Journal of Island & Coastal Archaeology, 1:215–232, 2006

ISSN: 1556-4894 print / 1556-1828 online
DOI:10.1080/15564890600831705

Human Colonization of the Palau Islands, Western Micronesia

Geoffrey Clark,[1] Atholl Anderson,[1] and Duncan Wright[2]
[1]*Department of Archaeology and Natural History, Research School of Pacific and Asian Studies, Australian National University, Canberra, Australia*
[2]*School of Geography and Environmental Science, Monash University, Victoria, Australia*

ABSTRACT

Adaptation to new environments is an important issue in colonization research with implications for accurately establishing the timing of human arrival and interpreting the dispersal pattern from the distribution of early archaeological sites. Island groups frequently contain a diverse range of landscapes and geographic variation in their colonization records that might reflect the environmental preference of prehistoric migrants. In the Palau Islands the large island of Babeldaob may have been colonized by 4300 cal BP on palaeoenvironmental evidence, while the oldest archaeological deposits in the small limestone islands of southern Palau date to ∼ca. 3000 cal BP. Does the discrepancy in colonization ages represent a predilection for the large volcanic island relative to small limestone islands? To examine the timing of human arrival in southern Palau an early site on Ulong Island was re-excavated, along with ancillary investigations to calculate a local reservoir value (ΔR) to apply to new marine shell ^{14}C ages and investigation of a buried sea-notch to estimate the impact of sea-level change and tectonic movement. Human arrival in southern Palau is dated to no earlier than 3100–2900 cal BP. Neolithic dispersal in other island environments in the Pacific is reviewed to see whether colonization of large islands tended to precede use of small

Received 9 December 2005; accepted 6 March 2006.
Address correspondence to Geoffrey Clark, Department of Archaeology and Natural History, Research School of Pacific and Asian Studies, Australian National University, Canberra ACT 0200, Australia. E-mail: geoffrey.clark@anu.edu.au

islands. The general pattern is for the oldest sites to be located on large islands, with human activity archaeologically visible throughout an archipelago within 100–300 years. A similar interval applied to Palau would put colonization at 3400–3100 cal BP, but this needs to be confirmed by palaeoenvironmental and archaeological investigations in coastal Babeldaob.

Keywords radiocarbon dating, marine reservoir, island colonization, Palau, Micronesia

INTRODUCTION

The age of human settlement in western Micronesia has important implications for understanding prehistoric maritime capacity, Austronesian migration patterns, and current debate about palaeoenvironmental and archaeological colonization ages, which differ from each other by a millennium or more in each archipelago (Athens and Ward 2001; Clark 2004; Dodson and Intoh 1999). Progress in resolving these issues is hindered by a scarcity of cultural deposits dating to ~ca. 3000 BP or older in the region, with around seven sites recorded from Guam, Saipan and Tinian in the Marianas (Rainbird 2004:82), two or three from Palau, and none from Yap.

The paucity of early sites in western Micronesia contrasts strongly with the roughly 200 Lapita Cultural Complex sites dated to between ca. 3300 and 2700 cal BP distributed from the Bismarck Archipelago to Samoa (Anderson et al. 2001a). Lapita sites are instructive as the visibility and integrity of colonization-era deposits in an archipelago declines as the magnitude of anthropogenic and natural processes acting on coastal landscapes increases (Dickinson et al. 1994; White et al. 2002). The exemplar is Samoa which has a single Lapita site removed by subsidence 4 m below its original position that is now underwater (Dickinson and Green 1998).

Palau and Yap with the fewest early sites have also subsided (Dickinson 2000:737, 2004:1021), while the southern Marianas where most of the pre-3000 cal BP sites have been recorded, is tectonically stable (Dickinson 2000). Palau was previously considered to have undergone tectonic uplift (Athens and Ward 2001; Masse 1990; Wickler 2001), and recent recognition of Holocene subsidence is significant as the archaeological visibility of early coastal sites has likely been reduced, and the integrity of old cultural deposits compromised, by tidal fluctuation, wave erosion, and storm surge.

In a recent compilation of radiocarbon dates from Palau, Liston (2005) identified four locations with valid calibrated age estimates extending to 3000 cal BP or older. Two of these (NT:3–10 and NA-4:12) on the main island of Babeldaob are not associated with an intact cultural deposit and date anthropogenic activity (Liston pers. comm.). The remaining locations are a burial site on Orrak Island and a cultural deposit on Ulong Island.

There are 19 radiocarbon determinations from Chelechol ra Orrak, and the three oldest on human bone gelatin have median ages spanning 4030–3200 cal BP. They, and other bone dates from Palau, must be considered cautiously as sample collagen was not assessed for contamination and degradation prior to dating by measurement of the C:N isotope ratio (Petchey and Green 2005:89). Leaving the bone dates aside, results on charcoal and marine shell indicate human use of Orrak by ca. 2900–2700 cal

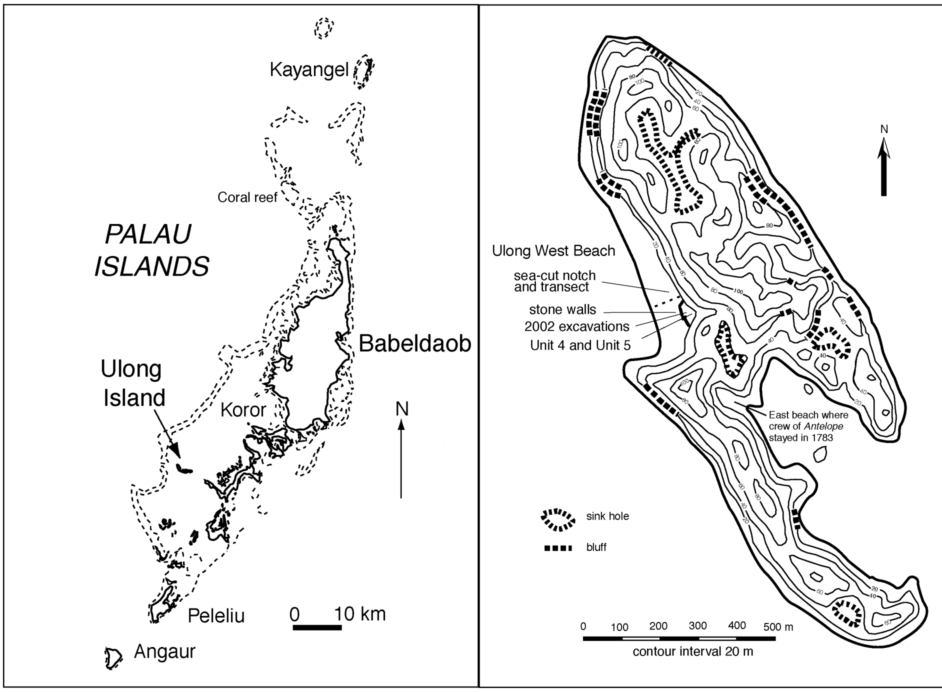

Figure 1. *The Palau Islands and location of Ulong and Babeldaob (left). Map of Ulong Island and location of 2002, 2003 investigations (Unit 4 and Unit 5) and position of sea cut notch and transect.*

BP (Fitzpatrick 2003; also see discussion of acceptability of Palau dates in Liston 2005).

The Ulong Island site has 22 ^{14}C dates, and the oldest cultural deposit has eroded ceramics from tidal reworking—consistent with subsidence—and a lens of marine shells and coral that might represent a storm deposit (Clark 2004, 2005). For these reasons Liston (2005) considered the two oldest determinations on marine shell with median ages of ca. 3000 cal BP from the deepest parts of the site as invalid. The site was re-excavated to clarify the age of the subsidence-effected lower deposit by 1) locating an intact basal deposit, 2) obtaining a ΔR value to apply to new marine shellfish determinations, and 3) estimating the extent of island subsidence.

Results indicate human arrival on Ulong Island between about 3100–2900 cal BP, raising an important question about deducing archipelago colonization from cultural deposits on small islands. The major geographic division in the Palau Archipelago is between the large volcanic island of Babeldaob with 80% of the land area (331 km^2) and more than 300 small uplifted coralline islands to the south of Babeldaob (Figure 1) that comprise about one-tenth of the total land area (Corwin et al. 1956). The uplifted karstic islands, known colloquially as the 'Rock Islands,' have steep, rugged, and long coastlines; shallow, infertile soils; and no perennial sources of fresh water. They are surrounded, however, by abundant marine resources (Carucci 1992; Masse 1989). Such islands are challenging environments for human occupation, although prehistoric village settlements were established on several about 1000 BP before being abandoned at 400–500 BP (Liston 1999; Masse et al. 2006; Phear et al. 2003; Wickler 2002).

It has been proposed that the first colonists to arrive in Palau concentrated on the coastal margins of the large volcanic island of Babeldaob, and use of small limestone islands like Orrak and Ulong, with an area less than 0.2% that of Babeldaob, was limited or delayed (Liston 2005; Wickler 2001). The Ulong Island deposit does suggest that early activity was narrowly focused on gathering and cooking marine foods, but the limited range of prehistoric pursuits left an unambiguous human signature. A review of intra-archipelago colonization by Neolithic groups in Oceania indicates human arrival might be delayed in peripheral archipelago settings by 100–300 years. We conclude that radiocarbon ages from small islands can provide a proxy age for archipelago colonization in Oceania. In the case of Palau, however, confirmation from the discovery of early coastal sites on the mainland, and correlation with palaeoenvironmental results, is still required.

ARCHAEOLOGICAL INVESTIGATIONS ON ULONG ISLAND

Excavation of Units 4 and 5

The early site on Ulong Island lies 27 km southwest of Babeldaob on the west coast of the island where a large sand plain developed between northern and southern limestone headlands. In the south is a deep cove where the first beach deposit would have accrued. It is a plausible location to expect old cultural material as in prehistory it was probably a sheltered embayment fringed by a narrow beach, where canoes could have landed, and with pedestrian access to other parts of the island from the eroded cove slope. Test excavations suggested that an intact part of an early cultural deposit recorded in 2002 existed close to where the sand plain meets the Miocene-Pleistocene limestone sides of the cove head (see Clark 2005). In 2003 two 1 m^2 test pits (Units 4 and 5) were excavated to sample this deposit.

Unit 4 was 3 m from the limestone slope and 8 m south of Unit 5 (Wright 2005). The units were excavated in 10 cm levels and the entire Unit 4 deposit was water sieved over 3 mm mesh. The stratigraphy was similar in both units and consisted of an upper deposit of dark brown silty soil underlain by a grey sandy silt, followed by a grey-yellow beach sand at ~130–240 cm depth containing abundant marine shell midden, fragments of limestone and smaller amounts of pottery, fish bone (Scaridae, Diodontidae, Nemipteridae), turtle, and a few shell artifacts (Figure 2). In Unit 5 Layer 2 was a grey ashy soil that did not occur in Unit 4, and in Layer 4 (Unit 5) there was a linear arrangement of coral and limestone boulders (Figure 2). In both units large pieces of limestone, coral and remains of marine shell were found at 140–160 cm as in previous excavations (Clark 2005). The basal deposit (Unit 5, Layer 6 and Layer 5 in Unit 4) contained 47 kg of marine shell in Unit 4 and 86 kg in Unit 5, with the main species by weight the large bivalves *Tridacna maxima*, *Tridacna gigas*, and *Hippopus hippopus* (83% in Unit 4 and 93% in Unit 5). Ceramics were the same as the calcareous-volcanic sand-tempered jars found previously (Clark 2005:360), with red slip found on several sherds protected from erosion by proximity to Tridacnidae valves. Evidence for moderate tidal exposure in the basal deposit was seen in edge and surface erosion of ceramic sherds, and in the fish bone

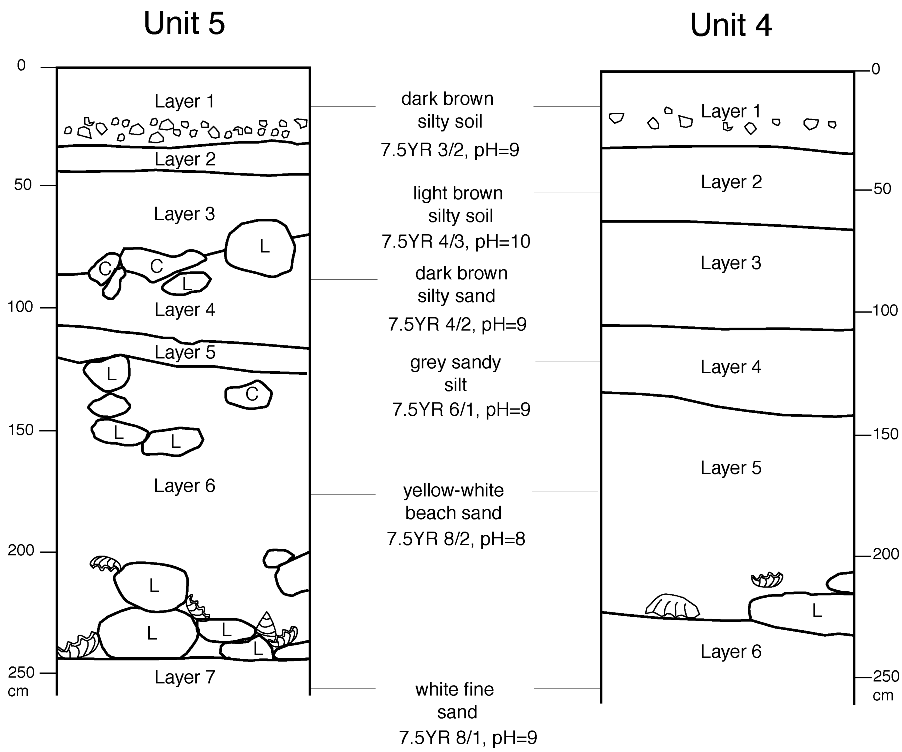

Figure 2. *Stratigraphy of Unit 4 and Unit 5, Ulong Island. L = limestone, C = coral.*

assemblage where large and robust elements were common in comparison to small bones.

There was an abrupt transition between the shell midden deposit at 220–240 cm depth and the underlying culturally sterile beach sand. In Unit 5 this was particularly clear with a thick deposit of marine shell weighing 28 kg in the 230–240 cm spit capping a beach sand devoid of cultural material. In Unit 4 where there was less marine shell, the bottom three spits (200–230 cm) of the cultural deposit also yielded substantial remains with 20 kg of shellfish recovered. The sterile beach sand was excavated down to 350 cm in each unit with a fine calcareous lime sand present at ~230–240 cm and increasingly coarse sand with fragments of coral and limestone at 300 cm. The natural beach deposit of Unit 4 contained a *Cypraea tigris* shell at 260–270 cm and an *Ostrea* sp. valve at 250–260 cm.

Marine shell was the preferred dating material given the presence of shellfish remains in the basal cultural deposit, and absence of stratigraphically secure charcoal (see below). To obtain accurate calibrated dates on marine shell it was necessary to first obtain a local reservoir value (ΔR) to apply to conventional radiocarbon ages (CRA).

Ulong Island ΔR

Marine shell is a common component of Pacific archaeological sites that can produce accurate calibrated age determinations for prehistoric occupation when environmental sources of ^{14}C absorbed by a mollusk are known. In practice this is complicated because of ocean variability in ^{14}C from upwelling, sea currents, and fluctuation in water temperature from ENSO events (Gagan et al. 2004; McPhaden and Zang 2002; Petchey et al. 2005). In addition to spatial and temporal oceanic variability in ^{14}C, terrestrial conditions can also be significant as old carbon from dissolved limestone or young carbon from rivers and surface run-off can influence ^{14}C in shellfish living in coastal and reef environments (Hogg et al. 1998; Spennemann and Head 1998). The ^{14}C age of a shellfish at a specific location relative to the global average used to calibrate determinations on marine shell is known as the ΔR, which can be calculated by radiocarbon dating shellfish of known prebomb age, or dating shell-charcoal samples from the same archaeological context. The size of ΔR is important to resolve in island settings where colonization chronologies commonly contain a significant number of shell determinations (Phelan 1999).

A recent study of ΔR values in the southwest Pacific on shells of known age recorded considerable variability, with a ΔR of 370 $\pm$ 25 years for Kavieng Harbour in New Ireland and a low ΔR for the Solomon Islands-Coral Sea of 45 $\pm$ 19 years (Petchey et al. 2005). On Guam, Southon et al. (2002) calculated a ΔR of 19 $\pm$ 50 years on a gastropod collected in 1903, where another gastropod produced a ΔR of 115 $\pm$ 50 years (Athens 1986). For Palau the magnitude of ΔR has been examined by dating shell-charcoal pairs from archaeological sites. Masse (1989) calculated a tentative ΔR of -63 ± 4 years, since revised to around -300 to -200 years (Masse et al. 2006). A similar range has been suggested by Fitzpatrick (2002), but in view of uncertainty about the coeval deposition of shell-charcoal pairs, as well as the possibility of geographic variation and species difference in ^{14}C (Anderson et al. 2001b; Dye 1994; Petchey et al. 2005), most researchers in Palau have used $\Delta R = 0$ (Clark 2004, 2005; Fitzpatrick 2003; Fitzpatrick and Boyle 2002; Liston 2005; Phear et al. 2003).

Marine shells of known age were recovered from a site on the east side of Ulong Island occupied by the crew of the *Antelope*, an East India Company Packet wrecked on the west barrier reef in AD 1783 (Nero and Thomas 2002). A valve of *H. hippopus* from a rubbish pit returned an age of 577 $\pm$ 35 BP (Wk16643) and a date of 868 $\pm$ 34 BP was obtained on the gastropod *Nerita undata*. *Nerita* is an algae grazer that uses a radula to scrape algal cells, flagellates, diatoms, and nematodes from rock substrate. Petchey et al. (2005) have noted how the food ingestion mechanism of shellfish can introduce depleted ^{14}C in the case of algae grazers and deposit feeders, with suspension feeders such as *Hippopus* recommended for ^{14}C analysis. Previous studies have shown that *Nerita* living on limestone/calcareous substrate can give inaccurate ages (Anderson et al. 2001b; Dye 1994), and radiocarbon dates on charcoal and bone samples from the AD 1783 rubbish pit confirm the *Nerita* result is unreliable (Clark In Prep. n.d.). The date on *Nerita* gives a ΔR of 330 years, close to the upper range suggested by Masse et al. (2006) on archaeological samples of *Strombus gibberulus/luhuanus*—another algae grazer on sand and limestone substrates in southern Palau (see Phelan 1999). Inter-species variation in ^{14}C is clearly significant in the west Pacific, and must be considered when selecting archaeological samples of marine shellfish for radiocarbon dating and ΔR calculation.

The age result for the suspension feeder *H. hippopus* is considered the more accurate of the two shellfish determinations with which to calculate a ΔR for Ulong Island. Large clams of the Tridacnidae family are slow growing and long-lived and have a potentially high inbuilt age. The dated *Hippopus* valve had a shell length of 23 cm suggesting an age of 5–10 years from known growth rates. The ^{14}C global marine average in AD 1783 according the Marine04 curve of Hughen et al. (2004) is $\sim$535 $\pm$ 23 years giving a ΔR of 42 $\pm$ 40 years, which makes little difference to calibrated results using $\Delta R = 0$.

Archaeological Dates

Seven marine shell and two dates on charcoal and a pot residue from the basal deposit (240 cm–150 cm depth) of Unit 4 and Unit 5 were analyzed at the Radiocarbon Dating Laboratory at the Australian National University (Canberra), Waikato Radiocarbon Dating Laboratory (Hamilton), and Rafter Radiocarbon Dating Laboratory (Wellington). Calibrations were made with the CALIB rev.4.3 software using method A at two standard deviations and the bidecadal curves for charcoal determinations of Stuiver and Reimer (1993) and Stuiver and Braziunas (1993) with ΔR set at 42 $\pm$ 40 years for marine shell dates. Samples were subjected to standard pretreatments, and the marine shell samples dated by the Waikato Laboratory were examined for recrystallization.

Samples of Tridacnidae from the shell midden near the top and base of Unit 4 (150–160 cm, 200–230 cm) and base of Unit 5 (230–240 cm) were selected for dating. *Tridacna* sp. and *H. hippopus* are suspension feeders less prone to ingesting ^{14}C depleted sediments and organisms compared with herbivore grazers and deposit feeders, and carnivorous mollusks which feed on them. Liston (2005:300) suspects that *Tridacna* spp. are potentially unsuitable to date because they are long-lived, can be fossilized and used to make tools that could be curated. The dating samples were all fresh midden shell, although an individual's age might be responsible for some variability in radiocarbon ages. The *C. tigris* shell in Unit 4 at 260–270 cm was used to date the beach sand below the cultural deposit.

The two oldest dates on cultural marine shell are on *H. hippopus* (Wk-15647, ANU-12120) and they overlap at 2σSD with two dates on *Tridacna* sp. (ANU-12115, ANU-12116). An age span of ca. 3100–2900 cal BP for the basal cultural deposit is likely. If the ^{14}C age variation between *Hippopus* and *Tridacna* sp. is systematic, then species-specific ΔR values may need to be calculated to accurately calibrate marine shell dates from archaeological sites. An alternative is that local conditions affect ΔR with variation between the west and east side of Ulong Island. Either of these propositions, if verified, imply multiple ΔRs will be needed in an archipelago and even on some small islands. Marine shell dates for Unit 5 are in approximate sequence with the natural beach deposit dated to 3600–3200 cal BP (ANU-12117) and a determination of 2950–2750 cal BP from 150–160 cm depth above the basal shell midden.

Charcoal and pot residue determinations are clearly anomalous compared to marine shell dates. The absence of charcoal below the 180 cm depth and the presence of sherd rounding was consistent with tidal exposure and removal of friable and light charcoal by mechanical abrasion and flotation. Macrocharcoal, whether as fragments or carbonized residues adhering to ceramic sherds, was found in the Unit 4 deposit from 10–20 cm down to 180–190 cm depth, and peaked at 130–140 cm where there were 15 grams of charcoal (Wright 2005). A charcoal piece from 210–220 cm depth dated by ANU-12119 was labeled as "questionable" in the field as no other charcoal was recorded in the lower levels of Unit 5. It was suspected that the piece had been inadvertently introduced from excavation walls, or by disturbance and transport of charcoal from upper layers by land crabs, tree roots, or human activity into deeper levels. A palynological study of sediments from 200 cm depth in Unit 4 did not record any microscopic charcoal (Wright 2005:Appendix F), suggesting that the dated charcoal piece was intrusive. A sample of pot residue from 170–180 cm (Table 1) also gave a more recent age than expected (Wk-14357), and the sherd may have been introduced by displacement from excavation walls. It appears the lowest section of the deposit has experienced turbation from tidal inundation and biological activity that has influenced the distribution of archaeological charcoal, with the former dispersing old charcoal and the latter introducing younger charcoal into older levels. In comparison large, heavy fragments and valves of Tridacnidae are less prone to vertical movement in the sediment column.

Island Subsidence

Subsidence of the Palau Islands has recently been put at ~0.6 mm/year by Dickinson (2004:1021), in contrast to a previous expectation of Holocene uplift (Athens and Ward 2001; Corwin et al. 1956; Easton and Ku 1980). Archaeologists such as Masse (1990) considered the absence of archaeological sites older than about 2000 BP in the purportedly uplifted environments of Palau as supporting late colonization, whereas Takayama (1981:4) believed the oldest sites may have been underwater and were archaeologically invisible. Subsidence is suggested by the absence of emergent palaeonotches in cliffs above the modern shoreline notch in the southern limestone islands of Palau, as expected if a mid-Holocene hydro-isostatic highstand in sea level with a similar magnitude to the Mariana Islands of around 1.5–1.8 m occurred. That subsidence may have affected the entire archipelago is suggested from non-marine peat at a depth of about 2.1 m below present mean sea level found in a core taken from the main island of Babeldaob (Athens and Ward 2001; Dickinson 2004).

The development of the sand plain on the west side of Ulong infilled the cove and buried a sea-cut notch northwest of the Unit 4 and Unit 5 excavation as it prograded seaward about 90 m to the current beach edge (Figure 1). Mapping the buried sea-notch in relation to current sea level was done to examine the direction of tectonic movement. Notches erode at different rates depending on limestone composition and wave energy, but the top and bottom of solution notches correlate approximately with mean high and low tide. The position of notches relative to current sea level can provide, therefore, an indication of the direction and magnitude of tectonic subsidence or uplift. A 1 m × 2 m trench was excavated against the limestone cliff north of where a prehistoric limestone wall partially enclosed the excavation area (Figure 1).

The top of the notch was found 80–90 cm below ground surface and it extended back 1.8 m into the cliff. A transect was cut from the notch excavation to the beach to allow mapping of the notch position relative to modern sea level using an optical level and 'E'

Table 1. **Ulong Island radiocarbon dates from Units 4 and 5.**

Lab Number	CRA	Cal. BP	^{13}C	Sample	Context
ANU-12119[a,d]	2330 ± 180	2780 (2350) 1900	−24.0 ± 2.0E[c]	Charcoal	UW, Unit 5: 210–220 cm
ANU-12118	3110 ± 60	3010 (2830) 2720	0.0 ± 2.0E	*Tridacna* sp.	UW, Unit 5: 230–240 cm
ANU-12120	3330 ± 80	3350 (3130) 2860	0.0 ± 2.0E	*H. hippopus*	UW, Unit 5: 230–240 cm
Wk-15646	3094 ± 36	2940 (2800) 2730	2.9 ± 0.2	*Tridacna* sp.	UW, Unit 4: 150–160 cm
Wk-14357[a] NZA-19373	2471 ± 39	2740 (2600*) 2360	−27.5 ± 0.2	Pot residue	UW, Unit 4: 170–180 cm
Wk-15647	3358 ± 40	3320 (3160) 2990	2.3 ± 0.2	*H. hippopus*	UW, Unit 4: 200–210 cm
ANU-12115	3210 ± 80	3210 (2940) 2750	0.0 ± 2.0E	*Tridacna* sp.	UW, Unit 4: 220–230 cm
ANU-12116	3230 ± 60	3200 (2970) 2780	0.0 ± 2.0E	*Tridacna* sp.	UW, Unit 4: 220–230 cm
ANU-12117	3550 ± 70[b]	3570 (3380) 3210	0.0 ± 2.0E	*Cyprea* cf. *tigris*	UW, Unit 4: 260–270 cm
Marine shell of AD 1783 age					
Wk-16643	577 ± 35	280 (150) 0	2.8 ± 0.2	*H. hippopus*	UE, Area 1: 40–50 cm
Wk-16644	868 ± 34[b]	530 (470) 360	−1.6 ± 0.2	*Nerita undata*	UE, Area 1: 50–60 cm

[a] AMS determination.
[b] Natural marine shell from below the basal cultural deposit. *Cypraea tigris* is an algae feeder.
[c] ^{13}C value estimated.
[d] Sample considered to be intrusive from overlying levels.
*Indicates multiple intercepts.

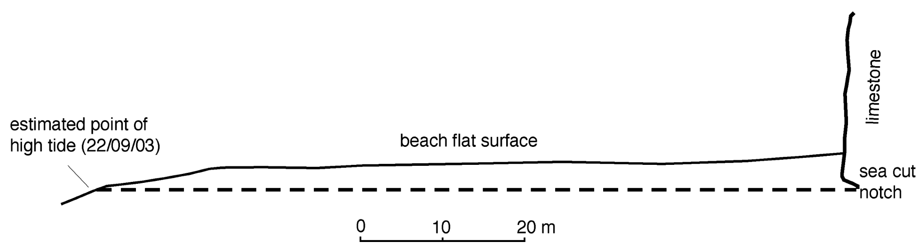

Figure 3. *Buried sea-cut notch compared to high tide position recorded 22/09/03.*

type staff (Figure 3). Ceramics from the notch base were of the 'backcurve' type, showing the notch was out of reach of the normal tidal range for at least 2,700–2,400 years (Clark 2005; Wright 2005). The notch position is close to the modern tidal range (1.6 m according to Kayanne et al. 2002) suggesting that subsidence tracked the post-mid-Holocene drawdown in sea level of ~1.5–1.8 m, and supporting Dickinson's (2004) contention for tectonic subsidence in southern Palau.

The amount of subsidence, if accurate, indicates that early coastal sites in Palau may be located at a depth close to, or below, current sea level, and may be preserved in coastal flats backed by steep terrain where rapid sediment deposition protected archaeological deposits from wave and tide action. At Ulong, however, almost 1 m of calcareous sediment was deposited over the basal cultural material between ~3100–2800 cal BP. The arrival of coral-reef derived sediment might indicate a sea-level fall that outstripped the subsidence rate after 3000 cal BP, exposing coral structures to erosion. Increased wave energy and temperature change can affect reef development and contribute calcareous sediments to beaches, and the frequency and intensity of severe El Niño events is thought to have increased after 3100 cal BP (e.g. Reidinger et al. 2002).

DISCUSSION

The precise date when people arrived on uninhabited islands is notoriously difficult to determine, and it is more practical to identify a colonization phase given the sampling and accuracy limitations of the archaeological record. In Pacific Islands the geographic extent of a prehistoric colonization phase has been recognized archaeologically from the stylistic similarity of the earliest material culture remains such as Lapita pottery and Archaic East Polynesian artifacts. Within island groups colonization phase deposits are frequently identified from faunal assemblages representing human predation on pristine environments, such as those with a high proportion of extinct or extirpated species, and taxa, particularly shellfish, that are substantially larger and more abundant than in contemporary settings (Bedford and Spriggs 2000; Steadman et al. 1994; Steadman et al. 2002). Early assemblages of material culture and fauna as defined above frequently co-occur in archaeological sites—when radiocarbon dated they provide a generally accepted span for the colonization phase.

The archaeological manifestation of colonization at a locality within an archipelago might feasibly be preceded by a substantial interval, however, when population size remained small and specific environments were actually, or perceived to be, unfavorable to human groups. Both situations are likely in Palau where a small group of colonists might have occupied favorable coastal niches on the large island of Babeldaob by 4500–4300 cal BP, as suggested by palaeoenvironmental data (Athens and Ward 2001), before an archaeologically visible phase of expansion to peripheral upland zones and small limestone islands at 3400–3000 cal BP (Welch 2001:182; Wickler 2001:190, 192, 194).

The early colonization age suggested in some palaeoenvironmental work on Babeldoab has yet to be confirmed (Clark 2005), and an alternative is that the intra-archipelagic colonization phase in Palau was of much shorter duration, in which case the record of human arrival on small islands could provide an economical means of specifying the colonization phase elsewhere. This is worth considering as the coastal margins of Babeldaob holding the earliest putative prehistoric remains have received the least archaeological attention and undergone significant landscape alteration (Athens and Ward 2001; Liston 2005; Wickler 2001).

Until archaeological work is carried out in the coastal niches of Babeldaob we are unable to determine directly how quickly people utilized the small limestone islands of Palau after arrival. However, as island groups frequently contain landmasses that vary greatly from one another in size, distance, and environmental resources, the prehistoric record of island colonization in other parts of the Pacific colonized in the Late Holocene by Neolithic groups with a well-developed maritime technology constitutes a useful data set to consider intra-archipelago variability in island use. Before doing so, it is necessary to specify why the oldest cultural deposit might be taken as representing initial human arrival on Ulong Island. The proposition may be in error, but its advantage is that a set of explicit archaeological criteria used to infer colonization can be more easily applied to small islands than to large.

Establishing Human Arrival on Small Islands

The oldest archaeological deposit on a small island might reasonably be construed as representing initial arrival when four criteria are met. First, other potentially attractive locations for early human occupation and use should not contain cultural assemblages or stratigraphic indicators of possible anthropogenic origin, such as charcoal deposits or mobilized terrestrial sediments of greater age. Ulong Island has a precipitous coastline except for two accessible beach flats on the western and eastern sides of the island where a boat landing could be made (Figure 1). Sub-surface investigations by Osborne (1979) of the large sand plain in the north, and extensive excavations on the east beach flat (Clark 2005) did not record evidence of cultural activity predating that in the south cove. Surface survey and excavation in southern Palau, including the platform islands of Angaur and Peleliu have not recorded cultural remains older than those at Ulong (Beardsley 1997; Clark and Wright 2003, 2005; Masse 1989), except possibly at Chelechol ra Orrak where the reliability of bone dates older than 3000 cal BP is uncertain.

Second, the accuracy of radiocarbon ages on old cultural deposits in Palau should be verified (Anderson et al. 2005; Clark 2004). The oldest dates on marine shell of ∼3000 cal BP from the 2002 excavation were not of definitive cultural origin, nor had a ΔR for Palau been directly calculated, and potentially had a value of 200–300 years. New ^{14}C determinations on midden shellfish remains from Units 4 and 5 were calibrated with a ΔR value of 42 ± 40 years calculated on prebomb shell of known age, indicating a deposit antiquity of 3100–2900 cal BP.

Third, the possibility that natural events had removed earlier cultural activity should be evaluated. In Palau and Yap the small number of cultural deposits dating to ~3000 cal BP suggests tectonic subsidence could have removed old archaeological deposits below sea level. Excavation of Unit 4 and Unit 5 showed that a natural beach deposit dating to ~3400 cal BP lay against the cove slope prior to human arrival 300–400 years later. The position of a buried sea notch in relation to modern sea level was consistent with a subsidence rate that appears to have matched, fortuitously, the mid-Holocene drawdown in sea level. Thus, it is likely that since mid-Holocene times the cove had a small sheltered beach, and cultural materials, such as pottery, stone, and marine shell deposited on it, although within range of high tidal events, were unlikely to have been completely removed (Felgate 2001).

Fourth, the earliest archaeological assemblage should contain artifacts or fauna indicative of a colonization phase deposit. The burden is on the faunal assemblage as basal ceramics and artifacts from Ulong have not been found elsewhere in Palau, and western Micronesian pottery has distinct characteristics so there is no widespread style horizon with which to infer a colonization age. Almost nothing is known of the variety and distribution of pre-human fauna in the Palau Islands despite palaeofaunal investigations (see Pregill and Steadman 2000), but in all probability there were, then as now, few edible terrestrial fauna to be found on limestone islands, and human subsistence was heavily oriented toward the collection of marine foods. The targeting of a small number of species of large meat-yielding marine mollusks at Ulong is not inconsistent with harvesting pristine stocks of shellfish.

In summary, the excavation of Units 4 and 5 in 2003, along with investigations elsewhere on Ulong Island and new radiocarbon dates suggest humans first visited the island at ~ca. 3000 cal BP. How much earlier a population might have resided on Babeldaob is uncertain, and we consider better known examples of archipelago colonization from Oceania to understand temporal variability in human dispersal through island groups during the colonization phase.

INTRA-ARCHIPELAGIC COLONIZATION OF PACIFIC ISLANDS

During the late Pleistocene humans reached several large and intervisible continental islands in the west Pacific, such as New Guinea, the Bismarck Archipelago, and the Solomon Islands (excluding the Reef/Santa Cruz group). The pattern is suggestive of a maritime ability adequate to reach neighboring islands, but it is unclear to what extent it was employed in intra-archipelagic dispersal (Anderson 2003). As a result we restrict ourselves to examples of island groups colonized by Neolithic groups who in occupying the distant archipelagoes of Oceania, like Palau, demonstrated a maritime capacity sufficient to utilize the majority of islands within each group.

Western Micronesia (Mariana Islands)

The largest of the Mariana Islands is the volcanic-limestone island of Guam in the south, adjacent to smaller predominantly limestone islands and a series of active volcanic cones in the north. The earliest archaeological sites on Guam, Tinian, and Saipan date to ~3500–3300 cal BP, and contain ceramics decorated with dentate stamping and rows of stamped circles that were infilled with lime (Butler 1994; Moore and Hunter-Anderson 1999). Leaving aside the palaeoecological record which suggests burning at 4300 cal BP on Guam that may be anthropogenic (Athens et al. 2004), the oldest securely dated archaeological sites in the archipelago appear to be approximately contemporaneous, and there is some linguistic evidence to suggest that Saipan may have been colonized before Guam (Blust 2000).

East Melanesia and West Polynesia

Extending from the Reef/Santa Cruz Island to Samoa are island groups first colonized by Lapita groups at 3100–2900 cal BP. Within several archipelagoes there is evidence of earlier colonization on large islands. In New Caledonia the oldest Lapita sites are on the large island of Grand Terre with smaller offshore limestone islands like the Loyalty Group colonized one or two centuries later (Sand 1997). In Fiji, similarly, the big island of Viti Levu was colonized at 3100–3000 cal BP before human occupation spread to the Lau Group, which includes a great number of small islands some 250 km to the east by 2900 cal BP (Clark and Anderson 2001). A cline in archipelago occupation is also seen in Tonga where the oldest site on the southern island of Tongatapu has an age of ~2950 cal BP, with more distant islands in central and northern Tonga colonized within a century or so (Burley and Dickinson 2001). However, the Vavau Group—where the largest island in the archipelago is located—has no Lapita sites despite having fertile agricultural soils (Orbell 1983), and colonizing groups appear to have preferentially occupied nearby small islands that possessed abundant marine resources (Burley and Witt 2005).

Central East Polynesia and South Polynesia

In Central East Polynesia, there is evidence of initial occupation at about AD 900–1000 in the Societies, Marquesas, and Easter Island (Anderson and Sinoto 2002). Claims for slightly earlier occupation, ~800 AD in the Pitcairn group (Weisler 1996), are debatable, and the most recent work in the southeastern region is producing later ages for colonization horizons in the Gambier Islands (Anderson et al. 2003). In Rapa the earliest dates suggest initial occupation in the eleventh century AD (Kennett et al. In Press). The current state of colonization records, particularly radiocarbon ages, does not disclose significant intra-archipelago variation in the timing of human arrival.

Initial colonization of South Polynesia (New Zealand and outlying subtropical and sub-Antarctic islands) occurred at virtually the same time on each of the groups. The earliest reliable radiocarbon ages throughout New Zealand date to the thirteenth century (Anderson 1991; Higham et al. 1999). So, too, do the earliest reliable dates for Enderby Island in the subpolar region (Anderson 2005), and for the earliest known sites in the subtropical region, in the Kermadecs (Higham and Johnson 1996), and on Norfolk Island (Anderson and White 2001). Current earliest dates for the Chathams are later, ~450 cal BP, but there are undated sites that contained artifacts indicative of settlement several hundred years earlier (Duff 1956:118). Colonization of the outlying groups seems to have arisen in mainland New Zealand, although indirectly in the case of Norfolk Island, and between the thirteenth and early fifteenth centuries. South Polynesia constituted as extensive an inhabited region as central East Polynesia or the earlier range of Lapita colonization in the western Pacific.

CONCLUSIONS

Studying human movement at the intra-archipelagic level has the advantage that components of colonization may be discerned that are otherwise difficult to distinguish in demographic wave of advance or "point-arrow/string of pearls" dispersal models (Moore 2001). Colonization of new landscapes involved learning and adapting to different environments and migrant adjustment to changed socio-demographic conditions at destination. It is supposed that habitat preference and selection during the initial colonization phase was toward culturally familiar landscapes, and as a result dispersal into unfamiliar or adverse habitats took place only when adequate knowledge had developed (Steele and Rockman 2003). In consequence, temporal variability in colonization from landscape selection might occur in an archipelago when islands vary markedly by size, type, and resources.

The discrepancy between palaeoenvironmental indicators of human arrival on Babeldaob at 4300 cal BP and archaeological sites on small islands dated to 3000 cal BP could represent a preference for environments on Babeldaob, and avoidance or ephemeral use of islands in southern Palau. Equally plausible is that an early colonization of Babeldaob at 4300 cal BP failed, or that a millennium or more of archaeological invisibility in the colonization record of Palau reflects deficiencies in current palaeoecological and archaeological data. In regard to the latter possibility an early subsidence-affected site on Ulong Island was re-excavated to clarify the age and nature of the basal cultural deposit, and to assess whether earlier cultural remains might have been removed by sea-level change and tectonic movement. Results indicated human arrival on Ulong Island at ~3000 cal BP and raised a broader question about the pattern of intra-archipelago colonization, and whether large islands tended to be utilized before small islands, and by what interval.

As hypothesized for Palau the earliest evidence for colonization is often found on the largest island(s) in an archipelago. In Tonga the biggest island was avoided, however, in favor of small islands near to it, emphasizing the importance of marine foods in the dispersal of Neolithic groups in Oceania, and the role of small islands in intra-archipelagic colonization. Human expansion through several island groups in the Pacific was relatively rapid and took 100–300 years in archipelagoes much larger than Palau and which have greater insular diversity. If a similar interval applies to Palau the arrival of people on Babeldaob would date to around 3400–3100 cal BP, still substantially adrift from the 4300 cal BP age suggested by palaeoecological results. Small islands do hold limited terrestrial resources relative to large islands, and their archaeological deposits are unlikely to contain either the earliest prehistoric remains or reflect the full extent of colonization activity. On Ulong Island, the oldest beach deposit indicates collection and consumption of fish and shellfish, whereas on Orrak Island karstic features were employed as burial sites for people from nearby Babeldaob, possibly reflecting prehistoric variation in island use. Nonetheless, small islands are environments where the physical remains of the colonization phase can be discerned, and are particularly useful to consider when archaeological and palaeoenvironmental records of human arrival on large islands are ambiguous.

ACKNOWLEDGEMENTS

Field work was supported by an Australian Research Council (ARC) grant and an ANU Faculties research grant to Clark, and an ANU post-graduate travel grant to Wright. Radiocarbon dates were funded by the Centre for Archaeological Research and ARC. We gratefully acknowledge the support in Palau of the Bureau of Arts and Culture (BAC, formerly the Division of Cultural Affairs) and the assistance of Rita Olsudong (National Archaeologist), and Vicky Kanai (former Director, BAC). Excavations were carried out with the permission of the Governor of Koror, the Honorable John Gibbons; and we also thank John Rutledge (Koror State) for his help. The expert crew of Vince Blaiyok, Dino Mibuk, and Lark Ngirkiklang facilitated excavations and field processing of excavated material. Finally, we thank the editors and three reviewers for their useful comments on an earlier version of the manuscript.

REFERENCES

Anderson, A., S. Bedford, G. Clark, I. Lilley, C. Sand, G. Summerhayes, and R. Torrence. 2001a. An inventory of Lapita sites containing dentate-stamped pottery. In *The Archaeology of Lapita Dispersal in Oceania* (G. Clark, A. Anderson, and T. Vunidilo, eds.):1–13. Terra Australis 17, Canberra: Pandanus Press.

Anderson, A., J. Chappell, G. Clark, and S. Phear. 2005. Comparative radiocarbon dating of pottery and charcoal samples from Babeldaob Island, Republic of Palau. *Radiocarbon* 47:1–9.

Anderson, A., T. Higham, and R. Wallace. 2001b. The radiocarbon chronology of the Norfolk Island archaeological sites. *Records of the Australian Museum, Supplement* 27:33–42.

Anderson, A. J. 1991. The chronology of colonization in New Zealand. *Antiquity* 65:767–795.

Anderson, A. J. 2003. Initial human dispersal in Remote Oceania: Pattern and explanation. In *Pacific Archaeology: Assessments and Prospects* (C. Sand, ed.):71–84. Noumea: Service des Musees et du Patrimoine.

Anderson, A. J. 2005. Subpolar settlement in South Polynesia. *Antiquity* 79:791–800.

Anderson, A. J., E. Conte, P. V. Kirch, and M. Weisler. 2003. Cultural chronology in Mangareva (Gambier Islands), French Polynesia: Evidence from recent radiocarbon dating. *Journal of the Polynesian Society* 112:119–140.

Anderson, A. J. and Y. H. Sinoto. 2002. New radiocarbon ages of colonization sites in East Polynesia. *Asian Perspectives* 41:242–257.

Anderson, A. J. and J. P. White (eds.). 2001. The prehistoric archaeology of Norfolk Island, Southwest Pacific. *Records of the Australian Museum, Supplement* 27.

Athens, J. S. 1986. *Archaeological Investigations at Tarague Beach, Guam*. Honolulu: International Archaeological Research Institute, Inc.

Athens, J. S., M. F. Dega, and J. V. Ward. 2004. Austronesian colonisation of the Mariana Islands: The palaeoenvironmental evidence. *Bulletin of the Indo-Pacific Prehistory Association* 24:21–30.

Athens, J. S. and J. V. Ward. 2001. Palaeoenvironmental evidence for early human settlement in Palau: The Ngerchau core. In *Pacific 2000. Proceedings of the Fifth International Conference on Easter Island and the Pacific* (C. M. Stevenson, G. Lee, and F. J. Morin, eds.):164–177. Easter Island Foundation, Los Osos: Bearsville Press.

Beardsley, F. 1997. *Fishponds, Taro Patches and Shell Middens: Archaeological Investigations on Peleliu, Republic of Palau, Data Recovery and Monitoring for the Palau Rural Water System Program*. Honolulu: International Archaeological Research Institute.

Bedford, S. and M. Spriggs. 2000. Crossing the Pwanmwou: Preliminary report on recent excavations adjacent to and south west of Mangaasi, Efate, Vanuatu. *Archaeology in Oceania* 35:120–126.

Blust, R. 2000. Chamorro historical phonology. *Oceanic Linguistics* 39:83–122.

Burley, D. V. and W. R. Dickinson. 2001. Origin and significance of a founding settlement in Polynesia. *Proceedings of the National Academy of Sciences* 98:11829–11831.

Burley, D. V. and J. Witt. 2005. Lapita in Vava'u—implications for the long pause in

Polynesian prehistory. Unpublished paper, Oceanic Explorations Conference Nukua'lofa, Tonga, August 1-7.
Butler, B. M. 1994. Early prehistoric settlement in the Marianas Islands: New evidence from Saipan. *Man and Culture in Oceania* 10:15-38.
Carucci, J. 1992. *Cultural and Natural Patterning in Prehistoric Marine Food Shell from Palau, Micronesia*. Ann Arbor: University Microfilms.
Clark, G. 2004. Radiocarbon dates for the Ulong site in Palau and implications for western Micronesian prehistory. *Archaeology in Oceania* 39:26-33.
Clark, G. 2005. A 3000-year culture sequence from Palau, Western Micronesia. *Asian Perspectives* 44:349-380.
Clark, G. and A. Anderson. 2001. The pattern of Lapita settlement in Fiji. *Archaeology in Oceania* 36:77-88.
Clark, G. and D. Wright. 2003. The colonisation of Palau: Preliminary results from Angaur and Ulong. In *Pacific Archaeology: Assessments and Prospects* (C. Sand, ed.):85-94. Noumea: Service des Musees et du Patrimoine.
Clark, G. and D. Wright. 2005. On the periphery? Archaeological investigations at Ngelong, Angaur Island, Palau. *Micronesica* 38:67-91.
Clark, G. R. In prep. n.d. Culture contact in the Palau Islands. To be submitted to *Antiquity*.
Corwin, C. G., C. L. Rogers, and P. O. Elmquist. 1956. *Military Geology of Palau Islands, Caroline Islands*. Intelligence Division, Office of the Engineer, Headquarters U.S. Army Far East.
Dickinson, W. R. 2000. Hydro-isostatic and tectonic influences on emergent Holocene paleoshorelines in the Marianas, western Pacific. *Journal of Coastal Research* 16:725-746.
Dickinson, W. R. 2004. Picture essay of Pacific Island coasts. *Journal of Coastal Research* 20:1012-1034.
Dickinson, W. R., D. V. Burley, and R. Shutler Jr. 1994. Impact of hydro-isostatic sea-level change on the geologic context of island archaeological sites, northern Ha'apai Group, Kingdom of Tonga. *Geoarchaeology* 9:85-111.
Dickinson, W. R. and R. C. Green. 1998. Geoarchaeological context of Holocene subsidence at the ferry berth Lapita site, Mulifanua, Upolu, Samoa. *Geoarchaeology* 13:239-263.
Dodson, J. R. and M. Intoh. 1999. Prehistory and palaeoecology of Yap, Federated States of Micronesia. *Quaternary International* 59:17-26.
Duff, R. 1956. *The Moa-hunter Period of Maori Culture*. Wellington: Government Printer.
Dye, T. 1994. Apparent ages of marine shells: Implications for archaeological dating in Hawaii. *Radiocarbon* 36:607-613.
Easton, W. H. and T. L. Ku. 1980. Holocene sea-level changes in Palau, western Caroline Islands. *Quaternary Research* 14:199-209.
Felgate, M. 2001. A Roviana ceramic sequence and the prehistory of Near Oceania: Work in progress. In *The Archaeology of Lapita Dispersal in Oceania* (G. Clark, A. Anderson, and T. Vunidilo, eds.):39-60. Terra Australis 17, Canberra: Pandanus Press.
Fitzpatrick, S. M. 2002. A radiocarbon chronology of Yapese stone money quarries in Palau. *Micronesica* 39:227-242.
Fitzpatrick, S. M. 2003. Early human burials in the Western Pacific: Evidence for a c.3000 year old occupation on Palau. *Antiquity.* 77:719-731.
Fitzpatrick, S. M. and J. E. Boyle. 2002. The antiquity of pearl shell (*Pinctada* sp.) burial artifacts in Palau, western Micronesia. *Radiocarbon* 44:691-699.
Gagan, M. K., E. J. Hendy, S. G. Haberle, and W. S. Hantoro. 2004. Post-glacial evolution of the Indo-Pacific Warm Pool and El Niño-Southern Oscillation. *Quaternary International* 118-119:127-143.
Higham, T. F. G. and J. Johnson. 1996. The prehistoric chronology of Raoul Island, the Kermadec group. *Archaeology in Oceania* 31:207-213.
Higham, T. G., A. J. Anderson, and C. Jacomb. 1999. Dating the first New Zealanders: The chronology of Wairau Bar. *Antiquity* 73:420-427.
Hogg, A. G., T. F. G. Higham, and J. Dahm. 1998. ^{14}C dating of modern marine and estuarine shellfish. *Radiocarbon* 40:975-984.
Hughen, K. A. 2004. Marine04 marine radiocarbon age calibration, 0-26 cal kyr BP. *Radiocarbon* 46:1059-1086.
Kayanne, Y. H., H. Yamano, and R. H. Randall. 2002. Holocene sea-level changes and barrier reef formation on an oceanic island, Palau Islands, western Pacific. *Sedimentary Geology* 150:47-60.
Kennett, D., A. J. Anderson, M. Prebble, E. Conte, and J. Southon. 2006. Prehistoric human impacts on Rapa, French Polynesia. *Antiquity* 80:340-354.
Liston, J. 1999. *Archaeological Data Recovery for the Compact Road, Babeldaob Island, Republic of Palau. Historic Preservation Investigations Phase II. Volume VII: Lab Analyses, Syntheses, and Recommendations*. Honolulu: International Archaeological Research Institute, Inc.

Liston, J. 2005. An assessment of radiocarbon dates from Palau, western Micronesia. *Radiocarbon* 47:295–354.

Masse, W. B. 1989. *The Archaeology and Ecology of Fishing in the Belau Islands, Micronesia, Part 1 and Part 2*. Ann Arbor: University Microfilms.

Masse, W. B. 1990. Radiocarbon dating, sea-level change and the peopling of Belau. *Micronesica Supplement* 2:213–230.

Masse, W. B., J. Liston, J. Carucci, and S. Athens. 2006. Evaluating the effects of climate change on environment, resource depletion, and culture in the Palau Islands between AD 1200 and 1600. *Quaternary International* 151:106–132.

McPhaden, M. J. and D. Zhang. 2002. Slowdown of the meridional overturning circulation in the upper Pacific Ocean. *Nature* 415:603–608.

Moore, J. H. 2001. Evaluating five models of colonization. *American Anthropologist* 103:395–408.

Moore, D. R. and R. L. Hunter-Anderson. 1999. Pots and pans in the intermediate Pre-Latte (2500–1600 BP) Mariana Islands, Micronesia. In *The Pacific from 5000 to 2000 BP. Colonisation and Transformations* (J-C. Galipaud and I. Lilley, eds.):487–504. Paris: IRD Editions.

Nero, K. and N. Thomas (eds.) 2002. *Account of the Pelew Islands*, by G. Keate. London and New York: Leicester University Press.

Orbell, G. E. 1983. *Soils of the Kingdom of Tonga. An Introduction*. Wellington: New Zealand Soil Bureau.

Osborne, D. 1979. Archaeological test excavations Palau Islands 1968–1969. *Micronesica Supplement* 1.

Petchey, F. and R. Green. 2005. Use of three stable isotopes to calibrate human bone radiocarbon determinations from Kainapirina (SAC), Watom Island, Papaua New Guinea. *Radiocarbon* 47:181–192.

Petchey, F., M. Phelan, and J. P. White. 2005. New ΔR values for the southwest Pacific Ocean. *Radiocarbon* 46:1005–1014.

Phear, S., G. Clark, and A. Anderson. 2003. A radiocarbon chronology for Palau. In *Pacific Archaeology: Assessments and Prospects* (C. Sand, ed.):241–249. Noumea: Service des Musees et du Patrimoine.

Phelan, M. 1999. A ΔR correction value for Samoa from known-age marine shells. *Radiocarbon* 41:99–101.

Pregill, G. K. and D. W. Steadman. 2000. Fossil vertebrates from Palau, Micronesia: A resource assessment. *Micronesica* 33:137–152.

Rainbird, P. 2004. *The Archaeology of Micronesia*. Cambridge: Cambridge University Press.

Reidinger, M. A., M. Steinitz-Kannan, W. M. Last, and M. Brenner. 2002. A 6100 ^{14}C yr record of El Niño activity from the Galapagos Islands. *Journal of Paleolimnology* 27:1–7.

Sand, C. 1997. The chronology of Lapita ware in New Caledonia. *Antiquity* 71:539–547.

Spennemann, D. H. R. and M. J. Head. 1998. Tongan pottery chronology, ^{14}C dates and the hardwater effect. *Quaternary Geochronology* 17:1047–1056.

Steadman, D., P. Vargas, and C. Cristino. 1994. Stratigraphy, chronology and cultural context of an early faunal assemblage from Easter Island. *Asian Perspectives* 33:79–96.

Steadman, D. W., G. Pregill, and D. V. Burley. 2002. Rapid prehistoric extinction of iguanas and birds in Polynesia. *Proceedings of the National Academy of Sciences* 99:3673–3677.

Steele, J. and M. Rockman. 2003. "Where do we go from here?" Modelling the decision-making process during exploratory dispersal. In *Colonization of Unfamiliar Landscapes; The Archaeology of Adaptation* (M. Rockman and J. Steele, eds.):130–143. London: Routledge.

Stuiver, M. and T. H. Braziunas. 1993. Modeling atmospheric ^{14}C influences and ^{14}C ages of marine samples to 10,000 BC. *Radiocarbon* 35:137–189.

Stuiver, M. and P. J. Reimer. 1993. Extended ^{14}C data base and revised CALIB 3.0 ^{14}C age calibration program. *Radiocarbon* 35:215–230.

Takayama, J. 1981. Early pottery and population movements in Micronesian prehistory. *Asian Perspectives* XXIV:1–10.

Weisler, M. I. 1996. Taking the mystery out of the Polynesian 'mystery' islands: A case study from Mangareva and the Pitcairn group. In *Oceanic Culture History: Essays in Honour of Roger Green* (J. Davidson, G. Irwin, F. Leach, A. Pawley, and D. Brown, eds.):615–629. Wellington: New Zealand Journal of Archaeology Special Publication.

Welch, D. J. 2001. Early upland expansion of Palauan settlement. In *Pacific 2000. Proceedings of the Fifth International Conference on Easter Island and the Pacific* (C. M. Stevenson, G. Lee, and F. J. Morin, eds.):179–184. Easter Island Foundation, Los Osos: Bearsville Press.

White, J. P., C. Coroneos, V. Neall, W. Boyd, and R. Torrence. 2002. FEA site, Boduna Island: Further investigations. In *Fifty Years in the Field* (S. Bedford, D. Burley, and C. Sand, eds.):101–107. Wellington: New Zealand Archaeological Association Monograph 25.

Wickler, S. 2001. The colonization of western Micronesia and early settlement of Palau. In *Pacific 2000. Proceedings of the Fifth International Conference on Easter Island and the Pacific* (C. M. Stevenson, G. Lee, and F. J. Morin, eds.):185–196. Easter Island Foundation, Los Osos: Bearsville Press.

Wickler, S. 2002. Terraces and villages: Transformation of the cultural landscape in Palau. In *Pacific Landscapes: Archaeological Approaches in Oceania* (T. Ladefoged and M. Graves, eds.):63–96. Easter Island Foundation, Los Osos: Bearsville Press.

Wright, D. 2005. *The Archaeology of Aulong Island and the Colonisation of Palau.* M.A. Thesis. Canberra: Australian National University.