Journal of Pacific Archaeology – Vol. 13 · No. 2 · 2024

– ARTICLE –

Polynesian Settlement of the Marquesas Islands: The chronology of Hanamiai in comparative context

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ABSTRACT

Hanamiai is a coastal dune site in the Marquesas Islands. The continuous cultural sequence extends from initial Polynesian colonization through European contact. We present a revised site chronology based on 14 new dates and Bayesian modeling of the entire series of 22 age estimates. Our results show that the start boundary for the earliest Hanamiai phase is AD 1160–1266 (95% credible interval). We also compared the Hanamiai chronology with the chronologies for seven other Marquesan sites. Finally, we estimated the tempo of Marquesan settlement and the age range for a transition in material culture from the Archaic to the Classic phase.

Keywords: Hanamiai, Marquesas Islands, Polynesia, radiocarbon dating, Bayesian modeling, initial colonization

INTRODUCTION

Founder settlements, defined as archaeological sites representing the first human settlement of previously uninhabited landscapes (Burley & Dickinson 2001), are essential for understanding human colonization of the Pacific Islands. Yet for reasons including landscape change and the comparatively small size of founder colonies, the archaeological record of founder settlements is still poorly known. In East Polynesia, more than sixty years of fieldwork has brought to light only a few sites displaying the hallmark trait of Polynesian founder settlements: diagnostically early artifact assemblages directly associated with faunal remains representing vulnerable native species, such as flightless birds, that later disappeared as a result of anthropogenic influence. Three of the best-known founder settlements – Hane (Sinoto 1966; Sinoto 1970; Conte & Molle 2014; Molle 2011), Hanamiai (Rolett 1998; Rolett 2021) and Haʻatuatua (Suggs 1961; Rolett & Conte 1995) – are coastal dune sites located in Te Fenua Enata, an archipelago known to the Western world as the Marquesas (Figure 1). To various degrees, but without exception, the chronologies of these sites have been debated, contested or rejected. In particular, recent discussion emphasizes the possibility that dated samples of unidentified wood charcoal may contain inbuilt age (*e.g.* Allen & Wallace 2007; Allen & Huebert 2014), a factor not fully appreciated until after the initial investigation of Hane, Hanamiai and Haʻatuatua.

The problem of unidentified wood charcoal relates to dating accuracy. Does the radiocarbon age of the sample accurately estimate the target event (*e.g.* does charcoal from a hearth date the use of that hearth)? Or does it instead date 'old wood' such as material from the trunk of a recently felled but long-lived tree or branches from a standing dead tree? On islands, the potential for in-built age is especially significant when dating wood charcoal from the earliest stages of human settlement. This is because founder colonies would have encountered forests dominated by older trees, standing dead trees and down wood (woody debris) in different stages of decay.

Chronologies based on samples of short-lived material (SLM) diminish the uncertainty surrounding dates for unidentified wood charcoal. A constraint, however, is that SLM plant remains (such as seeds, coconut endocarp and twigs) tend to be scarce in relation to the much larger quantities of wood charcoal present in Marquesan archaeological sites. As of 2011, when Wilmshurst and colleagues published a meta-analysis of radiocarbon dates for East Polynesia, only 15 of the 99 age estimates for Marquesan sites were based on plant SLM samples (Wilmshurst *et al.* 2011). None of the 15 SLM samples derive from Haʻatuatua, Hane or Hanamiai, which lie on separate islands within the Marquesas. Significantly, although a primary objective of Wilmshurst *et al.* was 'to establish the most accurate age, or ages, for initial colonization in East Polynesia' (2011: 1815), their screening of dates by use of a strict 'chronometric hygiene' protocol led to perhaps unintended results. One consequence was to remove the known Marquesan founder settlements from consideration. In addition, because the 15 SLM samples Wilmshurst *et al.* selected to represent the Marquesas derive from two sites on Nuku Hiva (Hakaea and Teavauʻua) the scope of their analysis shifted from an archipelago-wide survey to a narrow focus on only one of the eight major islands. More early dates for the Marquesas

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Submitted 11/2/23, accepted 30/1/24. First online 26/2/24

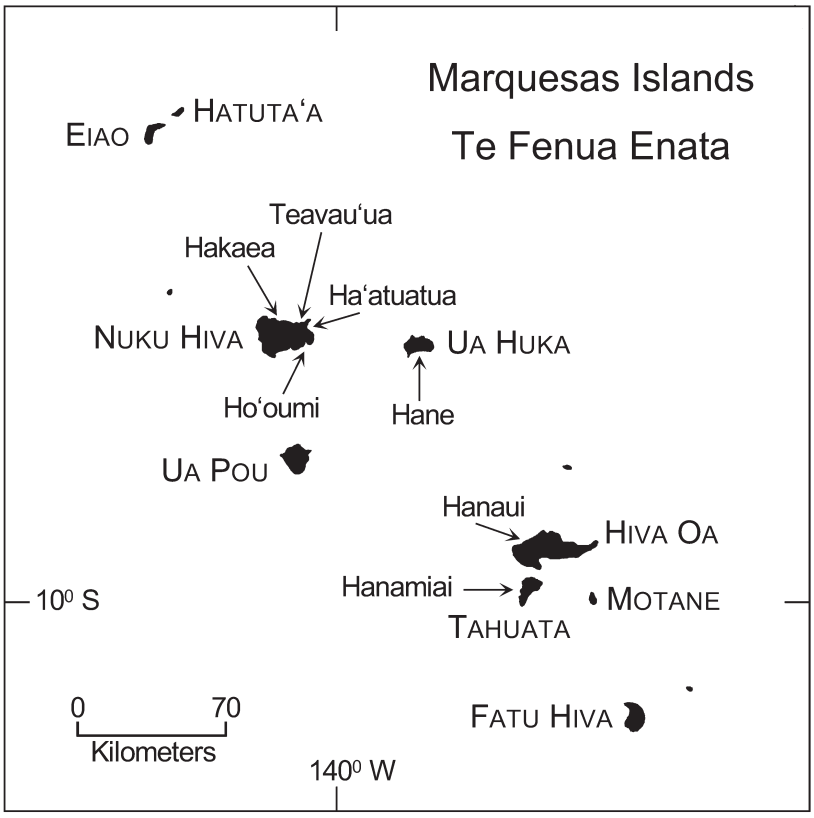


Figure 1. The Marquesas Islands, showing the location of Hanamiai and other archaeological sites discussed in this study.

have been published since 2011, including nineteen SLM dates for sites on Nuku Hiva (Allen 2014; Allen & McAlister 2013; Allen *et al.* 2021; Allen *et al.* 2022). There are also ten new age estimates, including SLM dates, from renewed excavations at the Hane dune (Conte & Molle 2014).

In addition to potential for in-built age, other variables can influence ^{14}C calibration, or the calculation to convert the laboratory-measured decay rate of ^{14}C to the calendar timescale. For example, organisms with marine diets take their carbon from the marine ^{14}C reservoir, which varies from place to place depending on currents and up-welling (Stuiver *et al.* 1986) and possibly over time, as well (see Supplement 1). Accordingly, dates for samples derived from the remains of animals with marine diets are calibrated for the marine reservoir effect. Different estimates of this effect are reviewed in Supplement 1.

Here we present a revised chronology of the Hanamiai founder settlement based on Bayesian modeling. The models incorporate both SLM and legacy non-SLM dates, and they are designed to identify and treat the effects of in-built age. Like other archaeological records, the Hanamiai record is an incomplete archive of the past, and interpretations of it are constrained by limitations of the field and lab sampling strategies employed in collecting data. As a result, the precision with which we can interpret the archaeological record is inherently limited. Bayesian approaches are particularly well suited for making sense of such real-world dilemmas because Bayesian statistics use probability distributions to 'formalize uncertain knowledge' (Buck & Meson 2015: 7). Bayesian approaches are explicitly designed to incorporate new knowledge into existing models. This too is a valuable feature in addressing problems like ours where continued excavations in the Marquesas and the publication of new age determinations regularly produce new data. Although no model can claim perfect correspondence to reality, updated and refined models will progressively advance the state of our knowledge.

The Hanamiai data include new results from the analysis of three samples of coconut endocarp charcoal, seven samples of worked pearl shell, and four samples of wood charcoal identified to species. Our results show that Bayesian models allow non-SLM legacy dates to be interpreted together with the newer ones. We also use Bayesian models to interpret the chronologies of seven additional sites on three other islands (see Supplements 1 and 2). This allows us to revisit the debate over the tempo of initial human settlement of the archipelago. Finally, we experiment with a model that estimates the date for changes from an 'Archaic' artifact tradition associated with the earliest Polynesian settlement of the Marquesas to a later, distinctively different 'Classic' tradition. Our findings shed new light on early human settlements in the Marquesas, including ones that may have played a significant role in early East Polynesian migrations.

The Hanamiai founder settlement

The Hanamiai archaeological site is a sand dune facing one of the largest and best-sheltered bays on Tahuata, in the southern Marquesas (Figure 2). The site itself is the remnant of a stable, fully vegetated coastal dune, while Hanamiai Valley is part of a large amphitheater-shaped formation. Vaitahu, a second valley within the same amphitheater, is known for the Vaieʻe artesian spring. Located at one end of Vaitahu Beach, Vaieʻe gushes from a rocky face onto the coast where it is readily visible from the bay. The spring provides enough fresh water to satisfy the needs of Vaitahu's present population of 400 inhabitants. This is important because permanently flowing streams that reach the coast are uncommon in the Marquesas and the archipelago is known for severe multi-year droughts (Thomas 1990; Allen 2010). Spanish explorers who landed at Tahuata in 1595 (Quiros 1904: 117), and James Cook who visited in 1774 (1961: 374), both noted Vaieʻe and they relied on it to replenish the supply of fresh water for their ships. With its high visibility, easy access and prominent location in a sheltered bay, Vaieʻe likely attracted the attention of early Polynesian settlers, even as it is valued by the modern population.

Discovered in 1984, initial fieldwork at the Hanamiai site (Figure 3) revealed deep calcareous sand deposits with a sequence of occupations marked by well-defined living floors, activity areas and house pavements (Rolett 1998). The main focus was a 21 m² areal excavation at Hanamiai North, where cultural deposits extended to 1.85 m beneath the ground surface (Figure 4). The excavation proceeded by 5 or 10 cm arbitrary levels within deposits, with sieving through screens of ⅛th in. mesh (Rolett 1998).

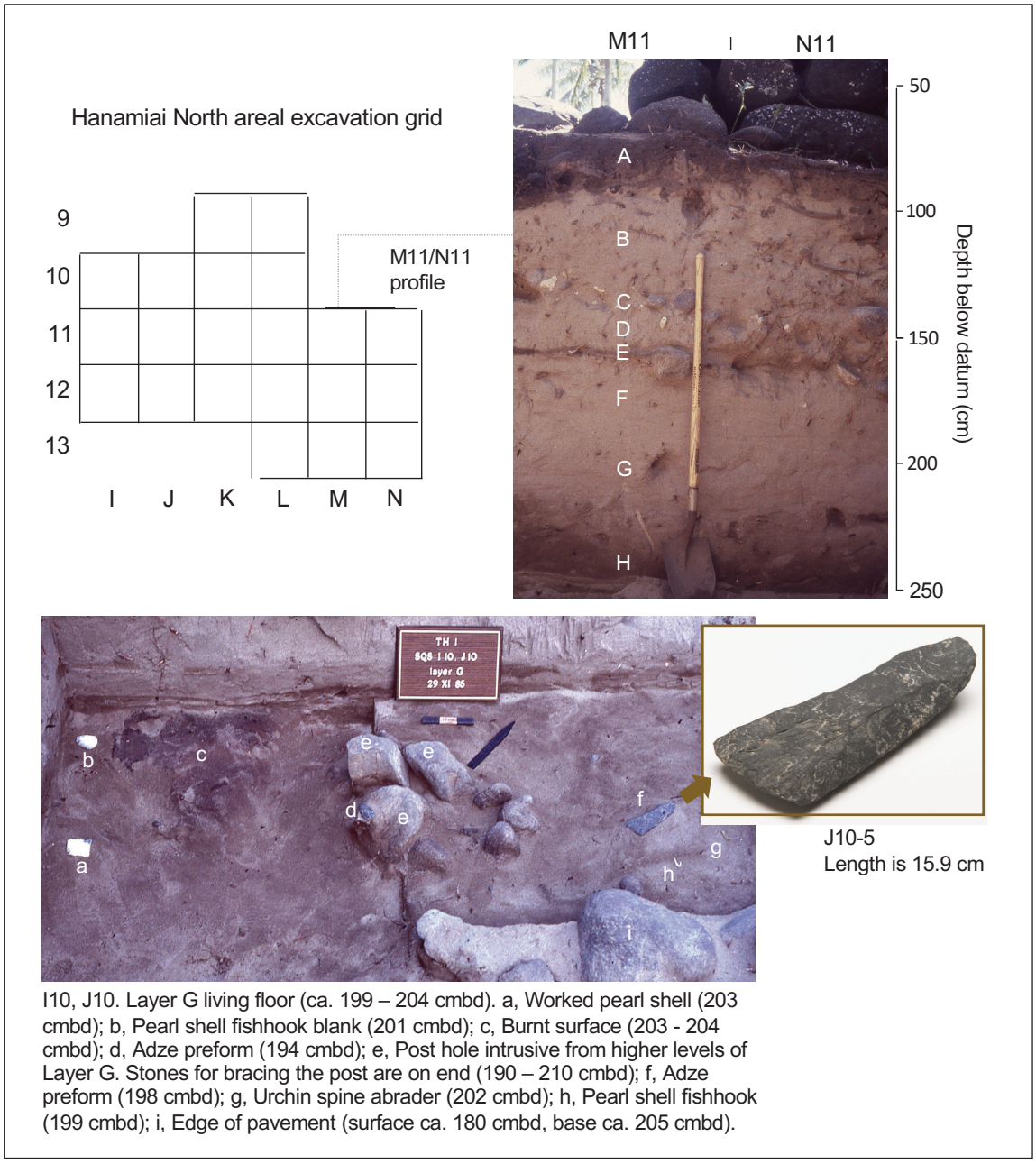
At Hanamiai North, faunal assemblages of the deepest cultural deposits are notable for the presence of extinct and extirpated species of landbirds, as well as extirpated species of land snails. The chronostratigraphic distribution of these species traces an abrupt environmental transformation linked with the initial human settlement of a pristine island landscape (Rolett 1998; Steadman 2006; Steadman & Rolett 1996). The original Hanamiai chronology, based on non-SLM legacy dates, estimated an age range of AD 1025–1300 for the founder settlement occupation (Rolett 1998). This occupation yielded abundant evidence suggesting use of the site as a general habitation area.

The Hanamiai North excavation area was disturbed by public works projects around 1990 and there has been no further fieldwork in this location. However, in 1997 and subsequent years, investigations some 50 m to the south discovered another promising excavation area (Figure 3). During multiple field seasons, more than 105 m² of excavations were completed at the new location, designated Hanamiai South (Rolett 2021). The Hanamiai South stratigraphic sequence varies considerably across the area investigated. One zone, consisting of the 1998 to 2010 excavation areas, is marked by comparatively recent cultural

Figure 2. Overview of Vaitahu and Hanamiai valleys. Vaitahu (with village) on left, Hanamiai on right. Vaieʻe artesian spring is marked by the yellow triangle; Hanamiai South archaeological site is marked by the yellow circle. Photo by B. Rolett.

Figure 3. Map of the Hanamiai archaeological site, as it appeared prior to disturbance by public works projects. Surface architectural features date to the Historic phase. Map created by Scott F. Allen. Data source: Barry V. Rolett, Robert Bollt.

deposits underlain by a thick, impenetrable stream deposit. Another zone identified in 2012 lies beyond the stream deposit. Here, a series of sandy cultural deposits extend from the ground surface to below the water table (Figure 5). The deepest deposit, which reaches to about 2.45–2.75 m beneath the ground surface, contains temporally sensitive artifacts representing the same Archaic material culture discovered in lower layers of the Hanamiai North excavation. An area comprising 30 m² of the earliest deposits was exposed over multiple field seasons. The Hanamiai South excavations yielded abundant faunal assemblages and although these have not been fully analyzed, it appears that the deepest deposit yields higher frequencies of bird bones than the later deposits. The earliest cultural layer also yielded carbonized fragments of coconut shell – these are the first SLM botanical specimens suitable for dating the Archaic phase Hanamiai settlement.



I10, J10. Layer G living floor (ca. 199 – 204 cmbd). a, Worked pearl shell (203 cmbd); b, Pearl shell fishhook blank (201 cmbd); c, Burnt surface (203 - 204 cmbd); d, Adze preform (194 cmbd); e, Post hole intrusive from higher levels of Layer G. Stones for bracing the post are on end (190 – 210 cmbd); f, Adze preform (198 cmbd); g, Urchin spine abrader (202 cmbd); h, Pearl shell fishhook (199 cmbd); i, Edge of pavement (surface ca. 180 cmbd, base ca. 205 cmbd).

Figure 4. Hanamiai North, showing layout of the areal excavation, a representative stratigraphic profile and a living floor from the Archaic phase founder settlement. Photos by B. Rolett.

Chronologically diagnostic artifacts and the Marquesan cultural sequence

Artifacts recovered from the deepest cultural layers at Hanamiai include ones representing the same characteristic material culture assemblage that distinguishes early Polynesian settlements throughout the Marquesas. Identified by untanged stone adzes, as well as distinctive fishing gear and personal ornaments, this set of cultural markers comprises a widely recognized 'Archaic East Polynesian' or 'Early East Polynesian' culture (Bellwood 1970; Duff 1950; Rolett 1993; Rolett 1998; Sinoto 1970; Walter *et al.* 2017). This Archaic material culture is associated with intentional long-distance voyaging during the early discovery and exploration of East Polynesia (Rolett 1996, 1998, 2002; Rolett *et al.* 2015; Kirch 2017; Weisler & Walter 2017). The central idea is that long-distance voyaging linked newly settled islands and others with larger, established populations. Communication maintained homogeneity by spreading innovations across interaction spheres.

Conceptually, the notion of an interaction sphere contrasts with earlier models that emphasized relative isolation

Figure 5. Overview of the 2013 Hanamiai South excavation. Hio Timau screening. Samuel Tiaiho digging in Layer F at around 310 cmbd. Photo by B. Rolett.

of the Marquesas following settlement from a West Polynesian homeland (Suggs 1961, Sinoto 1970). Suggs, whose fieldwork on Nuku Hiva included the first archaeological excavations in the Marquesas, suggested that the Marquesas and Society Islands were separate 'centers of diffusion' in the settlement of East Polynesia (1961a: 193). His five-stage Marquesan cultural sequence (Suggs 1961: 174–192) is remarkable for its interpretation of colonization processes as well as long-term developments in settlement patterns, demography, social structure and architecture, in addition to the subsistence economy and material culture. Suggs set the date for initial colonization at 150 BC. With only a limited number of radiocarbon age estimates for a large number of sites, Suggs' chronology relies heavily on stratigraphy and relative dating. This was achieved by attention to temporally sensitive artifacts such as tanged adzes and, in the case of architectural remains, stratified construction sequences.

Suggs interpreted Haʻatuatua as one of the first settlements on Nuku Hiva, using data from this site to define his Settlement and early Developmental periods (1961: 63,174). He attributed certain elements of the material culture of these periods to 'Melanesian influence' (1961: 111, 177, 179) in the ancestral Polynesian homeland. Suggs characterized his late Developmental and early Expansion periods by a major transformation involving the disappearance of most artifacts showing ties to the ancestral homeland. Replacing them, distinctive innovations including tanged adzes and poi pounders form the basis of a cultural tradition that continued into the succeeding Classic and Historic periods. Suggs framed these later changes in relation to explosive population growth, prestige rivalry, innovations in architecture and an economic shift to increasing reliance on breadfruit (1961: 181–187). Notably, Suggs highlighted similarities, rather than differences, among artifact assemblages of the Settlement and early Developmental periods. He also viewed artifact assemblages of the Expansion and Classic periods as largely equivalent to one another but distinct from earlier assemblages.

Here, we propose to subsume the artifact assemblages of Suggs' Settlement and Development periods into an Archaic phase, and to subsume the artifact assemblages of the Expansion and Classic periods into a Classic phase. Doing this acknowledges an early/late dichotomy recognized informally by Suggs and others (*e.g.* Allen 2004, 2014). Renaming the first stage in the sequence as the Archaic and defining it on the basis of its characteristic material culture also highlights the widespread similarities among early cultural traditions across East Polynesia.

In the Marquesas and elsewhere in East Polynesia, Archaic artifact traditions eventually fell out of use and were replaced by local traditions, with different local traditions developing across the geographic range of the Archaic. Subsuming Suggs' Expansion and Classic periods into a Classic phase contributes to the goal of foregrounding differences in material culture among the Archaic and later phases. The material culture of the Classic phase is documented both archaeologically and by collections made during Captain Cook's passage in 1774 (*e.g.* Kaeppler 1978). Thus, we propose a three-stage sequence consisting of the Archaic, Classic and Historic phases. Although our distinction between the Archaic and Classic phases is based on artifact assemblages, future efforts to establish independent chronologies for other cultural developments, as well as environmental transformations, would be of great interest.

Four kinds of artifacts are especially useful for drawing a distinction between the Archaic and Classic artifact assemblages: adzes, one-piece fishhooks, trolling lure points and poi pounders (Table 1, Figure 6). All four of these have been identified as temporally sensitive. The contrast between untanged and tanged adzes (Figure 6a, e), where the tang is a modification to facilitate hafting, is well established as a distinction between early and late Marquesan artifact assemblages (Suggs 1961, Sinoto 1970, Rolett 1998). At Hanamiai, five untanged adzes were found in the deepest stratigraphic deposits and seven tanged specimens derive from more recent layers (Table 1).

Table 1. *Chronologically diagnostic artifacts from excavations at the Hanamiai Site.*

	Hanamiai North				Hanamiai South															
Year of excavation	1984, 1985				1998, 2001				2008, 2010					2012, 2013, 2014						
																			Upper	Lower
Layer[1]	A, B	C, D	E, F	G, GH, H	A	B	C	D	A	B	C	D	E	A	B	C	D	E	F	F
Cultural phase[2]	HI	CL	TR	AR	HI	HI	HI	CL	HI	HI	HI	HI	NA	HI	HI	HI	HI	CL	CL	AR
ARTIFACTS[3]																				**Total**
One-piece fishhooks																				
Curved, angular shank	1	2	4	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13	**55**
Straight shank	27	12	3	7	–	4	24	33	1	4	4	1	–	–	–	2	33	8	2	1	**166**
Trolling lure points																				
'West Polynesian'	–	–	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**7**
'East Polynesian'	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	**2**
Adzes																				
Untanged	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	**5**
Tanged	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	3	2	–	1	–	**7**
Poi pounders	–	–	–	–	–	3	2	–	–	–	–	–	–	–	–	1	1	–	–	–	**7**
Cowrie-shell peelers	–	–	–	–	3	3	2	1	–	–	–	–	–	–	–	–	3	–	–	–	**12**

1 See Rolett 1998 for Hanamiai North stratigraphy; Rolett 2021 for Hanamiai South stratigraphy.

2 Attribution of cultural phases based on artifact assemblages. AR, Archaic (early prehistoric); TR, transitional; CL, Classic (late prehistoric); HI, Historic (after AD 1774); NA, unknown – lack of evidence.

3 See Rolett 2021 for additional information, including the distribution of European artifacts.

One-piece fishhooks are quite common in coastal sites and they also serve well as chronological markers. Both Suggs (1961) and Sinoto (1979) identified specific forms (*e.g.* jabbing hooks) as temporally sensitive. More generally, comparisons among multiple sites show that hooks with curved (Figure 6b) and angular (Figure 6c) shanks are predominant in early assemblages, while ones with straight shanks (Figure 6g) are most abundant in late assemblages (Rolett 1998: 159–175). The Hanamiai data illustrate this pattern with a sample of 55 curved and angular-shank hooks and 166 straight-shank hooks (Table 1).

Trolling lure points are also diagnostic. There are two forms, named after ethnographic variants collected in West and East Polynesia at the time of European contact (Sinoto 1979: 113). The 'West Polynesian' (Figure 6d) and 'East Polynesian' (Figure 6h) points differ in the shape of the perforated base. In addition, the West Polynesian points have a pronounced bend, while the East Polynesian points are comparatively straight. At Hanamiai, seven of the West Polynesian points were found in the deepest deposits and two of the East Polynesian kind are from more recent layers (Table 1). This, together with evidence from other Marquesan sites such as Haʻatuatua and Hoʻoumi (Suggs 1961: 83–84), suggests that the West Polynesian form was introduced at the time of initial settlement, while the East Polynesian form developed as a later innovation.

Finally, it is notable that the presence of poi pounders in chronologically late contexts contrasts with their absence in early assemblages (Suggs 1961: 103). All seven of the poi pounders found at Hanamiai are from late contexts (Table 1). Cowrie-shell peelers (Suggs 1961: 128) also appear late in the Hanamiai sequence (Table 1) and they too seem to be chronologically diagnostic. Modeling the Hanamiai site chronology together with this artifactual evidence and similar data from other Marquesan sites makes it possible to estimate the timing of the Archaic/Classic transition.

Our study yields open source Bayesian frameworks (distributed with Supplement 1) for estimating the timing of initial Polynesian settlement of the Marquesas, subsequent settlement tempo throughout the archipelago, and the transition in material culture from the Archaic to the Classic phase. Future investigations might augment these frameworks with additional SLM dates or make specific changes to the stratigraphic models that underpin them.

MATERIALS AND METHODS

The Hanamiai radiocarbon samples in stratigraphic and cultural context

Hanamiai North

The original series of age estimates for Hanamiai North is based on materials collected in the 1980s. Because the dated material consisted of unidentified wood charcoal, we set out to refine the Hanamiai chronology with new dates that minimize the potential for in-built age. However, because no short-lived plant material was found among

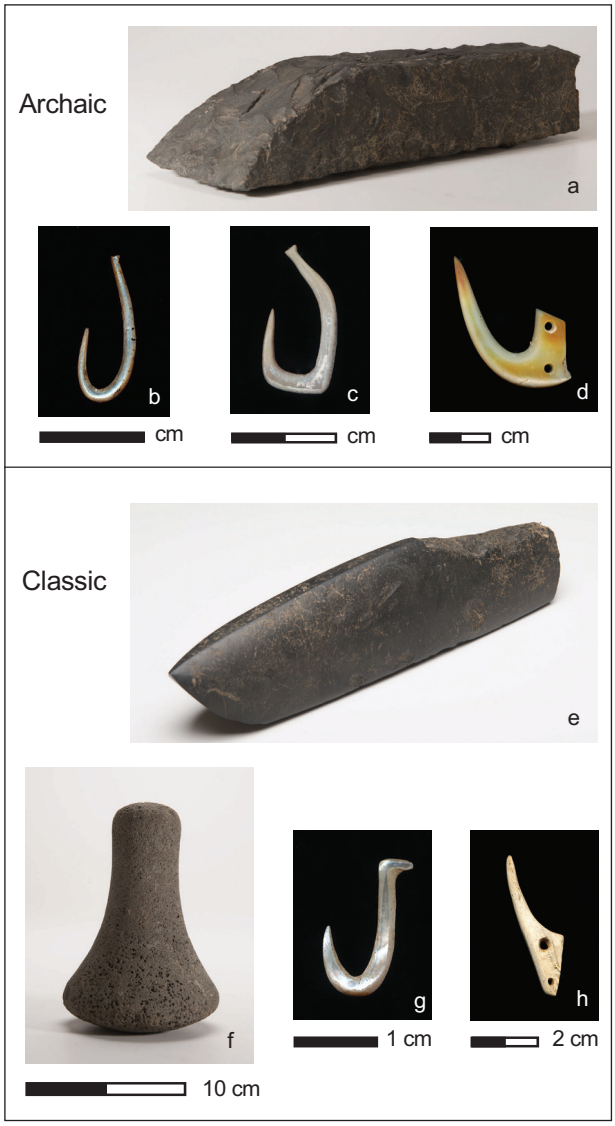


Figure 6. Diagnostic Archaic and Classic phase artifacts discovered at the Hanamiai site. Photos: D. Hazama, B. Rolett. Te Ana Peua Museum, Tahuata: a, 1002; b, P13-9; c, 1999; d, K9-5; e, 1004; f, 2001-335; g, 2701; h, 2001-263.

archived samples from the Hanamiai North excavations, we selected samples of worked pearl shell (*Pinctada margaritifera*). Pearl shell is fragile, its life-span is up to 15 years (Sims 1993) and there is no evidence suggesting it was curated in ancient times. Moreover, *P. margaritifera* is a filter feeder, so that it does not absorb carbon from calcareous substrates in such a way that can affect the in-built age of grazing shellfish. Together, these traits minimize the potential for in-built age in archaeological specimens and simplify correction for the marine reservoir effect.

We also dated four taxonomically identified wood charcoal specimens from Hanamiai North, to tackle head-on the 'old wood' problem, and to understand its potential influence on the original Hanamiai chronology. Three of the wood charcoal samples (θ_1, θ_2 and θ_4) consist of *Calophyllum inophyllum* (*temanu*) and *Cordia subcordata* (*tou*) (Table 2). These are native, long-lived (more than 100 years) trees with the potential for in-built age (Allen & Huebert 2014). Studies of wood charcoal assemblages from Marquesan sites on Nuku Hiva suggest that these species comprise elements of the Polynesian settlement era coastal strand vegetation (Huebert & Allen 2016). The fourth identified wood charcoal sample (θ_{67}) consists of coconut (*Cocos nucifera*). Coconut may have been present from the time of initial Polynesian colonization (Huebert & Allen 2016), and it too has the potential for in-built age (Allen & Huebert 2014).

Also important is the potential for the displacement of dating samples from their original stratigraphic contexts, as a result of natural and human activities. For example, tunnelling by crabs can cause extensive disturbance at some Marquesan coastal sites, including Teavau'ua (Allen 2004: 150, 154, 157) and Ha'atuatua (Supplement 1: 39) on Nuku Hiva, although the evidence for crab burrows at Hanamiai is minimal. Ten of the eighteen Hanamiai North age estimates date specimens collected *in situ* from burnt surfaces, hearths and earth ovens; their contexts are considered to be secure. For the isolated pieces of wood charcoal and pearl shell, the potential for stratigraphic displacement by taphonomic factors can be assessed through the fortuitous discovery of a tool made from the mandible of a medium-sized whale, likely pilot whale (*Globicephala macrorhychus*). The finished tool, which may have been used as a scraper, was discovered together with eighty-nine chipped fragments of the same material (Rolett 1998: 77). The fragments are mostly in the 1–3 cm size range and they apparently derive from manufacture of the finished tool – no other comparable bone fragments were found at Hanamiai. The finished tool was collected *in situ* at 246 cmbd in Layer H and depths for the fragments range from 210–265 cmbd (centimeters below datum) (Figure 7). The range of vertical distribution suggests that other remains of similar size, including the isolated pieces of charcoal and shell for dating the earliest Hanamiai North deposits, may have moved up to 36 cm from their original depths.

Evidence for the Hanamiai North founder settlement is from Layers G, H and GH (Rolett 1998). Together, these deposits comprise Phases I and II of the Hanamiai North cultural sequence. Their combined thickness in the areal excavation is about 50 cm. In addition to bones of a previously unknown flightless rail (*Gallirallus roletti*) (Kirchman & Steadman 2006) and other extinct birds (Rolett & Steadman 1996) (Figure 8), Layers H and GH yielded a rich array of artifacts. Stone adzes were found together with fishhooks and quantities of worked pearl shell. Figure 9 shows a view of the excavation in progress. Nine age estimates (including four new ones) date the contexts from which these artifacts and bones of the extinct birds were collected (Table 2). Overall, the Layer GH and H artifact and faunal assemblages are notably similar.

Table 2. *Radiocarbon age determinations for the Hanamiai site.*

θ[1]	Laboratory Code	Accesssion number	Material[2]	Taxon[3]	SLM or PA[4]	Excavation square	Layer	Depth[5]	Sample context[6]	^{13}C	δ18O	Conventional radiocarbon age
Original (1980s) Hanamiai North												
5	AA2,820–V3,738	–	WC	Unidentified	PA	M11	H	257	F	–25.0	–	890±80
6	AA2,819–V3,737	–	WC	Unidentified	PA	M11	H	234	BS	–25.0	–	790±80
3	Beta 15567	1985–23	WC	Unidentified	PA	I10	GH	235–240	H	–26.4	–	850±60
7	AA2,822–V3,740	–	WC	Unidentified	PA	I10	G	215–220	H	–25.0	–	870±80
65[7]	Beta 17468	–	WC	Unidentified	PA	I10	G	215–220	H	–24.8	–	1250±100
8	AA2,821–V3,739	–	WC	Unidentified	PA	K9, K10	F	179–184	EOB	–25.0	–	660±80
8	Beta 15566	–	WC	Unidentified	PA	K9, K10	F	179–184	EOB	–27.2	–	620±90
66	Beta 15565	–	WC	Unidentified	PA	K10	B	99	EOB	–26.6	–	130±100
New (2013 and later) Hanamiai North												
1	Beta 363627	1984–4	WC	*C. inophyllum*	PA	M12	H	257	F	–25.9	–	920±30
2	Beta 363628	1985–18	WC	*C. subcordata*	PA	M13	H	251	F	–25.4	–	850±30
9	Beta 436909	2134	PS	*P. margaritifera*	SLM	M12	H	250–255	F	1.2	–0.8	1040±30
4	Beta 363630	1985–30	WC	*C. inophyllum*	PA	N11	H	238	F	–27.8	–	840±30
67	Beta 363629	1985–23	WC	*Cocos nucifera*	PA	I10	GH	235–240	H	–25.9	–	750±30
10	Beta 436910	2135	PS	*P. margaritifera*	SLM	J10	GH	230–240	F	0.5	–0.5	1140±30
11	Beta 436911	2136	PS	*P. margaritifera*	SLM	K10	G	210–220	F	0.7	–1.7	1070±30
120	Beta 626055	2987	PS	*P. margaritifera*	SLM	J12	F	180–190	FS	3.1	–1.2	1050±30
122	Beta 626057	2989	PS	*P. margaritifera*	SLM	M13	D	170–175	FS	3.6	–1.2	980±30
119	Beta 626054	2986	PS	*P. margaritifera*	SLM	J12	C	145–155	FS	2.0	–1.2	710±30
121	Beta 626056	2988	PS	*P. margaritifera*	SLM	M13	C	135–140	FS	2.7	–0.9	700±30
Hanamiai South												
12	Beta 363631	2063	E	*Cocos nucifera*	SLM	E44.95 N80.50	F	297	H	–23.2	–	660±30
13	Beta 436912	2233	E	*Cocos nucifera*	SLM	E40–41 N77	F	318–330	FS	–23.1	–	740±30
14	Beta 436913	2482	E	*Cocos nucifera*	SLM	E42.0 N76.85	F	272	H	–22.7	–	770±30

1 Unknown calendar date of the dated event.
2 Abbreviations: E, endocarp; PS, pearl shell; WC, wood charcoal.
3 Abbreviations: C. inophyllum, Calophyllum inophyllum; C. subcordata, Cordia subcordata; P. margaritifera, Pinctada margaritifera.
4 Abbreviations: PA, potential in-built age; SLM, short-lived material.
5 Cm below datum.
6 Abbreviations: BS, burnt surface; EOB, earth oven bulk sample; F, fragment collected in situ; FS, fragment collected from screen; H, fragment collected from hearth.
7 Outlier identified by the Hanamiai chronology model.

Layer G revealed a well-preserved living floor associated with a massive stone pavement (Figure 4). Although the fishhooks and adzes discovered here represent Archaic forms, a sharp decline in the number and concentration of bird bones justifies the distinction of Layer G as a separate analytic unit (Hanamiai Phase II) of the founder settlement. There are three age estimates for an occupation about 15 cm below the Layer G stone pavement and its associated living floor.

Unlike Hane and Haʻatuatua, where there are gaps in the archaeological sequence after the founder settlement, the Hanamiai North sequence is fairly continuous from the founder settlement occupation until sustained contact with the Western world. Layer F, which overlays the Hanamiai founder settlement, has three age estimates. It stands out for evidence of activities involving the manufacture and reworking of adzes, but temporally-sensitive artifacts are scarce. The Hanamiai North dune area was flooded during the Layer F occupation, capping Layer F with a thin, silty deposit designated Layer E (Rolett 1998: 71, 79–81). Layer E provides an ideal stratigraphic marker extending across most of the areal excavation (Figure 4). As evidence for flooding, it is consistent with an emerging record of Pacific-wide paleotsunami events, including ones believed to have impacted the Marquesas (Allen *et al.* 2021, Goff *et al.* 2022). Together, the six age estimates for Layers C, D and F are useful for dating the possible paleotsunami event represented by Layer E. Finally, there is a single radiocarbon date for Layer B. Historic era artifacts from Layer B indicate that it was deposited during the 19th century.

Hanamiai South

The Hanamiai South founder settlement deposits were discovered 28 years after the excavations at Hanamiai North. They were excavated across 30 m^2 over three field seasons (2012, 2013, 2014) (Rolett 2021). These founder settlement deposits contain diagnostically Archaic artifacts like the

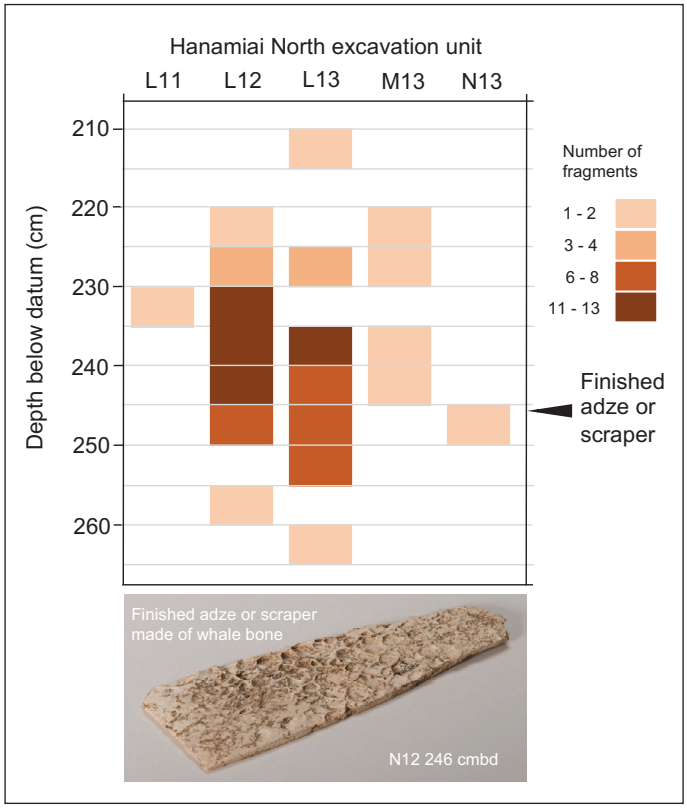


Figure 7. Distribution of whale bone fragments associated with an adze or scraper made of the same bone. Hanamiai North, lower levels of Layer H.

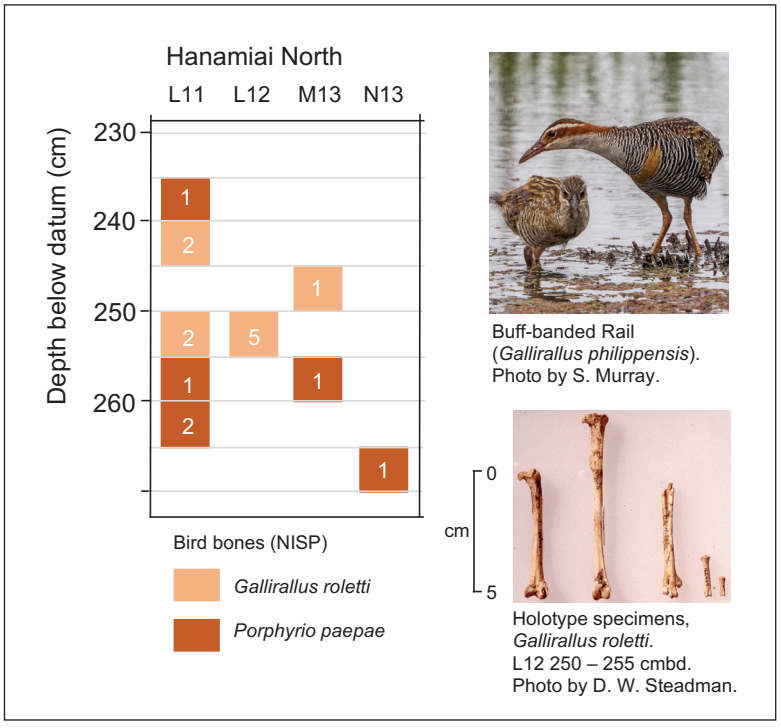
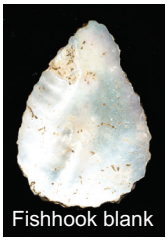


Figure 8. Distribution of bones of two species of extinct land birds (*Gallirallus roletti* and *Porphyrio paepae*) recovered from Layer H of the Hanamiai North excavation, by 5 cm levels. *Gallirallus philippensis*, upper right, is a surviving species closely related to *G. roletti.*

L13, Layer H 251 cmbd (ACC L13-9). Length is 18.3 cm.



L13, Layer H 253 cmbd (ACC L13-10). Length is 6.3 cm.

M12, Layer H 250-255 cmbd. Radiocarbon sample ACC 2134 (Beta 436909). Length is 4.6 cm.

View of the Hanamiai North founder settlement, excavation in progress in squares L11, M11 and L12. a and b, turtle bones; c, fishhook fragment; d, whale tooth; e, whale bones. Layer H 237-241 cmbd. Scale bar = 15 cm.

Figure 9. View of the Hanamiai North founder settlement deposits showing artifacts, as well as whale and turtle bones from the early occupations. Photos by B. Rolett.

ones found at Hanamiai North.

The deepest cultural deposit in the Hanamiai South stratigraphic sequence, Layer F, is a light-colored marine sand deposit dated by three samples of coconut endocarp charcoal. Layer F is around 100 cm thick and the upper levels contain comparatively little cultural material. By contrast, the lower levels yield abundant artifacts, including an adze polishing stone made from columnar basalt and a concentration of debitage associated with the manufacture of adzes. One-piece fishhooks from the lower levels consist of angular and curved shank forms like those typical of other Marquesan founder settlement sites. Two of the SLM age determinations for Layer F (θ_{12} and θ_{13}) are associated with the lower levels. Another age determination (θ_{14}) is for a hearth situated 30–50 cm above the lower levels, in a context with fewer artifacts and lower densities of bone and shell. An expanded version of the Materials and Methods section is found in Supplement 4.

Model-based chronologies

The application of Bayesian statistics offers an effective approach for building model-based chronologies. Designing good Bayesian models involves merging scientific data such as age determinations with expert knowledge relating to stratigraphy and other chronological relationships (Buck & Meson 2015). For instance, in designing the Hanamiai model, we took into consideration data that quantifies the potential displacement of dating samples from their original stratigraphic contexts. In addition, Bayesian models like those developed here should be tested and revised through experiments measuring reproducibility and sensitivity (Buck & Meson 2015). Reproducibility is the ability to achieve replicable results during multiple runs of the model. By contrast, sensitivity analysis tests the role of an independent variable to determine its contribution to uncertainty in the model. In our models, we use sensitivity analysis to quantify uncertainty associated with the application of three different values for the marine reservoir effect (ΔR). Tests we performed for reproducibility and sensitivity were achieved by running each of the site chronology models five times in OxCal (Ramsey 1995).

We compared the Hanamiai site chronology with the chronologies for seven other Marquesan sites (Table 3). As might be expected for a range of projects conducted over a span of more than 50 years, the research goals and field methods vary significantly. The number of age determinations for each site, as well as the choice of material dated, also varies widely although the most recent research emphasizes SLM dates. Basic background and contextual information for the seven sites are presented in Supplements 1, 2 and 3.

Supplement 1 also describes our modeling methods. In the case of Hanamiai, based on the demonstrated potential for residuality and intrusion (Figure 7), we decided to treat Hanamiai Phases I and II (Layers H, GH and G) as a single entity, Hanamiai I/II. This led to a model for the Hanamiai sequence that consists of Hanamiai Phase I/II (the founder settlement with Archaic artifacts), Hanamiai Phase III (Layers F and E, a transitional early/late occupa-

Table 3. *Summary excavation and contextual data for eight coastal Marquesan archaeological sites.*

Island	Tahuata	Ua Huka	Nuku Hiva				Hiva Oa	
Site	Hanamiai	Hane[3]	Ha'atuatua[4]	Teavau'ua	Ho'oumi[5]	Hakaea	East Hanaui	West Hanaui
Setting	Dune	Dune	Dune	Coastal flat	Coastal flat	Beach ridge	Rockshelter	Rockshelter
Excavation methods[1]	A, T	A, T	A, T	T, S	A, MD, T	T, S	A	A
Total area excavated	*ca.* 141 m²	*ca.* 118 m²	*ca.* 85 m²	*ca.* 18 m²	*ca.* 73 m²	*ca.* 7 m²	*ca.* 21 m²	*ca.* 20 m²
Diagnostic artifacts	Archaic, Classic	Archaic, Classic	Archaic, Classic	Classic	Archaic, Classic[6]	Archaic	Archaic, Classic	Classic
Extinct and extirpated land birds (no. of species identified)	9	11	5	NA	NA	NA	NA	NA
Radiocarbon dates								
Short-lived material (SLM)	✓	✓	✓	✓	✓	✓	none	none
Unidentified charcoal	✓	✓	✓	✓	none	none	✓	✓
References[2]	8, 11, 12, 17, 18, 20	7, 9, 15, 16, 17	13, 14, 17, 19	1, 2, 10	5, 6, 19	3, 4	16, 20	16, 20

1 A, areal excavations; MD, trenching with mechanical digger (backhoe); S, shovel pits; T, test pits.
2 References: 1) Allen 2004; 2) Allen 2014; 3) Allen and McAlister 2010; 4) Allen and McAlister 2021; 5) Allen *et al.* 2021; 6) Allen *et al.* 2022; 7) Conte and Molle 2014; 8) Kirchman and Steadman 2007; 9) Molle 2011; 10) Petchey *et al.* 2009; 11) Rolett 1998; 12) Rolett 2021; 13) Rolett and Conte 1995; 14) Rolett *et al.* 1997; 15) Sinoto 1966; 16) Sinoto 1970; 17) Steadman 2006; 18) Steadman and Rolett 1995; 19) Suggs 1961; 20) This paper.
3 First investigated during 1963–1964 fieldwork directed by Y. Sinoto. Later investigated during 2009 fieldwork directed by E. Conte and G. Molle. See Supplement 2 for details.
4 First investigated during 1956–1957 fieldwork directed by R. Suggs. Later investigated during 1992–1994 fieldwork directed by B. Rolett and E. Conte. See Supplement 2 for details.
5 First investigated during 1956–1957 fieldwork directed by R. Suggs. Later investigated during 2011 fieldwork directed by M. Allen. See Supplement 2 for details.
6 Suggs 1961 and Allen *et al.* 2021 interpret the artifact assemblages to represent both early and late stages in the Marquesan sequence. This paper interprets the artifact assemblages to represent the late (Classic) stage in the sequence. See Supplement 2 for details.

tion), Hanamiai Phase IV (Layers D and C, Classic phase occupations) and Hanamiai Phase V (Layers B and A, Historic phase occupations).

As set out in Supplement 1, our Bayesian chronological models for the seven other sites largely follow established stratigraphic sequences. Nevertheless, the Ha'atuatua model is confined to the main dune – it does not include the Area B excavations, and our Ho'oumi model is based on correlating stratigraphy across discontiguous excavation units, instead of modeling excavation units separately (Allen *et al.* 2021, 2022).

For all of the site chronologies, we conducted a series of systematic tests using the various ΔR estimates proposed for the Marquesas. The purpose of these tests was to identify outlier dates. Often it is not clear why specific dates present as outliers, but possibilities include in-built age and stratigraphic displacement of the dated sample by natural processes or human activities, as well as field and laboratory errors. We removed the outliers and calibrated each model five times to ensure replicability. We refer to the replicable calibrations as chronology solutions.

After establishing the site chronology solutions, we used the R statistical software package ArchaeoPhases (Philippe & Vibet 2019) to estimate the rate at which settlements were established during the early Polynesian colonization of the Marquesas. Finally, using the Chronomodel software (Lanos *et al.* 2015), we experimented with a model based on the site chronology solutions to estimate dates for the transition in Marquesan material culture from the Archaic to the Classic phase.

Estimating dates for the Archaic/Classic transition involved: (i) identifying temporally sensitive artifacts in the Hanamiai assemblages; (ii) using this evidence to distinguish among the Archaic, Classic and Historic phase Hanamiai assemblages; (iii) using the same criteria to identify Archaic and Classic artifact assemblages for other sites included in our study; and (iv) using age determinations for contexts associated with the selected artifact assemblages to estimate the transition. Certain sites were excluded from the Archaic/Classic transition model because the artifact assemblages have not been reported in detail or because of uncertainty in relating the site's chronological data to the artifact assemblages. The rationale for including or excluding specific sites is explained in the Supplement 2 site summaries. By way of example, we cite the case of Ho'oumi, where separate areas of the site were excavated by different teams in 1956 (Suggs 1961) and 2011 (Allen *et al.* 2021, Allen *et al.* 2022). While the 2011 research produced eighteen radiocarbon age estimates, almost no artifacts were recovered. In contrast, the 1956 fieldwork yielded large numbers of artifacts but there is only one age estimate for an excavated area of more than 70 m². Because the 1956 and 2011 excavation areas revealed different stratigraphic sequences, there is considerable uncertainty in directly relating the Ho'oumi chronological data to the artifact assemblages, even though the site chronology is significant for dating human activities. Thus, we included Ho'oumi in our tempo of settlement model but excluded it from the Archaic/Classic transition model.

RESULTS

Dating the Hanamiai sequence

Our model for the Hanamiai sequence consists of Hanamiai Phase I/II (the founder settlement with Archaic phase occupations), Hanamiai Phase III (a transitional occupation bridging the Archaic and Classic phases), Hanamiai Phase IV (a series of Classic phase occupations) and Hanamiai Phase V (the Historic phase). Significantly, the model includes three age estimates for Hanamiai Phase IV, whereas the original radiocarbon data set (Rolett 1998) contained none. The new data close a gap in the sequence – one that is critical for understanding the history of the Archaic/Classic transition. Altogether, this study adds 14 new age estimates to the Hanamiai sequence. Our Hanamiai model now covers a continuous time span from initial Polynesian colonization through the onset of European contact and the mid-19th century establishment of a French military fort (Delmas 1929: 40–45) on the ridge between Hanamiai and Vaitahu valleys.

A series of tests using different estimates for the marine reservoir effect identified two outliers in the Hanamiai model. Both outliers are age determinations for pieces of wood charcoal with apparent in-built age (Supplement 1: Table 2). Sensitivity tests indicated that the choice of ΔR has little effect on the model outcomes. Based on this finding, we applied a ΔR value of –81 ± 38, which derives from values calculated by Burr *et al.* (2009). Removing the outliers resulted in replicable calibrations, or chronology solutions, for the phase boundary estimates. Each phase has start (lower) and end (upper) boundary estimates dated by 95% credible intervals (Figure 10). The range of the start boundary for Hanamiai I/II is AD 1160–1266 and that for the end is AD 1314–1415. Hanamiai III has start and end boundary estimates of AD 1340–1440 and AD 1375–1582. Hanamiai IV has start and end boundary estimates of AD 1435–1701 and AD 1650–1880. Phase boundary estimates for Hanamiai V range from the late 18th until the mid-20th centuries.

A regional chronology for Marquesan settlement

A basic goal of our study is to clarify chronological relationships among the dated deposits of Marquesan founder settlements and other early sites. Toward this end, in establishing replicable chronology solutions for Hane, Haʻatuatua, Teavauʻua, Hakaea, Hoʻoumi, and the Hanaui rockshelters, we followed the same protocols applied to establish the Hanamiai chronology solution (see Supplement 1). In some cases, the evidence for dating these sites consists entirely of unidentified wood charcoal. In other cases, the dating evidence is entirely from short-lived material, or a mix of unidentified wood charcoal and short-lived material (Table 3). Given that certain studies (*e.g.* Wilmshurst *et al.* 2011) categorically reject age estimates deriving from unidentified wood charcoal, it is significant that our results show it is possible to integrate many of these dates into Bayesian-derived chronology solutions.

Age range estimates for the basal deposits of the six best-documented early sites are shown in Table 4 and Figure 11. The early Hane and Haʻatuatua settlements yielded phase boundary start ranges that precede the Hanamiai I/II start range of AD 1160–1266. However, as the Hane and Haʻatuatua end range estimates extend to the late 14th century and beyond, there is considerable overlap among the three chronologies. With regard to Hane, the phase boundary start range for the lower deposits is greatly influenced by age determinations on tentatively identified palm stele material and unidentified wood charcoal.

There are also varying degrees of overlap among the chronologies of Hanamiai I/II, Hakaea VII, Teavauʻua IV and Hoʻoumi A/B, producing what on the surface appears

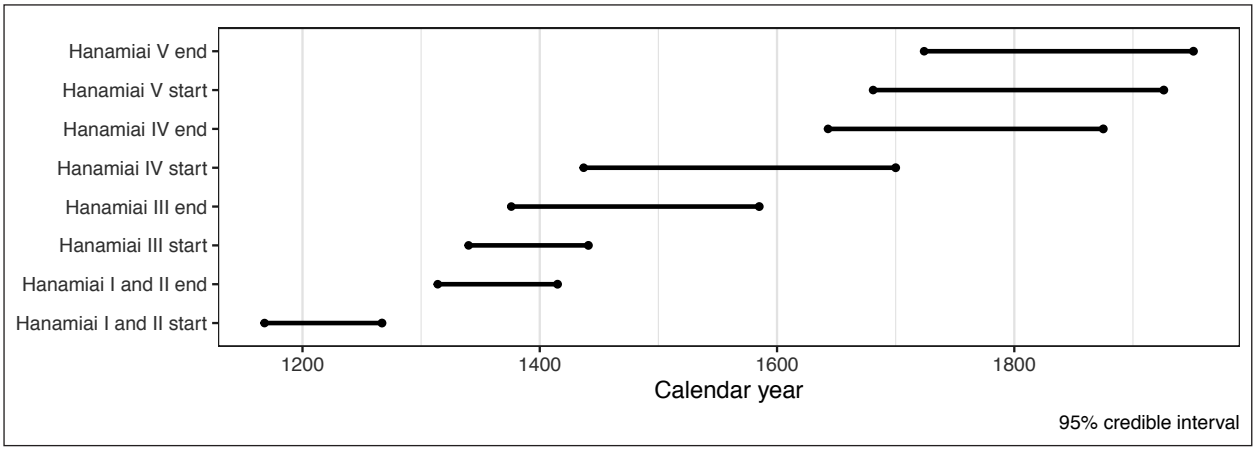


Figure 10. Phase boundary estimates for the Hanamiai chronology solution. Each phase has start and end boundary estimates dated by 95% credible intervals. The transition from the Archaic to the Classic phase occurred around AD 1371–1474. The Historic phase Hanamiai V deposits, for which there is a single radiocarbon age determination, are dated to the 19th century by numerous Euro-American artifacts.

Table 4. *Age estimates for the earliest cultural contexts of six Marquesan archaeological sites.*

		Phase boundary			
		Start	Start	End	End
Island	**Site context**[1]	range[2]	median	range[2]	median
Tahuata	Hanamiai I/II	1160–1266	1222	1314–1415	1368
Ua Huka	Hane Lower	931–1114	995	1311–1384	1349
Nuku Hiva	Hakaea VII	1174–1304	1273	1277–1372	1297
Nuku Hiva	Teavau'ua IV	1189–1377	1259	1291–1448	1376
Nuku Hiva	Ho'oumi A/B	1022–1173	1131	1359–1552	1452
Nuku Hiva	Ha'atuatua C	1032–1203	1127	1336–1439	1400

1. See Supplement 1 for the stratigraphic interpretations and models upon which these results are based. In some cases (e.g. Ho'oumi A/B) the models presented in this study differ from those used in previously published work. The rationale for the approach employed here is explained in Supplement 1.
2. 95% credible interval, calendar years AD.

to be a rather muddled set of chronological relationships. Allen algebra (Allen 1983) offers a quantitative approach for creating order among these relationships. As applied here, each stratigraphically defined zone or phase represents an indefinite interval. We use terms defined by the Allen algebra to compare the Hanamiai I/II time interval with the intervals of other early Marquesan sites such as Hane (Supplement 1: Figure 13).

Based on our model and the available data, the results indicate that cultural deposits at four sites (Hane, Ha'atuatua, East Hanaui and Ho'oumi) likely pre-date Hanamiai I/II, although the early deposits of these sites fall into the same general time period. The main obstacle in refining this conclusion is the lack of age estimates for pre-human deposits that might constrain the early boundaries for the initial deposits at these sites. Specifically, the model shows: Hanamiai I/II was overlapped by or deposited during Hane Lower (0.69 and 0.31 posterior probability, resp.) and Ha'atuatua C (0.22 and 0.76 posterior probability, resp.); Hanamiai I/II was deposited during East Hanaui VI and Ho'oumi A/B (0.96–0.97) posterior probability).

Our results also show that Hanamiai I/II likely predates cultural deposition at Hakaea, Teavau'ua and West Hanaui. Hanamiai I/II contains Hakaea VII (0.90 posterior probability), and it either contains or overlaps Teavau'ua IV (0.40 and 0.33 posterior probability, resp.). Finally, Hanamiai I/II likely precedes West Hanaui (0.54 posterior probability), although the limited information from that site also makes other relations possible.

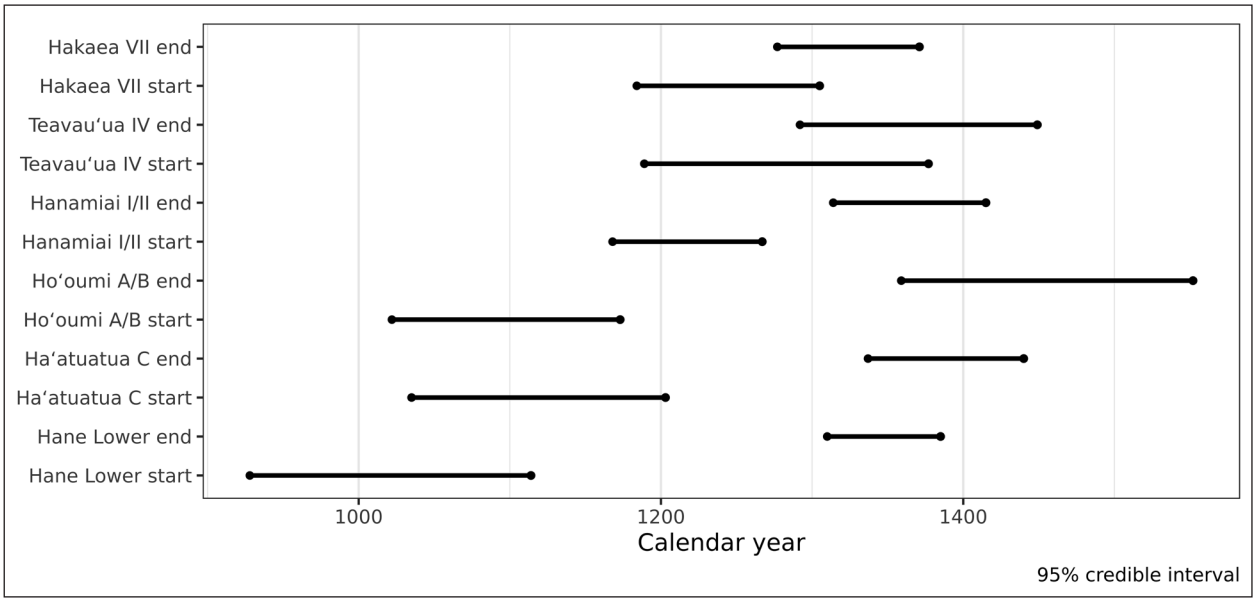


Figure 11. Age range estimates for basal deposits of the six best-documented early Marquesan archaeological sites. Each phase has start and end boundary estimates dated by 95% credible intervals. All six sites were established during the Archaic phase.

Dating the transition from the Archaic to the Classic phase

In an initial step to understand when a distinctively Marquesan material culture developed, we experimented with a chronological model to estimate the timing of the Archaic/Classic transition. We approach this problem at the level of the assemblage, rather than by attempting to trace the history of particular artifact classes. Our goal is to identify a point in time for the transition, while acknowledging that the model is not designed to describe a detailed process of change. Our model for the Archaic/Classic transition is based on the recorded presence, absence and relative abundance of chronologically diagnostic artifacts discovered at Hanamiai and other sites (Table 5, see also Supplement 1). It estimates a date for the transition that meets the following conditions: a) younger than Hanamiai III; b) older than Hanamiai IV; c) younger than Hanaui East VI; d) older than Hanaui East II; e) older than Hanaui West; f) younger than Hane Lower; g) older than Hane Upper; h) younger than Haʻatuatua B; i) younger than Hakaea V; and j) older than Hakaea III. Using these criteria, our model estimates that the Archaic/Classic transition occurred around AD 1386–1474. Because the Hanamiai III material culture appears transitional based on current observations, we also tested an alternate version of the model in which Hanamiai III is identified as Classic rather than Archaic. This changes the resulting age range by less than two decades, a comparatively insignificant length of time. Future research should make it possible to refine this estimate.

DISCUSSION

The revised Hanamiai chronology indicates that the site was settled between AD 1160–1266. The initial occupation is identified as a founder settlement, defined as the first human settlement of a previously uninhabited environment. Settlement, as used here, is meant to imply established human populations rather than ephemeral human activities (*e.g.* short term visits) that may have preceded them. In the Marquesan context, ephemeral human activities might be manifested in the archaeological record by scattered charcoal and low densities of faunal remains, with few associated artifacts or features such as combustion structures.

Based on these criteria, a founder settlement site could be associated with either the *colonization* or the *establishment* stages defined by Graves and Addison (1995), where colonization refers to the first arrival of humans and establishment refers to settlements with a reproductively viable population. Human activities identified by an environmental signature alone, or sites without diagnostically early artifacts, do not fit the criteria we propose. However, our comparative analysis includes chronological data from a number of such sites that are important in providing evidence for early human activities. Further investigation of sites such as Teavauʻua and Hakaea, for which the faunal data and artifact assemblages are currently limited, may identify additional founder settlements.

Using the same criteria, two other early Marquesan sites, Hane and Haʻatuatua, can also be identified as founder settlements. At Hanamiai, as well as Hane and

Table 5. *Presence, absence and relative abundance of chronologically diagnostic artifacts for Hanamiai and other Marquesan sites.*[1]

	Hanamiai[2]			Hane		Haʻatuatua	Hakaea	E. Hanaui		W. Hanaui
Context:	**I/II**	**III**	**IV**	**Lower**	**Upper**	**B[3]**	**VII, V**	**VI**	**II**	
Artifacts	**Archaic**	**Transitional**	**Classic**	**Archaic**	**Classic**	**Archaic**	**Archaic**	**Archaic**	**Classic**	**Classic**
One-piece fishhooks										
Curved, angular shank	++[4]	++	+	++	–	++	+	++	–	–
Straight shank	+	+	++	+	+	+	–	+	+	+
Trolling lure points										
'West Polynesian'	+	–	–	+	–	+	–	–	–	–
'East Polynesian'	–	–	+	–	–	–	–	–	–	–
Adzes										
Untanged[5]	+	–	–	++	–	++	–	–	–	–
Tanged	–	–	+	+	+	+	–	–	–	–
Breadfruit culture artifacts										
Cowrie-shell peelers	–	–	+	–	–	–	–	–	–	–
Poi pounders	–	–	–	–	+	–	–	–	–	–

1 This table records artifact assemblages selected for the Archaic/Classic transition model. Criteria for the selection of these assemblages are given in Supplement 2.
2 Sources: Hanamiai (Rolett 1998, Rolett 2021, this paper); Hane (Sinoto 1979); Haʻatuatua (Suggs 1961, Rolett and Conte 1995); Hakaea (Allen and McAlister 2010, Allen and McAlister 2021); East and West Hanaui (Supplement 2).
3 Haʻatuatua Layer C, stratigraphically below B, contains curved and angular shank one-piece fishhooks but none of the other artifact forms yielded by Layer B.
4 –, absent; +, present; ++, dominant (most common).
5 Untanged adzes include those with a slight reduction of the butt by pecking. See TH1-L13-9 from Hanamiai North (Rolett 1998:183 and Figs. 8.1, 8.2) for an example.

Haʻatuatua, faunal remains of extinct species are found associated with diagnostically Archaic artifacts. Among the three sites, however, only Hanamiai offers a continuous sequence of occupations extending from initial Polynesian colonization through the transition from the Archaic to the Classic phase and into the period of Western contact. It is also notable that the Hanamiai North sequence shows sedimentological evidence for a minor flood event (Rolett 1998: 79–81). Associated with the end of Hanamiai Phase III, our model estimates this inundation occurred around AD 1375–1582, with a median date of AD 1449.

The Marquesas are exposed to tsunamis and geological evidence points to the widespread impact of an especially large Pacific-wide paleotsunami generated near the Tonga Trench dated to around the 15th century (Goff *et al.* 2020, 2022). The timing for this event matches our estimate for the flooding of Hanamiai, and it also fits with the age range of AD 1422–1697 estimated by our Hoʻoumi model for a major coastal inundation documented by Allen *et al.* (2021).

Current data suggests that Hane, a pillar in the Marquesan archaeological sequence, was settled at least 50 years, and up to 200 years, before Hanamiai. Hane also stands apart from the other early sites – age estimates for Teavauʻua, Hakaea and Hoʻoumi are in the same general range as those for Hanamiai and Haʻatuatua. Our model shows that the start boundary for the Hane founder settlement (Hane Lower) is influenced by the age estimates on tentatively identified palm stele, for which the possibility of in-built age cannot be eliminated. These results lend support to the view, expressed earlier by Anderson and colleagues (2019: 11–12), that further analysis of SLM specimens could be valuable in resolving uncertainty surrounding the Hane chronology. This is especially the case because the lack of dates on pre-human deposits makes estimates for the Hane founder settlement sensitive to the effects of in-built age. Moreover, further research at sites such as Teavauʻua and Hakaea, which have early dates and small numbers of artifacts, but currently lack evidence of extinct fauna, may increase the number of known founder settlements for the Marquesas.

Polynesian colonization of the Marquesas

Environmental factors

Two of the three confirmed founder settlements (Hanamiai and Hane) are coastal sites located in sheltered leeward valleys. This finding likely reflects basic contrasts between leeward and windward Marquesan coastlines, where the absence of barrier reefs leaves windward Marquesan coasts exposed to rough seas. These conditions make windward coasts generally less suitable for fishing. It is also more difficult to launch and land canoes on windward coasts than in leeward settings. On the other hand, windward valleys receive greater rainfall, offering better conditions for plant growth. This is because when moist air from the trade winds is forced upwards while crossing an island's' central chain of mountains, orographic rain generated at high elevations descends the valleys in streams. Hanamiai, which joins Vaitahu to form a large amphitheater backed by mountains, is somewhat unusual. Orographic rain generated by Tahuata's central mountain chain falls mainly in windward valleys but the trade winds also carry much of it into Vaitahu and Hanamiai (Rolett 1998: 27). Thus, the upper reaches of these valleys are fairly well-watered, while the lower reaches face a sheltered bay ideal for fishing and a coast well suited for the everyday use of canoes. The Vaieʻe artesian spring, situated on the shoreline and easily accessible by land and sea, is an added benefit. Hence, we suggest that Vaitahu and Hanamiai were among the best settlement locations for Polynesian discoverers of the Marquesas.

The tempo of settlement

The tempo, or rate at which settlement occurred, is also significant for understanding Polynesian colonization of the Marquesas. Tempo may be influenced by factors including the initial size of the founder population, demography, seafaring ability and voyaging technology. We investigate tempo using site establishment data for the six best-documented early sites. Instead of asking if Hanamiai was settled before or after some other specific site, our tempo model estimates the rate at which site establishment progressed from the first to the sixth settlement, without regard to which specific site is ranked first, second, third and so on in the sequence. Given the model and data, the Marquesas were first settled in AD 931–1102, with a median date of AD 994 (Figure 12). The imprecision of this estimate derives mainly from a lack of pre-settlement dates to constrain the lower boundary, and the relatively few SLM dates from early contexts. Age ranges for the second and third site establishment occurrences reach from the 11th to the 12th century AD, while the sixth settlement in the sequence was established no later than the end of the 14th century AD. Our estimate for the first settlement is older than the 13th century dates proposed by Wilmshurst *et al.* (2011) in their support for the short chronology of East Polynesia. It is also older than the estimates of AD 1140 and 1330 computed by a recent genome-based analysis for dating the initial peopling of the Marquesas (Ioannidis *et al.* 2021).

Before the advent of SLM dating in Marquesan archaeology, Rolett (1998: 251) hypothesized a process of range expansion during which permanent settlement of the major islands occurred over a period of 500 years, or longer. That model is not supported by the data presented here. Instead, our results are more consistent with the notion of one early settlement followed by a lag, then rapid expansion over a period of decades. This particular model – initial discovery followed by a lag prior to rapid expansion – depends largely on the Hane chronology, for which the tentatively identified palm stele age estimates play an important role. With the current data, however, we cannot

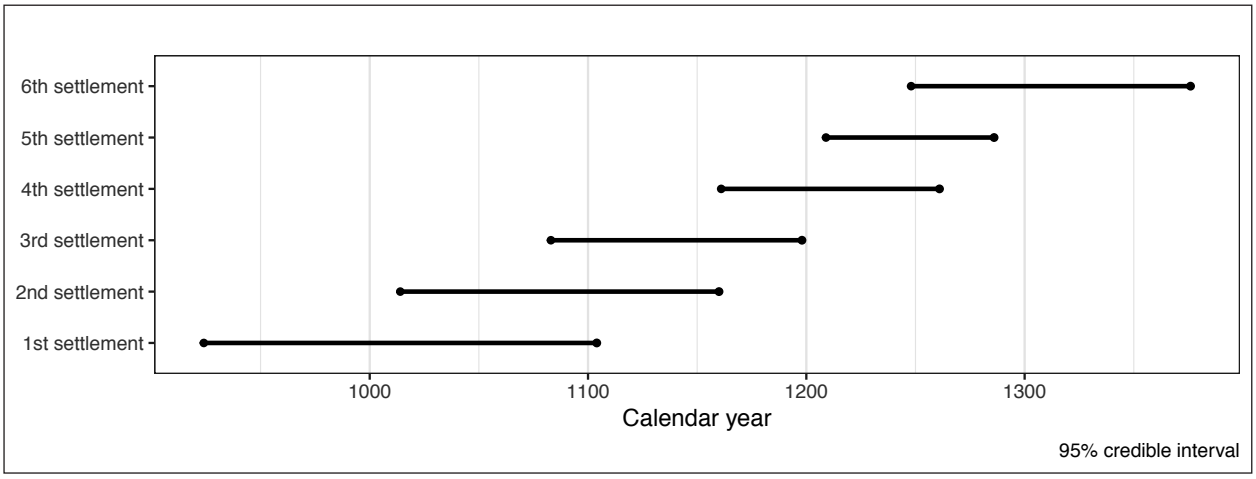


Figure 12. Estimates for the tempo of Marquesan settlement history based on chronologies for the six best-documented early sites. All six sites were established during the Archaic phase.

rule out the hypothesis that exploration and settlement of the Marquesas occurred during a single, rapid and continuous event beginning in the 12th or 13th century. This latter scenario implies sizable founder populations and high mobility, conditions that fit well with those proposed by Walter and colleagues (2017) in explaining the initial Polynesian settlement of New Zealand.

Further analysis of SLM specimens from across the Marquesas, including lower deposits of the well-controlled Hane excavation reported by Conte and Molle (2014), is needed to refine chronological models and to dispel what has been described as 'continually debilitating uncertainty about the quality of the evidence' (Anderson *et al.* 2019:12). Such analyses would help determine whether there was indeed a lag of up to 200 years between the colonization of Hane and other early sites or if the archipelago-wide colonization process may have been the result of a more rapid event.

The Archaic/Classic transition

The transition from the Archaic to the Classic phase, as reflected in Marquesan material culture, remains a largely unwritten chapter in the history of Te Fenua Enata. This gap is due, in part, to a concerted focus on understanding the earliest stages of the cultural sequence. As a result, archaeological research has emphasized dating early events and explaining the dynamics of human colonization. Our study highlights this trend in the context of Hanamiai, where 14 of the 22 age determinations are for the early deposits. Another problem, put simply, is that we cannot date what we cannot see. Detecting the Archaic/Classic transition can only be achieved through investigations of material culture based on rich and diverse artifact assemblages. Currently, the number of such artifact assemblages is limited (Table 5) and investigation of the Classic phase is constrained by the focus on early stages in the sequence. With these limitations in mind, our model estimates that the Archaic/Classic transition occurred around 1386–1474 or 1369–1449, depending on whether Hanamiai III is identified as Archaic or Classic. This is 300 to 400 years after the initial settlement of the Marquesas and 100 to 300 years after establishment of the settlement at Hanamiai based on current data and the models we have constructed.

It is not clear how the Archaic/Classic transition may be related to other significant transitions in the Marquesan sequence, such as changes in interisland voyaging spheres, evolution of the role of hereditary chiefs, and the shift to a breadfruit-dependent subsistence economy. Nevertheless, efforts to establish the chronology of the Archaic/Classic transition are an important step toward addressing these broader problems.

Old wood and in-built age

We return now to the 'old wood' problem and its potential influence on the original Hanamiai founder settlement chronology. Charcoal assemblages from early sites are likely to contain wood from forests dominated by older, native trees (Allen & Huebert 2014). Thus, we would expect that fuel wood burned at the Hanamiai founder settlement consists mainly of native tree species, rather than the Polynesian-introduced species that later dominated Marquesan managed forest ecosystems. Fuel wood from the earliest time periods likely included material from long-lived trees, as well as down wood with the potential for in-built age. It is also expected that age estimates based on SLM samples may appear systematically younger than dates on wood from long-lived trees, and that the offset is related to in-built age (*e.g.* Allen and Wallace 2007:1169). Our results are consistent with these expectations.

We identified and dated four samples of wood char-

coal from founder settlement occupations of the Hanamiai North sequence. These samples were collected from the same levels and close to bones of extinct land birds, as well as diagnostically Archaic artifacts. Three of the samples (θ_1, θ_2 and θ_4) were identified as native, long-lived trees (*Calophyllum inophyllum* and *Cordia subcordata*) (Table 2). Our model identified one of these samples (θ_1) as an outlier exhibiting in-built age.

In sum, our findings support concerns that age estimates for unidentified wood charcoal from early Marquesan settlements should be interpreted in light of the potential for in-built age (*e.g.* Spriggs and Anderson 1993; Allen & Wallace 2007; Allen & Huebert 2014). These concerns notwithstanding, our study presents a robust approach for designing Bayesian models with replicable results that integrate high-precision SLM dates with dates on other materials, including estimates based on unidentified wood charcoal. Our study demonstrates that while SLM dates remain the gold standard for chronology building, approaches eschewing the consideration of legacy dates exclude potentially useful data.

Acknowledgements

Fieldwork at the Hanamiai site was conducted with the authorisation of the Minister of Culture, Environment and Marine Resources of French Polynesia. The past and current Mayors of Tahuata (Tehaumate 'Tetahi' Tetahiotupa and Felix Barsinas) also authorized the research. We thank the community of Tahuata for their long-term support of the Hanamiai project. Artifacts from the excavations are housed and exhibited on Tahuata in the Te Ana Peua Museum. Excavations at Hanamiai North were funded by the National Science Foundation; those at Hanamiai South were funded by the Andover Foundation for Archaeological Research (AFAR). The 14 new radiocarbon dates reported here were funded by AFAR and the Department of Anthropology, University of Hawai'i, Mānoa. The paper benefited from discussions with Melinda Allen and comments by two anonymous reviewers.

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GUIDE TO SUPPLEMENTARY INFORMATION

Supplement 1: A Model-Based Summary of Marquesan Archaeological Age Determinations

File name: Supplement 1

ScholarSpace DOI: https://hdl.handle.net/10125/107693
Supplement 1 presents the results of Bayesian calibrations designed to investigate the archaeological chronology of the Marquesas Islands in East Polynesia. Bayesian calibrations carried out with OxCal software (Ramsey 1995) estimate chronologies for eight Marquesan archaeological sites: Hanamiai, Hane, Haʻatuatua, Hakaea, Teavauʻua, Hoʻoumi, East Hanaui, West Hanaui. Bayesian calibrations carried out with Chronomodel software (Lanos et al. 2015) estimate chronologies for temporally sensitive artifact types including one-piece fishhooks and adzes. The results provide the basis for a culture history that estimates: (i) the date the Marquesas were settled by Polynesians; (ii) the tempo of settlement establishment throughout the Marquesas; (iii) chronologies for excavated stratigraphic units at eight Marquesan sites; and (iv) the timing of cultural changes leading to the Classic Marquesan society described by Western explorers.

Supplement 2: Background data for the Hane, Haʻatuatua, Hoʻoumi, Teavauʻua, Hakaea, Hanaui East and Hanaui West archaeological sites, Marquesas Islands (East Polynesia)

File name: Supplement 2

ScholarSpace DOI: https://hdl.handle.net/10125/107693
Supplement 2 provides background data for the Hane, Haʻatuatua, Hoʻoumi, Teavauʻua, Hakaea, Hanaui East and Hanaui West archaeological sites in the Marquesas Islands of East Polynesia. Information provided here explains why these particular sites were selected for the models presented in Supplement 1. For each site, the background data includes environmental context, a brief history of the excavations, a description of the stratigraphic sequence, and information about the artifact assemblages.

Supplement 3: Radiocarbon dates for grid units E391-392 N402-403 of the Haʻatuatua archaeological site, Marquesas Islands (East Polynesia)

File name: Supplement 3

ScholarSpace DOI: https://hdl.handle.net/10125/107693
Supplement 3 presents the stratigraphic context and background information for three previously unpublished radiocarbon dates from the 1994 excavations at the Haʻatuatua archaeological site in the Marquesas Islands of East Polynesia. Of particular interest is a date on bones from the skeleton of a wedge-tailed shearwater (Puffinus pacificus) that died in its burrow before Polynesian colonization of the Haʻatuatua Dune or during the first few decades of settlement. This date helps to constrain age estimates for initial Polynesian settlement of the Haʻatuatua Dune.

Supplement 4: Expanded materials and methods section for 'Polynesian settlement of the Marquesas Islands: The chronology of Hanamiai in comparative context.'

File name: Supplement 4

ScholarSpace DOI: https://hdl.handle.net/10125/107693
Supplement 4 is an expanded version of the materials and methods section (Section 2) found in the main text for "Polynesian settlement of the Marquesas Islands: The chronology of Hanamiai in comparative context." The additional information presented here consists mainly of details describing the stratigraphic and cultural context of radiocarbon samples from Hanamiai North and South.