are widened by the river's erosional force, while others disappear where sedimentation takes hold. Within this low elevation landscape that sees no contour on the 1:100,000 topographic maps, and no land within 37 km of the coast above 16 m elevation, a single locale defies the pattern: the island that is made up of the Aird Hills, bounded on all sides by major riverways.

The Aird Hills consist of eight volcanic hills, the highest at 331 m above sea level. Since the time of first European contact continuing today, the Aird Hills have been home to the Porome whose clans inhabit major sections of the Kikori River delta from the Omati River in the west to near the Wai'i River in the east. They extend from the coast northward past Veiru, a total area of c.60 km east-west by c.50 km north-south. The Porome are surrounded by five language groups, Kairi Rumu in the north, Omati in the northwest, Minanibai in the west, Kerewo in the southwest and Ne Kiwai in the east. These latter two represent powerful tribes including the Kerewo and Urama, each with large, centralised coastal villages.

Ryan (cited in Goldman and Tauka, 1998, p. 59) reported in 1913 that the Urama consisted of 'seven villages, with a population of about 4000 people'; Herbert (1917, p. 87) recorded two villages in the Kikori River delta with a combined population of about 3000 people; Woodward (1920, p. 63) concluded that the Aird River delta on the eastern edge of Kerewo territory supported about 6500 people, and that the Kerewo numbered some 4000 and the Urama c.2000 (see also MacGregor, 1893, 1894a, 1894b). The Porome number about 600 today (Busse et al., 1993, p. 29).

In 1887 Theodore Bevan explored by steamer the delta waterways from the coast upstream via the Aird Hills. He contrasted 'The two largest tribes, and these were found on the coast' with 'the

small tribe behind Aird Hills and the Tumuan [which] combined were only some two or three hundred strong' (Bevan, 1890, p. 205). At the time of initial sustained European contact in the first decades of the twentieth century, the delta region from the Turama River in the west to the Purari River in the east contained many large villages, sometimes found in close proximity to each other, in contrast to the smaller, dispersed hamlets further inland. Hence, for the delta region, Ryan (1913) reports the presence of seven villages between Era Bay and Pai'a Inlet; five villages on the Pairo River at Era Bay (Naro, Ewa, Koiravi, Murou, Gibai-a); two villages on the Nakari River to the west of Port Bevan (Api-ava, Babai); three other villages to the immediate northwest of Babai (Gababari, Dubumubu, Ubuia); four villages on Goaribari (Goari, Namai, Kerewa, Dopima); seven villages near the mouth of the Omati River (Aidia, Mubagoa, Goro, Aimaha, Pai'a, Nagora, Kemai); and slightly more inland, villages near the Aird Hills. The Porome of the Aird Hills today recount stories of late nineteenth and early twentieth century Kerewo raids into Porome territory, some with devastating effects.

4. The Porome

During the early European contact period, the peoples of the Kikori River delta were, and to a large degree continue to be today, organised around patrilineal clans each consisting of a series of lineages tracing ancestry to one or more mythical apical ancestors. Individuals resided in villages each containing one or more longhouses, each longhouse constituting both a residential base for the men of a number of clans and the repository of sacred objects (including skull shrines) that connected and energised people with their ancestors, numinous beings, and life forces. The clans owned the stories of ancestral origins and migrations, and individual objects with sacred names held spiritual life. The land and the villages

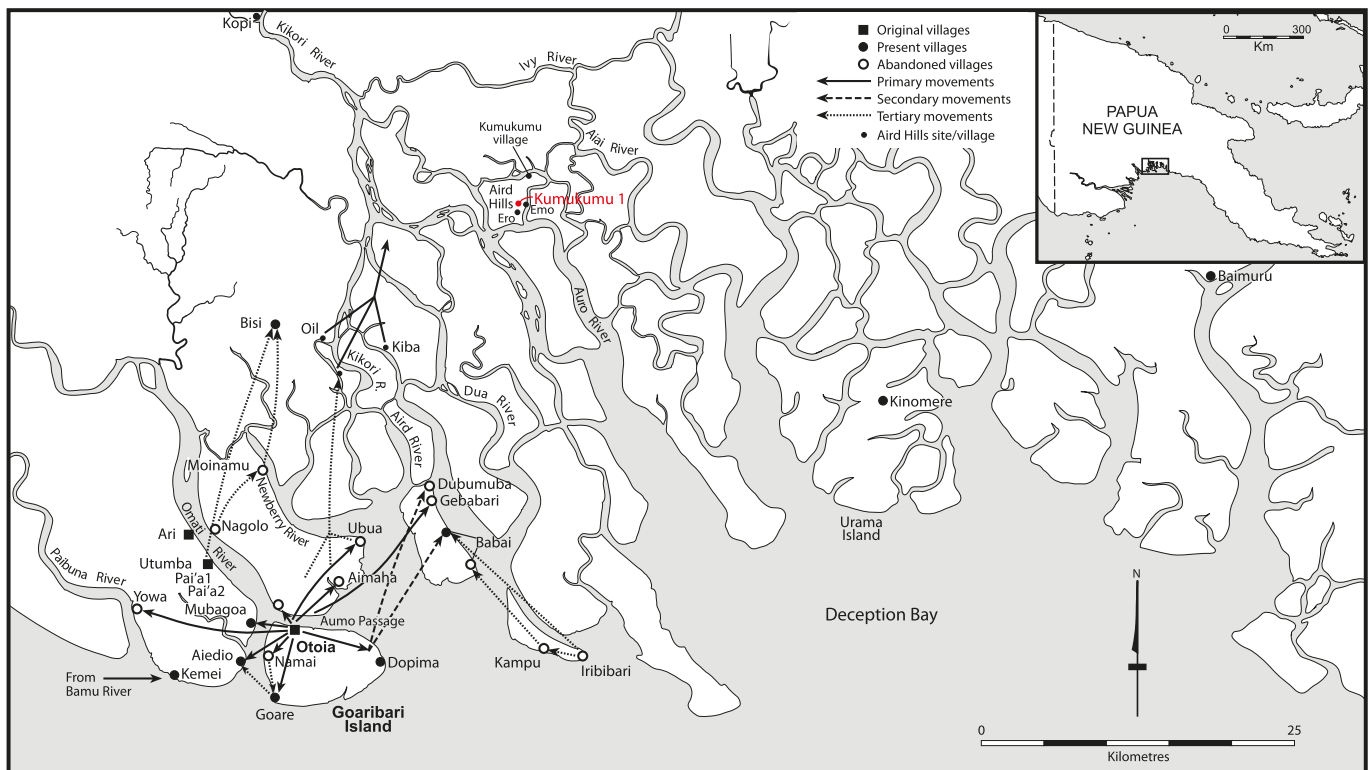


Fig. 1. The Omati-Kikori River delta region showing location of Kerewo and neighbouring village migration histories according to oral traditions, and the Aird Hills (after Goldman and Tauka, 1998:63).

were 'understood to be the product of ancestral action', as Joshua Bell (2002, p. 4) wrote for the Purari River delta further to the east, and the villages and longhouses themselves, as recipients of sacred objects and the material emplacement of ancestral migrations, were locales of connectivity between individuals, ancestors, customary rights and obligations of sacred charges. Much of this social cosmology continues to apply today (although the longhouses have disappeared), and in many instances places that once contained longhouses continue to hold ancestral and mythical powers and significance by way of historical connections.

Today as in the recent past, the Porome are divided into two major exogamous moieties each consisting of four or five land-owning, patrilineal clans: Umomoro, Taiburakamoro, Nerumoro, Baraimoro and Oramoro clans for the Karuramiro moiety; and Kuberimoro, Kubitimoro, Wareimoro and Birumoro clans for the Kaopaina moiety. Kumukumu (220 m above sea level), the easternmost of the Aird Hills's major hills and the one that backs Emo (the archaeological site previously known as Samoa; see below) was, according to Umomoro clan oral traditions, the province of the Umomoro and Taiburakamoro clans, although no-one dwells there today.

Today, Umomoro clan elders recall the following sequence of occupied ancestral villages for their clan (the associated dates are their suggested chronology based on their own genealogical reckonings, and not based on archaeological data). All these villages were located on low-lying lands. We have made no attempt here to reconcile this local oral history with historical documentary or archaeological evidence:

Villages occupied	Ancestors
Ero/Samoa/Wowou	Generation 10: 2009 AD
Ero	Generation 9: 1970s to 2009 AD
Ero/Wowou	Generation 8: 1960s AD
Keio, Ero	Generation 7: 1950s AD
Emo (= 'Samoa' village site)	Generation 6: Kairi, Kiwi, Epi, Veimoro and Ioubo, c.1900 AD
Kerekere	Generation 5: Arumi, Nabea, Buburemi and Avi, c.1800 AD
Emu	Generation 4: Kivore, Tito and Papoko, c.1700 AD
Waipabura (Kupare)	Generation 3: Kairi and Arumi, c.1600 AD
Kerewo (Bukumoro)	Generation 2: Epi and Keime, c.1500 AD
Aimiri (Kumukumu)	Generation 1: Kounato, c.1400 AD

5. Archaeological research in the Aird Hills

In the wake of colonial activities that promoted village centralisation, in the early 1900s the Porome villages of the Aird Hills relocated to a central location at Ero, adjacent to Ben Butcher's 1913 Aird Hill mission at the foot of the hill known as Kumukumu (Butcher, 1963). This hill backs and rises steeply northwest of Emo, the location of an ancient river-bordering village that includes the archaeological site of that name (PNG National Museum and Art Gallery site OAC, previously reported as the 'Samoa' site named after an early-twentieth century missionary village populated mainly by Kerewo) (cf. Rhoads, 1983; David et al., 2010; Thangavelu et al., 2011). Excavations at Emo revealed a sequence of four short-lived occupational phases dated to 1780 cal BP, 1560 cal BP, 1470 cal BP and 660 cal BP (David et al., 2010). Morphometric analyses of the 18,096 measurable *Batissa violacea* shells from Emo, representing 87% of a total MNI of 20,911 excavated shells of that species, revealed evidence of rapid predation pressures on shellfish at the start of each occupation phase, indicating site abandonment and a shift to the exploitation of more distant resource locations in the intervening periods (Thangavelu et al., 2011). These patterns

were interpreted as signalling settlement and subsistence responses to fluctuating headhunting raids (site abandonment) and active ancestral *hiri* trade partnerships (site re-establishment) during the last two millennia, a situation reminiscent of ethnographically documented patterns. However, until now the only archaeological site studied has been Emo, limiting our ability to further investigate, and test, spatial patterns and temporal trends in settlement-subsistence for the Aird Hills, with implications for understanding fluctuating responses to headhunting raids and trade partnerships.

Local Porome oral traditions today indicate that the densely forested Kumukumu upper hillslopes and hilltop, like those of neighbouring hills, served as a local Porome defensive location during periods of Kerewo headhunting. We were shown by local clan representatives in February 2009 a large, well-camouflaged archaeological site on the Kumukumu hilltop. With Porome representatives, we undertook an archaeological excavation at the site, aiming to determine in particular how the timing of defensive locations inter-phased with occupation at the more exposed Emo site some 400 m away as the crow flies, at the base of the hill on the banks of the Komo River.

6. Kumukumu

Kumukumu hill is covered by an upper canopy of old forest trees rising to heights of 30 m (Fig. 2). The organically-rich ground surface is covered by a thick layer of leaf litter. There is no evidence of past gardening activity anywhere on the hill, although ground visibility is low (0–25%). Kumukumu 1 is a set of neighbouring archaeological exposures, Feature 1 consisting of a 6 m × 3 m largely sub-surface exposure of cultural materials. The midden here represents one exposed part of an extensive and potentially contiguous site complex covering much of the southern and eastern upper flanks of the hill.

Following an invitation by senior members of the Umomoro clan to undertake archaeological excavations at Feature 1, after it had become exposed a few days previously when a storm uprooted a large tree, a site survey was conducted in the vicinity of the site. GPS determinations were often not possible due to the dense rainforest canopy cover.

Surveys commenced by walking a line from the excavation at Feature 1, northwest-ward to the summit of the hill onto the edge of its abrupt upper northern slope. Surveys then progressed clockwise in an easterly-southeasterly direction curving back northwest-ward to the excavation. The ground on the northern flank slopes down abruptly (c.45°), contrasting with the more moderately steep upper slopes of the southern side. No cultural material was apparent on the northern slope that faces away from both the Komo River to the east and the Auro River to the south, the main artery to the coast (Fig. 1). From the summit including its upper northern flanks, archaeological surveys followed the hill around toward the south in a 50 m-long arc from Feature 1 down-slope. In this surveyed corridor seven relatively distinct areas of cultural activity were apparent as surface exposures. Poor ground visibility and the regular presence of individual shells across the ground surface suggest that observed concentrations of cultural material may be exposed parts of one or more larger areas of contiguous cultural activity, although the observed exposures could not be connected during the survey. Due to their close spatial proximity, these relatively distinct cultural features are listed as separate components of a single Kumukumu summit site complex (Fig. 3). Further surveys are needed to better determine the potential connectedness of these archaeological exposures.



Fig. 2. The hill Kumukumu from the east, 25 February 2009 (photograph by Bruno David).

- Feature 1 is the 6 m × 3 m dense shell exposure revealed by the uprooted tree (Fig. 4A). It is located on the upper, southern slope of Kumukumu, c.1 km northwest and 200 m above Ero, the largest village in the Aird Hills today. Feature 1 occurs 60 m down-slope from the hilltop (0209720/9176385 [AGD66]) and represents the maximum elevation at which surface cultural material can be seen. The large fallen tree that exposed Feature 1 has a trunk diameter of 70 cm. The root-ball is some 3 m across and >1 m deep, exposing the entire c.1 m depth of cultural deposit down to sterile clay. The roots were thickly matted with cultural materials, mainly *Melanoides* sp., *B. violacea*, *Neritina* sp. and *Pythia scarabaeus* shells, with considerable quantities of charcoal also present. Five undecorated pottery sherds and one carved bone artefact (Fig. 5B) were found within the cultural deposits in the root hollow. The bone artefact remained in undisturbed, *in situ* sediments just below the edge of the root hollow; it was revealed when the root hollow was cleaned up to a short distance below undisturbed levels prior to excavation of Square A.
- Feature 2 is a 1 m × 1 m surface scatter of shell (0209654/9176386 [AGD66]) (Fig. 4B). This concentration is 30 m down-slope and 25° from excavation Square A at Feature 1.
- Feature 3 is a 5 m × 3 m surface scatter of shells 40 m down-slope and 90° (east) from Feature 1 Square A (Fig. 4C).
- Feature 4 is a 4 m × 4 m concentration of stratified shells 45 m down-slope and 130° from Feature 1 Square A (Fig. 4F).
- Feature 5 is a set of cupules on an exposed boulder surface 45 m down-slope and 135° southeast from Feature 1 Square A. These appear to be the product of nut-cracking activity.
- Feature 6 is a dense, clearly stratified deposit of shell that extends some 40 m–60 m down-slope, commencing 140° south-east of Feature 1 Square A, continuing southward to 190° of Square A (Fig. 4E). Its maximum dimension of 45 m follows the east-west contours of the hill, indicating that the large size of this shell midden cannot be explained as the product of down-slope erosion. Dense shell appears to be stratified for a maximum length of 26 m north–south, covering an area of 613 m².
- Feature 7 is a set of five cupules (probably made through nut-cracking) on an exposed boulder 65 m down-slope and 165° south of Feature 1 Square A (0209619/9176396 [AGD66]) (Fig. 4D).

7. Kumukumu 1

Prior to this research, the only archaeological site recorded from the Aird Hills other than Emo was site OAI, an ethnohistoric period village site of the early 1900s and also known by the name

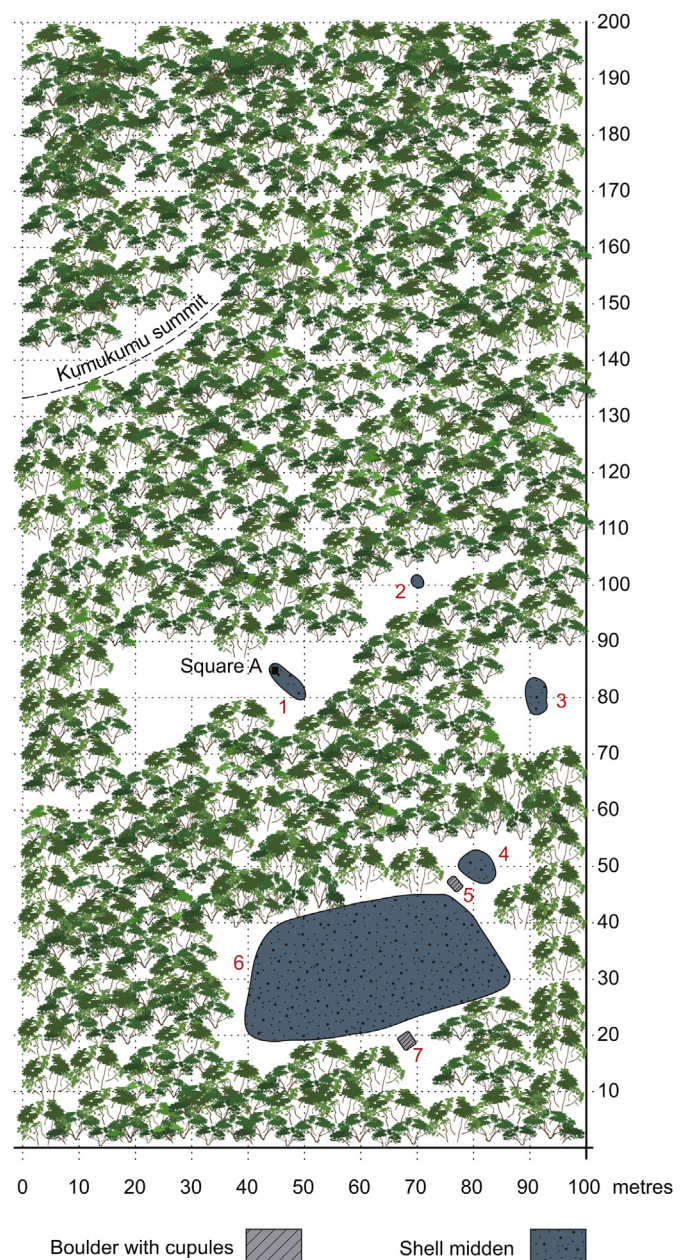


Fig. 3. Map of the Kumukumu summit site complex (north is oriented upwards).



Fig. 4. Major features of Kumukumu 1. A: Feature 1. B: Feature 2. C: Feature 3. D: Feature 7. E: Feature 6. F: Feature 4 (photographs by Bruno David and Robert Skelly).

Kumukumu. Following brief surveys guided by local residents, Rhoads (1983, p. 106) reported that the site was 'a Porome village site inhabited while the London Missionary Society station was established at Aird Hills in the early 1900s (Butcher, 1963, p. 142). It is situated on a low rise along the northeast slopes of the volcanic hills (7° 26'S, 144° 22'E). Shellfish remains constitute the dominant cultural material'. Following Rhoads (1983, Fig. 1) and Chance (1927), site OAI is located 2.1 km northwest of Kumukumu 1, along the northern edge of the Aird Hills by a river-side.

The location of Kumukumu 1 contrasts with OAI in the former's upper hill-slope location. The Square A archaeological excavations at Kumukumu 1 were undertaken on 22–24 February 2009. The climb from Ero to Kumukumu 1 is steep, slippery and strenuous, passing through dense lowland rainforest where in places the muddy slope rises at an inclination of 35°. Permanent fresh stream-water is available approximately half-way up the hill, although high

rainfall levels make water available within the forest throughout the year.

From its high strategic position, Kumukumu 1 allows direct observation of the river at its foot mainly to the east, including clear views of approaching canoes. The Auro River is a major tidal waterway that flows for 6 km to the southeast before reaching the open coastal waters of Bevan Sound. The Nabiu River, which can be seen through trees to the south of Kumukumu 1, joins the Auro River and together they provide two easily navigated passages to and from the coast.

7.1. Excavation of Square A

An area was selected for excavation against the southwest margin of the uprooted tree hollow, where sediments were cut back to expose a clean, undisturbed vertical face. A 30 cm × 30 cm

column (Square A) was excavated against the cleaned sediment face until culturally sterile basal clay was reached. Excavation was stopped at the top of the sterile clay at a maximum depth of 95 cm.

Square A was excavated in 44 Excavation Units (XUs) of average 2.2 cm thickness (Figs. 6 and 7). Table 1 presents details of each XU. Excavated sediments were wet-sieved in 2.1 mm mesh and sorted in the Monash University archaeology laboratories. A small, bulk sediment sample was kept from each XU for geomorphological and pollen analysis. From these sediment samples, pH, particle size and organic matter were analysed (Table 2).

Table 1
Details of XUs, Kumukumu 1 Square A.

XU	SU	Mean depth at top (cm)	Mean depth at centre (cm)	Mean depth at base (cm)	Mean thickness (cm)	Weight (kg)	Volume (litres)	Weight of >2.1 mm non-cultural sediments (g)	pH
1	1a	0.0	0.1	0.2	0.2	0.1	<0.5	0	7.31
2	1b	0.2	1.0	1.8	1.6	1.0	2.0	7	6.57
3	1b	1.8	3.1	4.3	2.5	1.3	3.0	57	6.66
4	1b	4.3	5.7	7.1	2.8	2.1	3.5	351	6.84
5	1b + 2a	7.1	8.7	10.2	3.1	1.3	2.5	126	7.14
6	2a	10.2	11.8	13.4	3.2	2.3	3.0	62	7.44
7	2b	13.4	14.9	16.3	2.9	2.0	2.5	40	7.50
8	2b	16.3	17.3	18.3	2.0	1.2	1.5	24	7.51
9	2b	18.3	19.0	19.7	1.4	1.3	2.0	19	7.61
10	2b	19.7	20.7	21.7	2.0	1.8	2.0	30	7.59
11	2b	21.7	22.2	22.6	0.9	1.6	2.0	38	7.55
12	2b	22.6	23.7	24.7	2.1	1.9	2.5	42	7.66
13	2b	24.7	26.0	27.3	2.6	2.8	3.0	43	7.55
14	2b	27.3	28.9	30.4	3.1	2.2	2.5	18	7.72
15	2b	30.4	30.8	31.2	0.8	1.4	2.0	21	7.76
16	2b + 2c	31.2	32.0	32.7	1.5	1.4	2.0	11	7.72
17	2c	32.7	33.6	34.4	1.7	1.4	2.0	10	7.77
18	2c + 2d	34.4	35.2	36.0	1.6	1.6	2.0	34	7.79
19	2c + 2d	36.0	37.1	38.2	2.2	1.9	2.0	44	7.86
20	2c + 2d	38.2	38.9	39.6	1.4	1.3	2.0	3	7.82
21	2c + 2d	39.6	40.5	41.4	1.8	1.5	2.5	13	7.87
22	2d + 2e	41.4	42.2	43.0	1.6	1.5	2.5	13	8.03
23	2d + 2e	43.0	43.9	44.7	1.7	1.7	3.0	45	7.93
24	2d + 2e	44.7	45.6	46.5	1.8	1.6	2.0	15	7.87
25	2d + 2e	46.5	47.6	48.6	2.1	1.8	3.0	6	7.98
26	2d + 2e	48.6	49.5	50.4	1.8	1.5	2.0	7	7.87
27	2d + 2e + 2f	50.4	51.7	52.9	2.5	1.4	2.5	2	7.71
28	2e + 2f	52.9	54.6	56.2	3.3	1.8	3.0	13	7.74
29	2e + 2f	56.2	57.2	58.2	2.0	1.2	1.5	4	7.86
30	2e + 2f	58.2	58.9	59.5	1.3	1.7	3.5	400	8.00
31	2e + 2f	59.5	60.5	61.4	1.9	1.2	1.5	4	7.93
32	2f	61.4	62.3	63.1	1.7	1.3	1.5	39	8.04
33	2f	63.1	64.1	65.0	1.9	2.7	3.5	2750	8.01
34	2f	65.0	65.6	66.2	1.2	1.4	2.0	7	7.97
35	2f	66.2	67.3	68.3	2.1	1.5	2.0	6	8.01
36	2f + 2g	68.3	69.0	69.7	1.4	1.2	2.5	3	7.87
37	2f + 2g	69.7	70.8	71.8	2.1	1.4	2.0	64	7.85
38	2g	71.8	73.4	75.0	3.2	1.8	2.0	138	7.88
39	2g	75.0	76.3	77.5	2.5	1.1	1.5	23	7.84
40	2g	77.5	78.4	79.3	1.8	1.4	2.0	31	7.89
41	2g	79.3	80.4	81.5	2.2	1.5	2.0	28	7.93
42	2g	81.5	83.6	85.7	4.2	2.0	2.0	341	7.87
43	2g + 3	85.7	88.1	90.4	4.7	0.8	1.0		7.83
44	2g + 3	90.4	92.6	94.8	4.4	0.5	0.5	46	7.81
Total					2.2	67.4	95.5	4975	

Three major Stratigraphic Units (SUs) were identified during the excavation, with SU1 being divided into SU1a and SU1b, and SU2 into seven sub-SUs (SU2a-SU2g). SU1 is loam containing large amounts of decomposing organic matter (mainly leaf litter) from the rainforest floor. The SU2 sub-layers are each rich in shell in silty loams. The SU2 sub-layers mainly signal species-specific shell banding in a continuous dense shell deposit. The sloping boundaries of these different sub-XUs could not always be differentiated

during excavation but became apparent in the sections after completion of the excavation. The base of shell-rich SU2 rapidly gives way to culturally sterile, highly compact and consolidated clays in SU3. Details of the sub-SUs are given in Table 3.

8. Excavation results

Eight AMS radiocarbon determinations were obtained on individual pieces of charcoal collected *in situ* from Square A and plotted in three dimensions. A further charcoal sample (Wk-25290) was

collected *in situ* from 4 cm to the southeast at exactly the same depth as the carved bone, just below the base of the tree root hollow, 52 cm to the northeast of Square A (Table 4). It is estimated (deducting the elevation of the charcoal sample from that of the southwest corner of the Square A surface 52 cm away) that Wk-25290 came from 62 cm depth.

Despite the shell banding representing differentiated deposits within SU2, the radiocarbon determinations do not suggest a

Table 2
Characteristics of excavated sediments, Kumukumu 1 Square A.

XU	Organic matter (%)	Particles >1000 μm (% weight)	Particle size distribution of particles $\leq 1000 \mu\text{m}$ (% volume)					
			Sand (1000–63 μm)	Coarse sand (1000–600 μm)	Medium sand (600–212 μm)	Fine sand (212–63 μm)	Silt (63–2 μm)	Clay (<2 μm)
1	79.8	0.8	37.2	4.7	11.1	21.4	49.2	13.6
2	51.1	0.1	45.9	0.0	6.8	39.1	45.1	9.0
3	44.9	1.8	9.8	0.0	0.5	9.3	80.9	9.3
4	35.3	1.3	11.1	0.0	1.7	9.4	78.7	10.2
5	25.6	12.7	12.7	0.0	3.7	9.0	76.5	10.8
6	12.9	35.3	13.1	0.0	1.3	11.8	73.4	13.5
7	10.2	44.6	13.5	0.0	1.2	12.3	73.5	13.0
8	15.2	31.2	7.1	0.0	0.1	7.0	80.5	12.4
9	9.1	45.5	0.3	0.0	0.0	0.3	81.5	18.2
10	8.3	37.8	0.8	0.0	0.0	0.8	83.4	15.8
11	9.6	44.1	18.0	0.1	2.8	15.1	70.0	12.0
13	8.0	48.0	22.5	1.1	4.8	16.6	63.7	13.8
13A	8.4	46.6	0.9	0.0	0.0	0.9	83.7	15.4
13B	5.9	56.3	0.5	0.0	0.0	0.5	78.6	20.9
13C	6.9	47.2	0.1	0.0	0.0	0.1	80.8	19.1
14A	4.8	54.0	0.1	0.0	0.0	0.1	79.5	20.4
14B	7.1	46.9	0.1	0.0	0.0	0.1	80.8	19.1
14C	6.2	46.6	0.0	0.0	0.0	0.0	78.1	21.9
15	5.7	37.9	16.8	0.0	4.4	12.4	68.4	14.8
16	6.1	35.2	21.8	0.0	6.3	15.5	62.4	15.8
17	5.2	50.2	0.0	0.0	0.0	0.0	79.3	20.7
18	5.0	54.9	6.3	0.0	0.0	6.3	72.9	20.8
19	3.0	57.8	10.7	0.0	0.0	10.7	69.9	19.4
20	4.7	55.5	1.8	0.0	0.0	1.8	77.7	20.5
21	3.6	59.3	3.8	0.0	0.0	3.8	74.2	22.0
22	2.4	70.9	0.1	0.0	0.0	0.1	75.7	24.2
23	3.7	61.6	14.5	0.0	3.6	10.9	66.9	18.6
24	4.1	51.6	19.9	0.0	6.1	13.8	63.2	16.9
25	4.1	73.3	19.9	0.0	6.1	13.8	63.2	16.9
26	4.2	57.6	9.7	0.0	0.1	9.6	72.2	18.1
27	3.0	62.1	9.7	0.0	0.0	9.7	69.8	20.5
28	4.7	63.9	8.8	0.0	0.0	8.8	72.9	18.3
29	3.3	59.5	3.0	0.0	0.0	3.0	76.5	20.5
30	3.4	67.1	21.6	0.0	7.5	14.1	62.2	16.2
31A	5.2	42.0	18.9	0.0	4.7	14.2	68.5	12.6
31B	3.9	45.0	15.2	0.0	4.2	11.0	69.8	15.0
31C	3.1	64.8	15.7	0.0	2.0	13.7	66.2	18.1
32	3.0	64.2	18.1	0.0	4.5	13.6	64.3	17.6
33	3.5	57.4	14.5	0.1	2.4	12.0	70.7	14.8
34	2.5	57.7	21.1	0.1	5.0	16.0	62.6	16.3
35	2.7	62.2	34.1	5.6	12.8	15.7	52.1	13.8
36	6.1	49.3	21.2	0.0	5.5	15.7	63.8	15.0
37	4.3	52.1	21.5	0.0	8.2	13.3	61.7	16.8
38	4.4	46.4	13.7	0.0	0.0	13.7	67.0	19.3
39	5.9	45.1	12.7	0.0	0.1	12.6	70.4	16.9
40	5.6	41.4	0.0	0.0	0.0	0.0	78.2	21.8
41	5.2	40.2	12.1	0.0	1.3	10.8	70.9	17.0
42	5.2	22.6	10.4	0.0	1.3	9.1	72.2	17.4
43	9.3	3.3	8.9	0.0	0.9	8.0	76.3	14.8
44	8.7	8.4	11.5	0.0	0.8	10.7	72.8	15.7

prolonged period of deposition. In the analysis of the radiocarbon dates, we have used OxCal v4.1.7 (Bronk-Ramsey, 2013) to determine the age of onset, end and duration of midden deposition. Because there is no archaeological evidence of a hiatus, we have assumed that all radiocarbon dates belong to a single phase of occupation (a random scatter of events in no particular order) with a uniform boundary (Bronk-Ramsey, 2009a). It is unknown whether this phase consists of intermittent or continuous site use. Because it is well established that, through the 'old wood' phenomenon (that is, the inbuilt age of wood in a living tree, as opposed to the storage age of a dead tree; e.g., Kurokawa et al., 2003; Vieira et al., 2005), all wood charcoal determinations will predate by an unknown amount of time the archaeological context of interest (e.g. Anderson, 1991; Spriggs

and Anderson, 1993), we have opted to apply an outlier correction for charcoal dates, as informed by Bronk-Ramsey (2009b). The correction factor employed is based on the prior knowledge that the site, and thus the wood used, came from a rainforest setting, and applies the following formula: $(\text{Exp}(1, -10, 0), \text{U}(0, 3), "t")$ whereby the exponential distribution runs from -10 to 0 with a time-constant of 1 , ensuring modification only to those outliers that are older. The shifts are then scaled by a common scaling factor that can lie anywhere between 10^0 and 10^3 years. This approach weighs samples according to how likely they are to be correct based on assumptions that compose the model and rely on a model-averaging approach to arrive at an acceptable hypothesis. This model gives a deposition date of between 620–581 and 552–469 cal BP for the top and

Table 3
Stratigraphic Units, Kumukumu 1.

SU	Maximum depth below ground (cm)	Description
1a	2	Surface sediments consisting of decomposing leaf litter with minor amounts of loam. No grass covers the ground surface. No cultural materials were seen during excavation. Boundary with underlying SU1b is marked.
1b	14	The upper surface of SU1b is firm. It is well demarcated from underlying sediments by the presence of dark humic loam held together by very many rootlets up to 1 cm Ø. No <i>in situ</i> cultural materials were seen during excavation, although small amounts of shell were adhering to some rootlets (interpreted as post-depositionally brought up from underlying SU2 by root activity). Sediments homogeneous across square, moderately consolidated. Boundary with underlying SU2a is fairly well marked, taking place over a depth of c.1 cm.
2a	17	Fragmented shell rapidly becoming abundant in a silty loam matrix. Rootlets continue to be numerous. Boundary with SU2b is fairly well marked, taking place over a depth of c.2 cm.
2b	38	Thick layer of shell in silty loam of similar consistency to SU2a. What differentiates SU2a is the abundance of <i>Batissa violacea</i> shells lying flat, both the species predominance and the shells' consistent orientation clearly identified during excavation. Boundary with SU2c is well marked, taking place over a depth of c.1 cm.
2c	41	A distinctive, dense concentration of <i>Neritina</i> sp. shell in silty loam.
2d	50	Similar to SU2c, except that <i>B. violacea</i> now predominates. While most shells lie flat, they occur in all orientations.
2e	60	Layer of dense silty loam with <i>Neritina</i> sp. shell predominating.
2f	74	Thick layer of burnt shell, with <i>B. violacea</i> and <i>Neritina</i> sp. predominating, with large patches of charcoal amidst the shell-rich silty loam matrix. SU2f is very distinctively a burnt layer. Sediments are depauperate in soil and rich in shell. <i>B. violacea</i> shells lie mainly flat.
2g	85	Loose layer of <i>Neritina</i> sp. shell sitting on increasingly clayey silty-loam sediments.
3	>95	Culturally sterile thick clay. Excavation in Square A proceeded only to the base of the SU2g-SU3 interface due to difficulties of penetrating the clay, but hacking into the clay after completion of the excavation, and exposure of the deeper stratigraphy nearby below 95 cm depth, confirms the continuation of culturally sterile, very compact and consolidated thick clays below the deepest systematically excavated XU in Square A. Some rocks, c.10 cm thick, separate the culturally sterile clay of SU3 from the shell-rich cultural sediments of SU2g above it. The interface between SU2g and SU3 takes place over a depth of c.8 cm.

Table 4

Radiocarbon determinations, Kumukumu 1. All ^{14}C ages are AMS on charcoal. Calibrations undertaken using OxCal v4.17 (INTCAL09 curve selection) (Reimer et al., 2009). n/a = $\delta^{13}\text{C}\text{‰}$ measured and taken into account in calculation of radiocarbon age, but not separately reported.

XU	Depth below ground (cm)	SU	Wk- laboratory code	$\delta^{13}\text{C}\text{‰}$	% Modern	^{14}C age (years BP)	Unmodelled calibrated age BP (68.3% probability)	Unmodelled calibrated age BP (95.4% probability)	Median calibrated age BP
Square A									
7	15.3	2b	25,291	-27.1 ± 0.2	93.1 ± 0.2	572 ± 30	630–600 560–540	647–585 567–529	601
12	24.0	2b	25,292	-26.3 ± 0.2	93.0 ± 0.2	583 ± 30	635–596 562–544	651–581 570–534	603
16	27.3	2b–2c interface	25,293	-30.7 ± 0.2	94.0 ± 0.2	495 ± 30	536–511	551–500	524
24	43.6	2d	25,295	-27.0 ± 0.2	93.5 ± 0.2	538 ± 30	621–610 554–522	633–597 561–513	545
26	49.8	2e	25,296	-28.3 ± 0.2	92.4 ± 0.2	632 ± 30	656–632 598–561	665–552	599
32	63.3	2f	25,298	-29.3 ± 0.2	93.6 ± 0.2	531 ± 30	552–518	631–599 560–510	540
36	64.9	2f	25,299	-27.8 ± 0.2	93.1 ± 0.2	572 ± 30	630–600 560–540	647–585 567–529	601
41	77.3	2g	25,300	-27.4 ± 0.2	93.1 ± 0.3	578 ± 30	633–597 561–542	650–582 569–530	602
Hollow of uprooted tree, charcoal sample adjacent to carved bone									
Not applicable	c.61.8	Not applicable	25,290	n/a	92.8 ± 0.2	604 ± 30	645–620 612–587 566–553	654–543	603

661–526 cal BP (95.4% probability) for the base of the midden. An overall span of 0–116 years has been calculated and a rapid deposition rate is testified to by the overlap between the top and basal dates (Fig. 8). The Feature 1 midden at Kumukumu 1, as represented by the Square A excavation, was thus laid down over a time span ranging from less than one year to maximum 116 years, with the most likely correct scenario being somewhere in between, around 600 cal BP.

8.1. Cultural materials

Table 5 lists the excavated materials from Square A. With the exception of XU30, XU33 and XU42 which each contain some rocks

a few centimetres long, in all other XUs from SU2a-SU2g (i.e. the XU6-XU42 sequence, representing all excavated sediments other than the near-surface SU1 and basal SU3), cultural materials make up 87%–100% by weight of sediments >2.1 mm long. Between 24% and 73% of all excavated sediments from SU2a-SU2g (i.e. including the ≤ 2.1 mm residue fraction) consists of >2.1 mm long cultural materials, further emphasising the very high density of cultural materials throughout the cultural deposit. That is, virtually the entire 95 cm depth of deposit consists of coarse-grained cultural materials (overwhelmingly shell) poorly-consolidated with very low quantities of fine sediments (probably contributing to the eventual collapse of the large tree that grew in much of the midden).

Table 5
Excavated materials, Kumukumu 1 Square A.

Excavation unit	% of total sediments consisting of >2.1 mm cultural materials (by weight)	% of >2.1 mm sediments cultural (by weight)	Animal bone (g)	Crustacea (g)	Shell (g)	Egg shell (g)	Charcoal (g)	Flaked artefacts (#)	Flaked artefacts (g)	Pottery sherds (#)	Pottery sherds (g)	Fragment of grinding stone (#)	Fragment of grinding stone (g)	Land snails (MNI)	Land snails (g)	Roots (g)	Vegetation other than seeds & roots (g)	Insects (g)	Seeds (g)
1	0	1			0.01												0.14		1.43
2	1	31	6.25		4.41		0.04			1	1.4					1.29	2.93	0.01	12.77
3	1	18			12.63		0.30			1	6.8						0.09		3.45
4	3	13	1.02		40.42		2.92	2	0.04	8	9.4								1.32
5	21	68	0.52		257.68		2.38			2	7.5					0.12			0.02
6	35	93	2.37		796.76		9.63					2	0.02						0.01
7	42	95	3.14		815.98		2.04	1	0.07	1	9.5								0.01
8	52	96	2.79		619.18		0.87			1	1.9								0.01
9	52	97	2.92		671.43	0.02	0.65							3	0.02				
10	47	97	2.19		850.65		1.38							2	0.01				
11	48	95	2.60		769.62		0.49												
12	50	96	3.07		953.40		1.66												0.01
13	51	97	6.94		1423.05	0.02	0.78												
14	54	99	6.86		1186.52		1.04							4	0.03				
15	55	97	1.74		770.20		0.12												
16	52	98	3.96		717.87		1.09							1	0.01				
17	59	99	2.33		824.84		0.18											0.01	
18	64	97	4.03		1014.05		0.43												
19	64	97	3.28		1148.42		0.57					1	59.39						
20	73	100	2.33		949.57		0.20			1	0.2								
21	69	99	1.19		1028.90		1.71												
22	65	99	2.45		969.06		0.66												
23	64	96	0.95		1089.56		0.56							5	0.04				
24	66	99	1.45		1054.88		0.71												0.01
25	66	100	2.22		1185.03		1.00							1	0.01				
26	69	99	1.17		1029.02		1.27												
27	69	100	1.56	0.22	963.35		0.68							1	0.01				
28	67	99	3.99		1201.33		0.90							2	0.06				
29	70	100	1.71		834.46		0.20												
30	50	68	1.44		840.91		0.24							1	0.01				
31	59	99	2.11		702.48		0.43	1	0.01					2	0.02				
32	61	95	0.51		796.50		0.37												
33	25	19	1.17		662.98		0.36							2	0.01				
34	60	99	0.79	0.11	832.96	0.01	0.33							6	0.05				
35	64	99	1.13	0.51	957.05		0.83							2	0.02				
36	63	100	0.68	0.02	749.36	0.01	10.17							2	0.02				
37	55	92	1.07		755.29		7.86							4	0.01				
38	51	87	4.85		908.25		0.94							5	0.02				
39	47	96	11.05		504.54	0.01	1.38												
40	45	95	3.96	0.11	618.48		0.76							3	0.02				
41	36	95	0.90		532.61		0.06												
42	24	58	4.44		475.25		0.04												
43	1	100			7.67														
44	0	0			0.23														
Total	49	87	107.43	1.05	32,526.84	0.07	58.23	4	0.12	15	36.7	1	59.39	48	0.39	1.41	3.16	0.02	19.04



Fig. 5. A: Drilled and highly polished fish spine needle. B: Carved bone artefact excavated from *in situ* sediments near the base of the uprooted tree hollow (photographs by Steve Morton).

8.2. Charcoal

Charcoal occurs in reasonable quantities in all cultural XUs (SU2), including those at stratigraphic interfaces with SU1 above and SU3 below (Table 5). It is represented in all XUs from XU2 to XU42, often in localised patches.

8.3. Shell

The Square A excavations revealed a MNI of 14,772 *Neritina* sp., 5706 *Melanoides* sp., 2081 *B. violacea* and 709 *P. scarabaeus* shells (Table 6). As 0.0855 m³ was excavated (30 cm × 30 cm × 95 cm depth) – only 0.0792 m³ of which contains shell MNI, spanning XU3 (top = 2 cm depth) to XU43 (base = 90 cm depth), i.e. 88 cm thickness – the MNI shell densities in the Square A cultural levels are 186,515 *Neritina* sp./m³, 72,045 *Melanoides* sp./m³, 26,275 *B. violacea*/m³ and 8952 *P. scarabaeus*/m³, amounting to more than a quarter a million shell MNI per cubic metre (293,787 shellfish/m³) for the four taxa combined.



Fig. 6. Kumukumu 1 Square A excavation in progress (photograph by Bruno David).

The above figures are comparable with shell densities excavated at Emo, the village site at the base of the hill. Here shell densities were: 28,431 *Neritina* sp./m³, 282,052 *Melanoides* sp./m³, 52,138 *B. violacea*/m³ and 30,740 *P. scarabaeus*/m³, amounting to 393,362 shellfish MNI/m³ for the four taxa combined (David et al., 2010, pp. 46–47).

The Kumukumu summit site complex has a total 663 m² of exposed dense surface shell deposit as determined from the surveys (see above). These occur as four separate, relatively small exposures (Features 1–4) plus the larger Feature 6 that we have already noted cannot be explained simply as the result of near-surface down-slope sheet erosion of an originally significantly smaller midden. The densities of shells in these surface exposures suggest similar densities as those found in the excavation square (and as evident also at Emo). We thus estimate by extrapolation from the Feature 1 excavation square that the site contains in the vicinity of 123,659,445 *Neritina* sp., 47,765,835 *Melanoides* sp., 17,420,325 *B. violacea* and 5,935,176 *P. scarabaeus* MNI, totalling nearly 200 million shellfish (194,780,781 shell MNI). These compare with the total 295 million shellfish MNI of the same four species calculated to be represented at Emo 400 m away (David et al., 2010, pp. 46–47). While these numbers from Kumukumu 1 do not take into account variations in the depth of shell midden material across the hillside, in species variations across space, nor do they include any additional areas that may only have subsurface

Table 6
Excavated cultural shell, Kumukumu 1 Square A.

XU	Unidentified shell fragments	<i>Batissa violacea</i>				<i>Neritina sp.</i>		<i>Pythia scarabaeus</i>				<i>Melanoides sp.</i>		<i>Neritina violacea</i>		<i>Cerithidea sp.</i>		<i>Cerithiidae?</i>				
		Weight (g)	MNE: L valve, posterior cardinal tooth gap (unburnt)	MNE: R valve, posterior cardinal tooth (unburnt)	MNE: L valve, posterior cardinal tooth gap (burnt)	MNE: R valve, posterior cardinal tooth (burnt)	MNI	Weight (g)	MNI	MNE: (=MNI) >50% aperture	Weight (g)	MNE: Isolated apex	MNE: Attached apex	MNI: Total apex	Weight (g)	MNE: >50% aperture (=MNI)	Weight (g)	MNI	Weight (g)	MNI	Weight (g)	
1	<0.1																					
2						4.4																
3	0.1		2			2	12.6															
4	1.4	4	2			4	37.2															
5	<0.1	32	36			36	231.4															
6	50.1	73	62			73	617.6															
7	79.8	65	81			81	563.7															
8	31.1	48	54			54	434.4															
9	43.8	42	59			59	459.1															
10	84.2	74	76			76	555.4															
11	99.5	68	85			85	446.4	1														
12	117.6	65	82			82	588.9															
13	93.7	108	90	1	1	109	924.5															
14	118.7	66	83			83	679.3															
15	56.1	40	49			49	506.1															
16	65.8	35	31			35	274.4	1														
17	23.6	37	37			37	399.6	3														
18	31.5	43	47			47	530.1															
19	45.0	56	65			65	654.1															
20	41.7	48	50			50	538.5															
21	20.7	61	56	1	2	62	658.6															
22	7.4	44	70			70	593.5	4														
23	32.2	65	68			68	723.6	1														
24	11.3	47	58			58	513.2	2														
25	45.2	37	48			48	454.5															
26	59.2	35	33	1	1	36	376.9															
27	54.5	31	30	3	7	37	387.0	1														
28	75.6	37	32	13	13	50	491.3															
29	56.4	26	25	29	29	55	528.2															
30	68.5	26	23	31	34	57	504.5	2														
31	78.6	23	19	22	16	45	466.8															
32	114.4	12	20	31	23	43	524.2															
33	147.1	11	13	28	28	41	371.2															
34	38.0	25	29	29	36	65	665.8															
35	68.4	19	25	27	27	52	786.0															
36	70.2	29	27	20	20	49	621.6															
37		31	33	22	23	56	646.7															
38	123.7	37	40	23	19	60	640.7	1														
39	36.6	22	21	12	11	34	349.2															
40	59.3	36	33			36	380.4															
41	12.5	38	34			38	412.7															
42	20.2	34	34			34	358.3															
43	1.5		2			2	4.5															
44	0.2																					
Total	2185.1	1594	1724	293	290	2081	19,916.9	16	14,772	8225.0	709	12	721	222.3	5706	1977.3	5	0.09	4	0.04	1	0.01

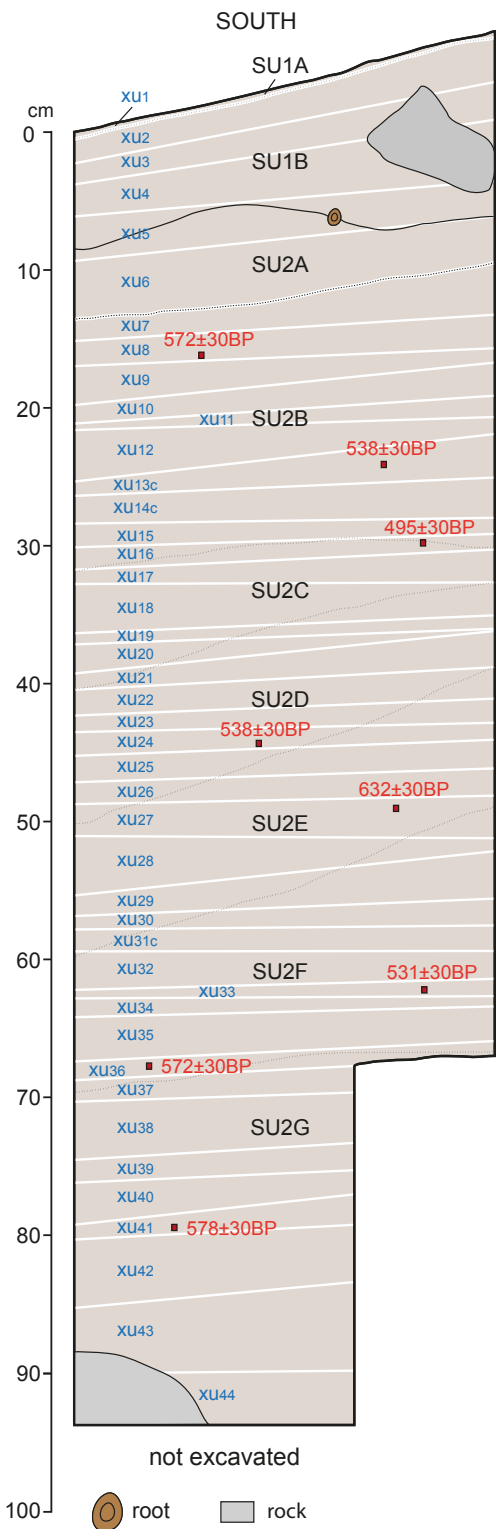


Fig. 7. Kumukumu 1 Square A south section with XUs and radiocarbon dates back-plotted.

shell and therefore have remained unrecorded, they give a good sense of the kinds of shell densities and species range present. We note that shell material only became exposed in the area of Feature 1 (i.e. of Square A) through the root hollow; similar, unrecorded subsurface deposits are very likely to occur elsewhere in the

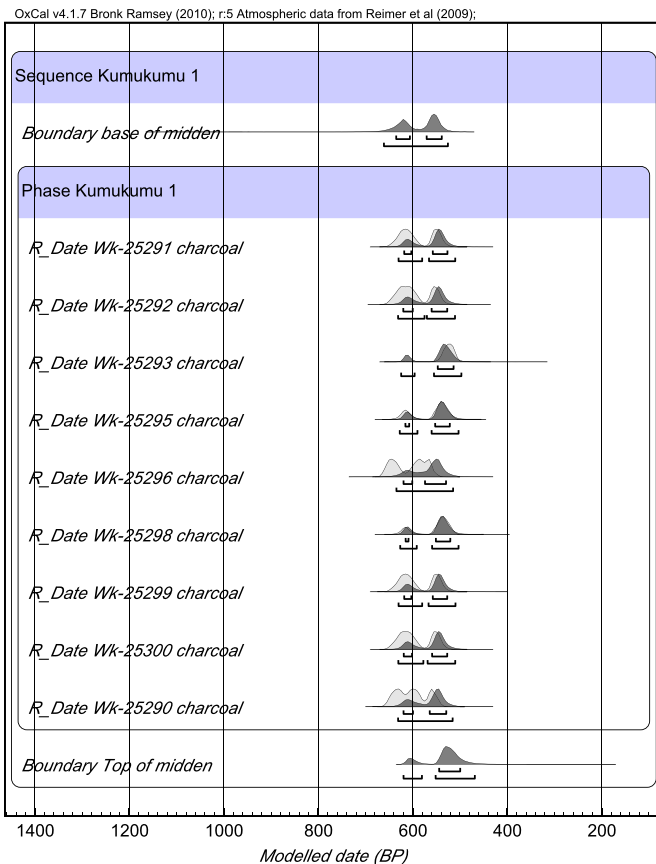


Fig. 8. Modelled sequence at Kumukumu 1 showing the 68.2% and 95.4% probability calibrated age ranges. The light grey date distributions show the calibrated ages for each individual sample. The solid black distributions show the calculated ranges when applying the Bayesian model outlined in the text (quoted probabilities vary slightly by run).

vicinity, adding further to the total number of shells across the Kumukumu summit landscape.

These extraordinary shell numbers and densities are found along the upper slope near the apex of the steep, rainforest-clad, 220 m-high hill. *B. violacea*, *Melanoides* sp. and *Neritina* sp. shellfish live in freshwater and estuarine environments that interface in mangrove ecosystems such as those found in the lowlands in the immediate vicinity of the base of Kumukumu. Each of these taxa can be found in abundance as living specimens on or near the mudflats and waterways at the base of the hill. However, *P. scarabeus* is a mangrove species that can only exist in the presence of an adjacent terrestrial woodland environment (Smith, 1992). Poraituk and Ulijaszek (1981, p. 13) have noted for the Purari River delta shortly to the east that *Neritina* was the taxon 'most frequently collected' by local peoples ethnographically, 'and was found regularly at all localities investigated'. In some areas it 'appeared in colonies of hundreds or more. Larger snails were found crawling on tree trunks and nypa fronds. Due to its abundance villagers often collect it for food'. Poraituk and Ulijaszek (1981, p. 14) also note that a species of *Pythia* 'is the most commonly found on rotten leaves and branches ... the species is found out of the water'.

Of interest is the total absence of the only terrestrial species, *P. scarabeus* in the upper, XU3–XU7 levels of the Kumukumu 1 excavation square, along with both its absolute and relative rarity from XU8 to XU11, contrasting with the continued abundance in very high numbers of *Neritina* sp., *Melanoides* sp. and *B. violacea* to XU6 at the top of the SU2 cultural horizon proper. We interpret this

temporal trend to indicate a depletion of the only numerically significant terrestrial mollusc species represented in the assemblage. Given the short-duration of occupation implied by the radiocarbon determinations, this suggests that the residents of Kumukumu 1 quickly depleted the nearby terrestrial environment. However, the very high numbers of aquatic and river-bordering resources, especially *Neritina* sp., *Melanooides* sp. and *B. violacea* shellfish, indicates that throughout much, if not all periods of refuge, residents continued to frequent and exploit low-lying (river-level) resource zones closer to and thus more susceptible to actually or potentially nearby raiders in search of human heads.

The nearby Emo archaeological evidence nevertheless suggests that those aquatic resource zones frequented on the upper hillslopes in the Aird Hills were not the same as those exploited from village bases during more secure times, as morphometrics on *B. violacea* shells at Emo indicate a diminution of shell size during the course of occupation in this visually exposed river-frontage village, followed by the recovery of shellfish to pre-exploitation sizes upon site re-occupation following each of its phases of abandonment, suggesting that during those periods of village abandonment predation pressures were eased. The implication is that when the village of Emo was abandoned, resources zones other

than those exploited during its occupation were targeted by people who lived in or used this general part of the Aird Hills. Given the short distance involved (a few hundred metres) between Emo and Kumukumu 1, we suggest that as people retreated inland and up-slope, riverine resources further penetrating into the Aird Hills (and thus less visible from the major waterways frequented by Kerewo raiders) were targeted for food resources rather than the regular village resource zones that contained essentially the same range and richness of taxa.

8.4. Land snail shell

The land snail shells recovered from the excavation are largely endemic species (*Cyclophorid* sp., *Kaliella* sp., *Microcystina* sp., *Pseudocyclotus* sp., *Moulinia* sp.) that inhabit the rainforests of the local region; none are interpreted as food remains (Table 7). Two species, however, the subulinids *Allopeas gracile* and *Allopeas clavulinus*, are modern day 'tramp' species that have been and are spread by human activity. Their presence in the sequence is probably an indication of a high level of inter-regional connections involving population movements and the translocation possibly involving trade of material items (such as sago, ceramics and logs for hulls).

Table 7
Excavated land snail shell, Kumukumu 1 Square A.

XU	<i>Cyclophorid</i> sp.		<i>Allopeas gracile</i>		<i>Allopeas clavulinus</i>		<i>Kaliella</i> sp.		<i>Microcystina</i> sp.		<i>Pseudocyclotus</i> sp.		<i>Moulinia</i> sp.	
	MNI	Weight (g)	MNI	Weight (g)	MNI	Weight (g)	MNI	Weight (g)	MNI	Weight (g)	MNI	Weight (g)	MNI	Weight (g)
1														
2														
3														
4														
5														
6	1	0.01	1	0.01										
7														
8														
9			2	0.01			1	0.01						
10			2	0.01										
11														
12														
13														
14			3	0.02	1	0.01								
15														
16					1	0.01								
17														
18														
19														
20														
21														
22														
23			5	0.04										
24														
25													1	0.01
26														
27									1	0.01				
28			1	0.01							1	0.05		
29														
30													1	0.01
31			1	0.01									1	0.01
32														
33			2	0.01										
34			4	0.04	2	0.01								
35			1	0.01	1	0.01								
36			1	0.01					1	0.01				
37			4	0.01										
38			4	0.01					1	0.01				
39														
40					2	0.01							1	0.01
41														
42														
43														
44														
Total	1	0.01	31	0.20	7	0.05	1	0.01	3	0.03	1	0.05	4	0.04

8.5. Bone

In stark contrast to the vast quantities of shellfish recovered, the excavation produced only small quantities of vertebrate remains. These were dispersed between XU2 and XU42, with an average of 2.60 g for XU1–XU42 and a peak value of only 11.05 g from XU39. A plot of bone weights through the stratigraphic profile contains suggestions of several vertical clusters centred on XU2, XU8, XU16, XU28 and XU39 (Fig. 9). These clusters do not correspond with fluctuations in shell intensities down the deposit. All excavated bone is in an exceptional state of preservation and most XUs below XU8 also yielded fish scales in good condition. There appears to have been little or no post-depositional degradation and loss of faunal remains. Very small quantities of crab exoskeleton and bird eggshell are present, the former only below XU26 and the latter in two clusters in XU9–XU13 and XU34–XU39.

Two-thirds of the total quantity of bone are attributable to bony fish, but the proportion of fish remains in many XUs exceeds 80%. At least eight families of fish are represented, including eels that may have been taken from freshwater streams and various others that are certainly derived from the major estuarine channel (Table 7). Holocentridae are tentatively identified; they are fishes of coral reef environments and their occurrence needs confirmation. The most abundant diagnostic fish element is the lenticular otolith of catfish of the family Ariidae, of which a dozen or more species might be expected to occur along the lower to middle reaches of the Kikori River (cf. Roberts, 1978). Almost all of the excavated fish taxa would have been suitable for eating and much of the fish bone is burnt, presumably during cooking and after disposal. One exception is the puffer fish family Tetraodontidae that is represented in multiple XUs; these have poisonous organs that render their flesh toxic, even after cooking, but their thick skin may have been used as a raw

material for artefact manufacture or they may have been used as a source of toxin. The minimum number of individual fish required to account for the excavated remains is probably around 25–30. Most of these were small fish, but XU9 and XU35 yielded remains of large fishes, being members of the Ariidae and Sparidae, respectively.

The remainder of the bone assemblage comprises mammals and reptiles (Table 8). Identified mammals include bandicoots (represented by postcranial remains only), the Ground Cuscus (*Phalanger gymnotis*), a Giant White-tailed Rat (*Uromys cf. caudimaculatus*) and a native rat (*Rattus* sp.), all of which could have been obtained through casual hunting and/or snaring in local lowland rainforest. Pig remains are present from the lowest excavated levels and they occur at intervals through the deposit. Dog was recovered only in XU15. The pigs may represent the remains of feral pigs, obtained through hunting, but might also include some domestic animals.

The reptile bone includes vertebral fragments from large individuals of the families Boidae (pythons) and Varanidae (monitors), and carapace or plastron fragments of Chelidae (freshwater turtles). These remains are consistent with casual hunting in forest and along the river edge.

Crab remains were recovered only in the lower part of the profile (XU27, XU34–XU36 and XU40) and only ever in very small quantities (Table 5). Two different kinds of crabs are represented, the mud crab *Scylla serrata* and a probable portunid (also likely to inhabit muddy shore habitats). These taxa are most active at night and their rarity in the deposit may reflect reluctance on the part of the site inhabitants to venture close to the river after dark.

Small quantities of bird eggshell were recovered from XU9, XU13, XU34, XU36 and XU39. All are consistent in thickness and texture with eggs of mound-building megapodes, of which several species occur in the lowlands of the Gulf of Papua. The scarcity of

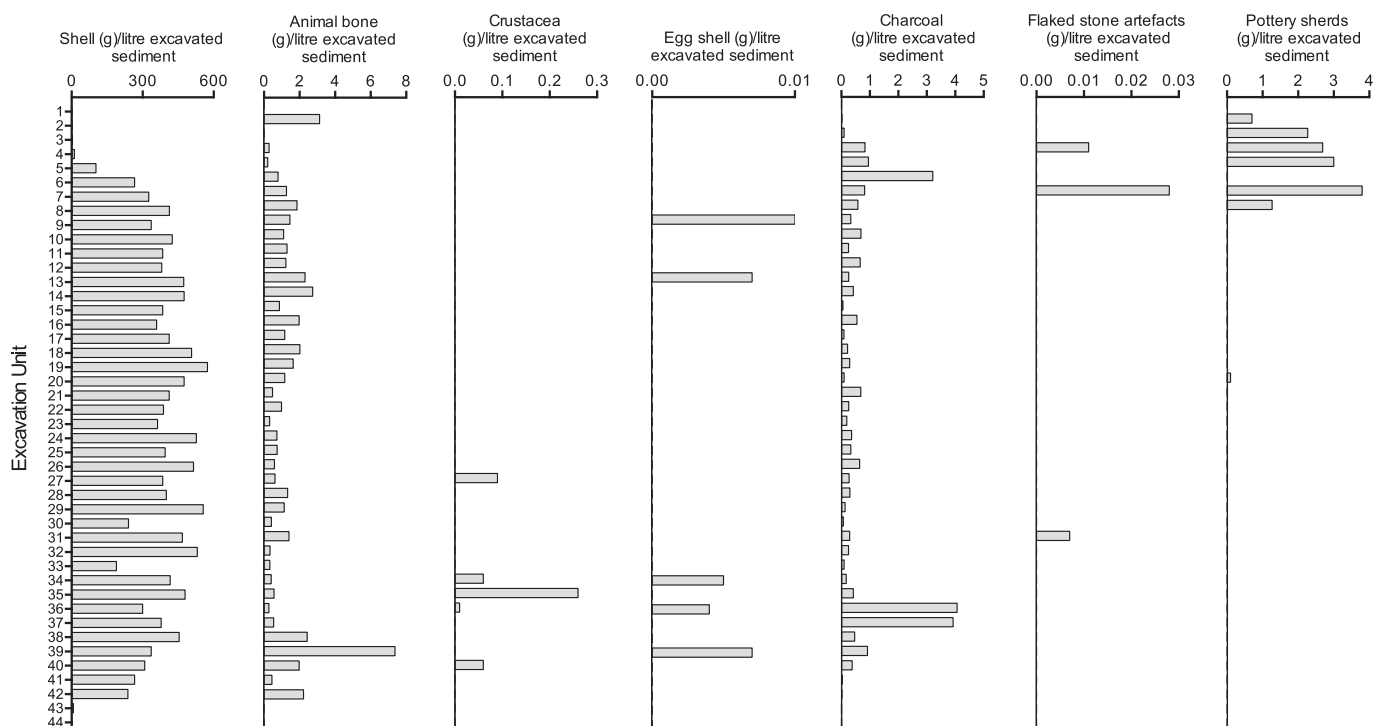


Fig. 9. Vertical distribution of grams of cultural materials per litre of excavated sediment, by XU. The various peaks and troughs in the quantities of animal bone do not correspond well with variations in quantities of deposited shell.

Table 8

Number of identified specimens of each taxon recognised in the faunal assemblage from each XU.

XU	Mammals						Reptiles			Fish										
	<i>Canis lupus</i>	<i>Sus scrofa</i>	Peramelidae	Phalangeridae	<i>Phalanger gymnotis</i>	<i>Rattus sp.</i>	<i>Uromys cf. caudimaculatus</i>	Small lizard	<i>Varanus</i>	Boidae	Snake	Chelidae	Anguillidae	Ariidae	Holocentridae?	Mugilidae	Pomadyasidae	Sparidae	Tetraodontidae	Fish type E
1																				
2																				
3																				
4	1																			
5																				
6									1											
7						1			1		1	1								
8														1						
9				1										1		1			1	
10														1					1	
11												1		1						
12						1						1		1		2				
13	1									1									1	
14																1				
15	1	1							1											
16								1								1				
17																				
18																				
19																				
20														1					1	
21																				
22														1						
23																			1	
24	1																			
25																				
26								1						1						
27														1						
28	1												1						2	
29	1																			1
30														1					1	
31																				
32																			1	
33														1						
34																				
35																			1	
36																			1	
37																				
38	1																			
39	2																			
40	?Vertebra fragments					1							1							
41	?Rib fragments													1						
42	1																			
43																				
44																				

eggshell in the site may reflect a rapid depletion of this resource and retreat of the megapodes away from the immediate area during periods of regular human presence.

8.6. Bone artefacts and other modifications

A very well preserved, nearly complete bone needle measuring 80.3 mm in length and weighing 1.1 g was recovered in eight pieces from XU38 (Fig. 5A). It was manufactured on a lightly burnt fish spine and has been modified through longitudinal surface scraping and the drilling of a basal hole. The hole was drilled from one side, as evidenced by circular striations producing a concave recess on one side only; the other side has been chamfered. The basal hole has the beginning of a pilot hole, indicating that there were at least two attempts to make the needle eye from one side. The surface of the bone bears a high gloss over much of its length. Recovery of almost all fragments of the artefact in a single XU, despite the occurrence of multiple fractures sometime after deposition but before excavation, points to a high level of stratigraphic integrity of the deposit. This is also evident from the recovery in several XUs of pairs of catfish otoliths (i.e. left and right from same individual).

One fragment of cortical bone from XU42 has several oblique scoring marks probably made with a stone tool. The fragment cannot be identified with any certainty, but it is consistent in cortical thickness and surface character with pig bone.

The carved bone artefact excavated from *in situ* sediments near the base of the uprooted tree hollow is cylindrical in form, although the cross-section is roughly triangular with bluntly rounded apices. It measures 47.7 mm in length and has transverse widths (measured from each flat surface to the opposing apex, in the middle of the artefact) of 16.3 mm, 16.8 mm and 17.7 mm. The form of the bone is consistent with the source bone being a human radius, with the fragment representing the distal part of the diaphysis. The outer surface of the bone is highly modified but the medullary canal appears to be unaltered. A series of 12 narrow grooves encircle the artefact and both ends appear to have broken off at the location of additional grooves. Whether or not this was intentional is impossible to say. The majority of the grooves are approximately equally spaced, but one pair is almost double the distance apart of any others. At both ends the fracture edges are sharp; hence, the artefact bears no indication of having being strung on a cord or of having held the butt of another artefact. Although no similar artefact has yet been identified from ethnographic sources, further research in this area might yield a parallel that will inform on the functional and wider cultural significance of this unusual artefact.

8.7. Pottery

A total of 15 sherds weighing 36.7 g were excavated from Square A. The largest sherds, and the only three measuring more than 3 cm maximum length, measure 4.5 cm (from XU7), 4.2 cm (XU3) and 3.7 cm (from XU5) long. The mean maximum thickness of all sherds is 5.4 ± 1.2 mm. All are plain body (i.e. non-rim) sherds. All except one came from XU8 or above; the exception is a single small sherd weighing 0.2 g from XU20 and with similar characteristics to the other sherds. All sherds are tempered with mineral sand. Although only two sherds conjoin (from XU7 and XU8), it is possible but not certain that they all came from a single vessel. The uppermost 14 sherds (93%) came from the same upper levels of the cultural deposit that also contain the depauperate *P. scarabaeus* shell assemblage, suggesting that during the period represented by this horizon something different to the previous period of occupation was taking place. Given the paucity of diagnostic details on the excavated sherds, the total absence of decorated sherds and the

rarity of plainware sherds in the exposed, uprooted area of Feature 1 as well as on the other archaeological exposures of the Kumukumu summit site complex, we conclude that 1) ceramics were rarely used in this site complex; and 2) those ceramics that did make their way to the site were mainly if not exclusively plainware vessels.

8.8. Stone artefacts

Three stone artefacts were recovered weighing in total 59.5 g. One flaked piece made from quartzitic sandstone in XU4 (0.02 g) and one flaked piece made of quartzite in XU7 (0.07 g) composed the flaked assemblage. The absence of cores and flakes, the tiny size of the flaked artefacts, and the rarity of stone artefacts indicate limited on-site knapping restricted to tool maintenance rather than manufacture. A piece of volcanoclastic sandstone identified in XU19 (59.4 g) exhibits striation marks consistent with a broken fragment of an originally larger grinding implement.

8.9. Comparison of the Kumukumu 1 assemblage with Emo Phase 4

The Kumukumu 1 assemblage either narrowly post-dates or partially overlaps the final phase of intensive occupation of the nearby Emo site. Comparison of the Kumukumu 1 assemblage with cultural materials recovered from Emo Phase 4 is thus of special interest, with Squares A and B of Emo treated separately as a way of assessing the internal variability of one of two records. Both assemblages are treated as single entities, with each probably having a similar temporal span of decades rather than centuries.

The two assemblages are quantitatively similar in many respects, including the abundance of shellfish derived from the freshwater and estuarine environments; the rarity to absence of *P. scarabaeus*; the overall scarcity of vertebrate bone; the presence of significant taxic diversity both in the fish and the terrestrial vertebrate remains, indicative of varied modes of acquisition verging on opportunism, and essentially the same range of taxa; and the scarcity of flaked stone. Other points of special similarity are the occurrence of pig remains in numerous excavation units within both assemblages; the presence of burnt stones indicative of the use of *mumu* earth ovens; and the presence of evidence for the use of anvils, presumably for opening nuts (these are small mobile anvils in Emo Phase 4 and two large *in situ* boulders (Features 5 and 7) at Kumukumu 1. Points of distinction between the assemblages from each site include the apparently elevated quantity of shellfish at Kumukumu 1 relative to other classes of cultural remains (approximately six times as much), and the reduced quantity of ceramics at Kumukumu 1.

9. Discussion: historicising headhunting along the south coast of New Guinea

The most likely interpretation of the relatively large number of ^{14}C charcoal dates now available from archaeological sites in the Aird Hills suggests that intensive occupation of Kumukumu 1 on the summit of the hill narrowly post-dates the final phase of intensive occupation of the nearby Emo site, which lies at the base of the hill. Whether or not occupation of the sites occurred consecutively or with a period of overlap probably cannot be resolved and may not be vital to know. What is more important, given the proximity of the two sites, is the high degree of similarity between the two assemblages which we take as evidence of a spatial relocation of a single group of people rather than temporal replacement of one group of people by another. Where people ate their food and carried out other activities evidently changed from a riverside location to a hilltop location, but the kinds of things they

were eating and doing appears to have been more or less the same, irrespective of the change of scenery. However, as noted above, there does appear to have been a shift in emphasis with an apparently even greater reliance during the occupation of Kumukumu 1 being placed on freshwater and estuarine shellfish as a principal protein source. The likely relocation from Emo to Kumukumu 1 did not involve the translocation of pottery; this is probably of some significance as pottery was found to be a feature of permanent village sites but not of hunting camps or other short-duration sites elsewhere along the Kikori River (David, 2008). The implication is that Kumukumu 1 was probably anticipated to be a short-duration occupation site from the onset, such as a refuge or defensive location at times of raids (but see below).

What would cause people to carry millions of shellfish to the top of Kumukumu hill rather than consume them at the base of the hill, as their immediate ancestors had done? Porome people themselves offered one interpretation – that fear of headhunting raiders drove their ancestors to retreat to the more elevated site. However, other explanations are certainly plausible. For example, retreat from the river edge may have been caused by an increase in abundance of biting insects (e.g. sandflies) after 700 cal BP due to some change in riverside ecology. Or the local riverside location may have become unsuitable for habitation for a different cultural reason, such as a perceived threat from entities within the spirit realm. Today, people along the middle reaches of the Purari River avoid certain sections of the river which are inhabited by potentially malevolent spirits or which have negative historical associations, such as sites of mass drowning in canoe accidents (Aplin, unpublished data).

To discriminate local from potentially regional causes it is necessary to integrate the evidence from the Aird Hills into a broader regional history. Several broad frameworks have been proposed in recent years, the most recent and geographically proximate being the schema of Rhoads and Mackenzie (1991) who identified five distinct phases of cultural occupation spanning the last 4000 years for the mid Kikori River region:

- *Pre-ceramic*: 4000–2000 years ago. Pottery is absent from region.
- *Early Ceramic* (Early and Late Phases): 2000–1200 years ago. Axe-adzes from the western Owen Stanley Mountains first appear and become particularly numerous after c.1500 years ago.
- *Intermediate*: 1200–500 years ago. Owen Stanley Mountains axe-adzes continue to enter the Kikori River region, but in significantly lower quantities than during the Late Phase of the Early Ceramic.
- *Recent Ceramic*: 500–300 years ago. Owen Stanley Mountains axe-adzes continue to appear and *hiri* trade goods commence in the Kikori River region archaeological sites.
- *Proto-historic*: 300 years ago–AD 1920. Western Highlands stone axe-adzes make their earliest sustained appearance, along with the continued presence of Owen Stanley Mountains axe-adzes.

Recent improvements in dating the mid Kikori River sites – including 1) significantly increased number of radiocarbon determinations, 2) technological developments in sample pretreatment, 3) the emergence of AMS radiocarbon dating of tiny samples, and 4) better understanding of ΔR values for local *B. violacea* shells – has enabled a refinement of temporal trends for the mid Kikori River, including the identification of pulses of occupation and abandonment of sites and of parts of the landscape. David (2008) thus identified largely through independent data from newly dug sites two major occupational phases for the mid Kikori River: an Early Major Pulse dating to c.1450–950 cal BP, and a Late Major Pulse dating to c.500–0 cal BP that closely matches the combined

Recent Ceramic and Proto-Historic Phases of Rhoads and Mackenzie (1991). Each of these periods of peak occupation is characterized by major increases in deposition of cultural materials within a range of archaeological sites and site types; increases in numbers of occupied sites; and increases in the incidence of radiocarbon dates (indicative of the presence of people and occupational events). The Late Major Pulse of occupation for the mid Kikori River, dating to c.500–0 cal BP, begins shortly after the final abandonment of Emo (Phase 4, abandoned c.660 cal BP) and use of Kumukumu 1 (c.600 cal BP) in the Kikori River delta region 23 km southeast of the mid Kikori River sites (with estimated ages rounded off to closest 50 years, at 95.4% probability calibrations). The question remains as to whether the abandonment of the Aird Hills coastal site of Emo and use of the hilltop site of Kumukumu 1 c.600 cal BP, and the onset of intensive site occupation in secluded places away from the major waterways in the mid Kikori River sites around 500 cal BP are coincidental, or somehow indicate a broader connected pattern of (social) landscape engagement. We suggest an important clue is the onset of peak deposition of ceramic sherds in the mid Kikori River sites, signaling a re-invigoration of ancestral *hiri* trade relations between recipient delta peoples and Austronesian-speaking pottery manufacturers from the east c.500 cal BP or shortly beforehand. The archaeological visibility of this trade dynamic begins to become noticeable across the Gulf Province by heightened occupational evidence in the mid Kikori River sites; abandonment of the river-bordering site of Emo in the Aird Hills; the occupation and rapid abandonment of the hill-top refuge of Feature 1 at Kumukumu 1 in the Aird Hills; and the onset of dense villages on Goaribari along the coast (Barker et al., 2012), all within the past c.600–400 cal BP. The close timing of these various transformations in landscape engagement from the coast upstream to the mid Kikori River, including retreats from river-bordering Emo to hill-top Kumukumu 1 and the onset of large-scale villages on river delta islands, suggest the emergence of sustained headhunting practices by delta peoples of this part of the south coast of New Guinea, and with this the souring of inter-regional relations between the peoples of the Aird Hills and their southern neighbours.

On a wider geographic scale, the Early Ceramic Phase in the mid Kikori River region might be viewed as a peripheral expression of a more widespread development of ceramic-making traditions along the Papuan south coast starting around 2000 cal BP, with the various early pottery styles grouped under the term Early Papuan Pottery (EPP) by Summerhayes and Allen (2007). Until recently, the origins of this apparently early phase of ceramics were obscure and not obviously connected to the earlier Lapita tradition which appears to have undergone an initial flourishing in the Bismarck Archipelago around 3300 years ago before spreading more widely into Near and Remote Oceania. However, discovery of unquestionable Lapita pottery in multiple sites at Caution Bay to the west of Port Moresby (David et al., 2011; McNiven et al., 2011), in contexts securely dated to 2900–2600 cal BP, and of transitional pottery styles linking these through to so-called EPP wares (David et al., 2012), provides the formerly-lacking history for the Early Ceramic Phase.

The date of closure of the Early Ceramic Phase along the mid Kikori River, cited as 1200 cal BP, coincides with a widespread transformation of pottery-making traditions along the Papuan south coast, involving loss of much decorative emphasis and supposedly a reduction of standardization. In the mid Kikori River region, the centuries after 1200 cal BP are essentially aceramic, presumably due to a breakdown of the trade networks that previously had carried earlier ceramic wares to the region. Rhoads referred to the subsequent aceramic period of the mid Kikori River as the 'Papuan hiccup' (Rhoads, 1982, p. 146) (following an earlier

personal suggestion of a more widespread ‘ceramic hiccup’ by Irwin) (see also Irwin, 1991). The dating of this ‘hiccup’ appears to differ somewhat from place to place, and it is uncertain whether it was caused by the same set of circumstances everywhere. However, typical expressions are changes in regional settlement patterns, such as a hiatus in the cultural sequence at Yule Island/Hall Sound between 1200 and 700 years ago (Vanderwal, 1973), and the lack of evidence for long-distance maritime trade, perhaps reflecting a more general breakdown of communication networks.

The Recent Ceramic and Proto-historic Phases represent the direct ancestry of the ethnographically-documented *hiri* trade system that carried pots and other ‘high-value’ trade goods, including shell beads, to the Gulf of Papua in return for back-loads of sago starch. As previously noted, the *hiri* system probably both depended on and simultaneously promoted the development at the receiving end of what were in effect large ‘towns’ – regionally atypical agglomerates of multiple, originally discrete villages held together by common purpose – to provide both the locational and political stability, and the critical market ‘mass’, that were needed to attract commercial traders from afar (Frankel and Rhoads, 1994; David et al., 2010; Barker et al., 2012). Paradoxically though, while these aggrandized polities provided the stability necessary to sustain the *hiri* system, they also created regional tension through the development of violent cultural elements, including headhunting, that demanded predation on and in some cases subjugation of other tribal groups. This tension created ripples that spread out throughout the coastal waterways of the Gulf of Papua, extended up the major waterways into its hinterland, and spread outwards, across the open waters of Torres Strait as far as the coast of Cape York.

The Aird Hills are situated at the interface of the middle and lower reaches of the Kikori River – the point where the river ceases to flow in a well-defined, incised course through forested hills and sets out on its journey through the complex network of anastomosing passages that make up the conjoined deltaic systems of the Omati–Kikori–Purari Rivers and their swampy, mudflat islands. The ecological contrasts between the two zones, and their numerous implications for human lifestyles, cannot be overstated. Within the deltaic zone abundant sources of protein are available from the waterways, in the form of shellfish, scale fish and crustaceans, while the numerous permanent and semi-permanent islands support large natural stands of sago palms, along with planted groves of coconut palms and various fruit trees. Movement within the deltaic zone is relatively straightforward provided that suitable watercraft are available. The network of readily navigable waterways allows for continuous lateral travel between the Omati River delta in the west and the Purari River delta in the east, and for relatively rapid movement across many hundreds of kilometres. Accordingly, events in any one area can have major flow-on effects in demographics, settlement patterns and other cultural practices between distant tribal groups even when not directly known to each other.

The inland reaches of each of the main rivers are also accessible from anywhere in the conjoined delta. However, once a system is entered it is essentially linear and travel away from the main arterial trunks is slow, whether by small canoe or on foot. Aquatic resources fall away rapidly as one ascends the main rivers, although fish abundance is maintained until water temperature falls below critical levels. Natural plant resources are scarce and the great majority of sago and other food plants that can be found along the major rivers is the product of deliberate planting.

The archaeological evidence from the Aird Hills reveals that around 700 years ago people were living in a relatively exposed position at Emo. They were receiving significant quantities of pottery including the characteristic *uro* vessels of the ethnographic *hiri* and thus were either having direct interaction with seasonal

traders or were receiving these vessels through intermediaries. The subsistence evidence indicates a heavy reliance on the exploitation of freshwater and estuarine shellfish, to the extent that populations of these resources were significantly impacted. Other protein-gathering activities included fishing both in the main river channels and in smaller streams, occasional capture of other aquatic vertebrates such as turtles, and the hunting and/or snaring in surrounding rainforest of wild game such as possums, wallabies, bandicoots and rats. Pigs were probably also hunted from feral populations, but their frequency in Phase 4 at Emo suggests that they were also kept as domestic animals, most likely using managed sago stands as a focus for pig rearing as described by Hughes (1970; see also Rhoads, 1980; Hide, 2003). Overall, the impression gained is a period of relative safety and consequent residential stability, with people experiencing both the advantages of access to trade goods but also the disadvantages of sustained activity at one geographic focus. For it is clear that sustained occupation of Emo placed local protein resources under significant exploitative pressure. Residents of Emo were forced to consume smaller shellfish than their ancestors who had lived at the same site (Thangavelu et al., 2011), and wild game appears to have been relatively scarce, at least in proximity to the village. On the other hand, a stable residential base may have allowed for the mounting of hunting expeditions to more remote sites by groups of individuals, and for family groups to spend time away from the relative safety of a larger village to occupy more temporary (*kombati*) camps at which they could produce the all-important sago and to incidentally hunt, fish and gather other wild resources. The protein derived from both of these kinds of activities – hunting expeditions mainly by men and *kombati* occupancy by families (by analogy with the local ethnography) – is effectively invisible at a village site, as most or all of the captured animals are consumed and remains disposed of at other locations.

The timing of the shift in occupational focus from Emo to Kumukumu 1 around 600 years ago may reflect a temporary disruption of amicable relations, with a retreat to a less vulnerable position on the upper slopes of the Aird Hills. Support for this notion comes from local oral tradition but also from the reduction in the quantity of pottery found within the Kumukumu 1 deposit, relative to Phase 4 of Emo, perhaps indicating a cessation in the supply of new trade goods and the gradual breakage and discard of heritage pots. However, whatever the motivation for the shift in residential focus, it is clear that many aspects of life continued without major disruption, including the exploitation of riverine shellfish and bony fish, the probable rearing of domestic pigs, and the likely continued import of chert and other stone from northern sources. This evidence of continuity in subsistence strategies and cultural connectivity perhaps argues against a phase of major disruption but rather one of heightened concern and vigilance.

The practice of headhunting as a social institution clearly played a prominent role in the centuries leading up to the colonial era. Among its numerous, historically well-documented impacts were the centralisation of settlements for defensive purposes; the aggrandisement of island-based coastal regional polities; large-scale population displacements; and the temporary or permanent retreat and dispersal of less powerful or raided groups to more secluded locations.

By virtue of their central position within this coastline, the islands of the Kikori River delta, including the Aird Hills – themselves an island at the hinterland-marine fringe – might be especially sensitive to heightened cross-cultural influences, inter-group competition and, with this, heightened or accelerated processes of centralisation and aggrandisement among some groups, as well as its converse – the subjugation, fragmentation and dispersal of less powerful neighbouring groups.

Acknowledgements

We gratefully thank the people of Ero, Bernard Sanderre, Cathy Alex and the staff at Community Development Initiative (CDI) at Kikori for their support and friendship in the field; Dirio Epi and his family for their welcome in the field; Marawake Umoia, Napai Veiomio and Nick Araho for assisting with the excavations at Kumukumu 1; Ray Cas (Monash University) for identification of the archaeological stone; Ursula Pietrzak and Nicole Pancer for undertaking the particle size analyses and sediment pHs; Steve Morton (Monash University) for taking the photographs for Fig. 5; Kara Rasmanis for drafting Figs. 1, 3 and 7; Georgina Skelly for calculating the area of dense shell midden at Feature 6; Jeff Fox for conserving the bone needle; Angela Frost for assistance with the faunal analysis; and Ian McNiven, Sean Ulm and three anonymous referees for useful comments on an earlier draft of this paper. This project was undertaken with the generous assistance of Australian Research Council Discovery grant and QEII Fellowship DP0877782 and DORA (to BD) DP130102514.

References

- Anderson, A., 1991. The chronology of colonization in New Zealand. *Antiquity* 65, 767–795.
- Barker, B., Lamb, L., David, B., Korokai, K., Bowman, J., Kuaso, A., 2012. Otoia, ancestral village of the Kerewo: archaeological excavations at a men's long-house (*dubu daima*) on the island of Goaribari (Gulf Province, Papua New Guinea) and implications for the historical emergence of regional polities. In: Haberle, S., David, B. (Eds.), *Peopled Landscapes: Archaeological and Biogeographic Approaches to Landscapes*. Terra Australis, vol. 34. ANU E Press, Canberra, pp. 157–176.
- Bell, J.A., 2002. Final Report for Gr. 6700 to Aid Research on 'Intersecting Histories and Material Culture: Examining Social Transformation in the Purari Delta, Papua New Guinea'. Unpublished report in author's possession.
- Bevan, T.F., 1890. *Toil, Travel and Discovery in British New Guinea*. Paul, Trench, Trubner, London.
- Bronk-Ramsey, C., 2009a. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51, 337–360.
- Bronk-Ramsey, C., 2009b. Dealing with outliers and offsets in radiocarbon dating. *Radiocarbon* 51, 1023–1045.
- Bronk-Ramsey, C., 2010. OxCal Program v4.17. Radiocarbon Accelerator Unit. University of Oxford, Oxford.
- Bronk-Ramsey, C., 2013. OxCal Program v4.1.7. Radiocarbon Accelerator Unit. University of Oxford, Oxford.
- Busse, M., Turner, S., Araho, N., 1993. *The People of Lake Kutubu and Kikori: Changing Meanings of Daily Life*. Papua New Guinea National Museum and Art Gallery, Port Moresby.
- Butcher, B., 1963. *We Lived With Headhunters*. Hodder and Stoughton, London.
- Chance, S.H., 1927. Map Showing Upper Era River and Surrounding Districts. Territory of Papua Annual Report for the Year 1925–1926. Government Printer, Melbourne.
- David, B., 2008. Rethinking cultural chronologies and past landscape engagement in the Kopy region, Gulf Province, Papua New Guinea. *The Holocene* 18, 463–479.
- David, B., Geneste, J.-M., Aplin, K., Delannoy, J.-J., Araho, N., Clarkson, C., Connell, K., Haberle, S., Barker, B., Lamb, L., Stanicic, J., Fairbairn, A., Skelly, R., Rowe, C., 2010. The Emo site (OAC), Gulf Province, Papua New Guinea: resolving long-standing questions of antiquity and implications for the history of the ancestral *hiri* maritime trade. *Australian Archaeology* 70, 39–54.
- David, B., McNiven, I.J., Richards, T., Connaughton, S.P., Leavesley, M., Barker, B., Rowe, C., 2011. Lapita sites in the Central province of mainland Papua New Guinea. *World Archaeology* 43, 576–594.
- David, B., McNiven, I.J., Leavesley, M., Barker, B., Mandui, H., Richards, T., Skelly, R., 2012. A new ceramic assemblage from Caution bay, south coast of mainland PNG: the linear shell edge-impressed tradition from Bogi 1. *Journal of Pacific Archaeology* 3, 73–89.
- Frankel, D., Rhoads, J.W. (Eds.), 1994. *Archaeology of a Coastal Exchange System: Sites and Ceramics in the Gulf of Papua*. Research Papers in Archaeology and Natural History, vol. 25. Research School of Pacific Studies, Australian National University, Canberra.
- Goldman, L., Tauka, R., 1998. *Omati Social Mapping Report*. Report to Chevron Asiatic, Brisbane.
- Haddon, A.C., 1918. The Agiba Cult of the Kerewo Culture. In: *Man* (OS), vol. 18, pp. 177–183.
- Herbert, C.L., 1917. Delta division. In: *Papua Annual Report for the Year 1914–15*. Government Printer, Melbourne, pp. 86–89.
- Hide, R., 2003. *Pig Husbandry in New Guinea: a Literature Review and Bibliography*. In: Australian Centre for International Agricultural Research Monograph, vol. 108. Canberra.
- Hughes, I.M., 1970. Pigs, sago and limestone: the adaptive use of natural enclosures and planted sago in pig management. *Mankind* 7, 272–278.
- Irwin, G., 1991. Themes in the prehistory of coastal Papua and the Massim. In: Pawley, A. (Ed.), *Man and a Half: Essays in Pacific Anthropology and Ethnobiology in Honour of Ralph Bulmer*. The Polynesian Society, Auckland, pp. 503–510.
- Knauff, B.M., 1993. *South Coast New Guinea Cultures: History, Comparison, Diachronic*. Cambridge University Press, Cambridge.
- Kurokawa, H., Yoshida, T., Nakamura, T., Lai, J., Nakashizuka, T., 2003. The age of tropical rain-forest canopy species, Borneo ironwood (*Eusideroxylon zwageri*) determined by ^{14}C dating. *Journal of Tropical Ecology* 19, 1–7.
- MacGregor, W.M., 1893. Despatch continuing the report of visit of inspection to the Western division of the possession. In: *Annual Report on British New Guinea from 1st July 1891, to 30th June 1892; with Appendices*. Government Printer, Brisbane, pp. 37–48.
- MacGregor, W.M., 1894a. *British New Guinea*. In: *Annual Report on British New Guinea from 1st July 1892, to 30th June 1893; with Appendices*. Government Printer, Melbourne, pp. xv–xxxiv.
- MacGregor, W.M., 1894b. Despatch reporting inspection of the Gulf of Papua from Hall Sound to Port Bevan. In: *Annual Report on British New Guinea from 1st July 1892, to 30th June 1893; with Appendices*. Government Printer, Melbourne, pp. 24–36.
- McNiven, I.J., David, B., Richards, T., Aplin, K., Asmussen, B., Mialanes, J., Leavesley, M., Faulkner, P., Ulm, S., 2011. New direction in human colonisation of the Pacific: Lapita settlement of south coast New Guinea. *Australian Archaeology* 72, 1–6.
- Poraituk, S., Ulijaszek, S., 1981. Molluscs in the Subsistence Diet of Some Purari Delta People. In: *Purari River (Wabo) Hydroelectric Scheme Environmental Studies*, vol. 20. Office of Environment and Conservation and Department of Minerals and Energy, Waigani and Konedobu.
- Reimer, P., Baillie, M., Bard, E., Bayliss, A., Beck, J., Blackwell, P., Bronk Ramsey, C., Buck, C., Burr, G., Edwards, R., Friedrich, M., Grootes, P., Guilderson, T., Hajdas, I., Heaton, T., Hogg, A., Hughen, K., Kaiser, K., Kromer, B., McCormac, F., Manning, S., Reimer, R., Richards, D., Southon, J., Talamo, S., Turney, C., van der Plicht, J., Weyhenmeyer, C., 2009. Intcal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon* 51, 1111–1150.
- Rhoads, J.W., 1980. *Through a Glass Darkly: Present and Past Land-use Systems of Papuan Sagopalm Users* (Ph.D. thesis). Australian National University, Canberra.
- Rhoads, J.W., 1982. Prehistoric Papuan exchange systems: the *hiri* and its antecedents. In: Dutton, T.E. (Ed.), *The Hiri in History: Further Aspects of Long Distance Motu Trade in Central Papua*, Pacific Research Monograph, vol. 8. The Australian National University, Canberra, pp. 131–151.
- Rhoads, J.W., 1983. Prehistoric sites from the Kikori region, Papua New Guinea. *Australian Archaeology* 16, 96–114.
- Rhoads, J.W., Mackenzie, D., 1991. Stone axe trade in prehistoric Papua: the travels of the Python. *Proceedings of the Prehistoric Society* 57, 35–49.
- Roberts, T.R., 1978. An Ichthyological Survey of the Fly River in Papua New Guinea with Descriptions of New Species. In: *Smithsonian Contributions to Anthropology*, vol. 281. Smithsonian Institution Press, Washington.
- Ryan, H.J., 1913. *Magisterial Report, Delta Division*. Cited in L. Goldman and R. Tauka (1998), *Omati social mapping report, Annexure 3*. Report to Chevron Asiatic, Brisbane.
- Skelly, R.J., David, B., Hiri: *Archaeology of Long-distance Maritime Trade along the South Coast of Papua New Guinea* (in press). University of Hawaii Press, Honolulu.
- Smith, B.J., 1992. Non-marine Mollusca. In: Houston, W.W.K. (Ed.), *Zoological Catalogue of Australia*, vol. 8. Australian Government Publishing Service, Canberra, pp. 1–398.
- Spriggs, M., Anderson, A., 1993. Late colonization of east Polynesia. *Antiquity* 67, 200–217.
- Summerhayes, G., Allen, J., 2007. Lapita writ small: revisiting the Austronesian colonisation of the Papuan coast. In: Bedford, S., Sand, C., Connaughton, S. (Eds.), *Oceanic Explorations: Lapita and Western Pacific Settlement*. Terra Australis, vol. 26. ANU E Press, Canberra, pp. 97–122.
- Thangavelu, A., David, B., Barker, B., Geneste, J.-M., Delannoy, J.-J., Lamb, L., Araho, N., Skelly, R., 2011. Morphometric analyses of *Batissa violacea* shells from Emo (OAC), Gulf Province, Papua New Guinea. *Archaeology in Oceania* 46, 67–75.
- Vanderwal, R.L., 1973. *Prehistoric Studies in Central Coastal Papua* (Ph.D. thesis). Australian National University, Canberra.
- Vanderwal, R.L., no date. *Frank Hurley in the Gulf of Papua: Photographs of the 1921–1923 Expedition*. Unpublished manuscript in author's possession.
- Vieira, S., Trumbore, S., Amargo, P.B., Selhorst, D., Chambers, J.Q., Higuchi, N., Martinel, L.A., 2005. Slow growth rates of Amazonian trees: consequences for carbon cycling. *Proceedings of the National Academy of Sciences of the United States of America* 102, 18502–18507.
- Wirz, P., 1937. The Kaiamunu-Ebiha-Gi-Cult in the Delta Region and Western division of Papua. *Journal of the Royal Anthropological Institute of Great Britain and Ireland* 67, 407–413.
- Woodward, R.A., 1920. Delta division, 1920–1921. In: *Papua Annual Report for the Year 1918–19, Appendix 2*. Government Printer, Melbourne, pp. 61–63.