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– ARTICLE –

Late Pre-Contact Construction and Use of an ‘Archaic’ Shrine at the Pālehua Complex (Honouliuli District, O‘ahu Island, Hawai‘i)

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ABSTRACT

The Pālehua enclosure in upland Honouliuli (O‘ahu Island, Hawai‘i) is a celestially-significant ritual structure believed to be associated with the annual Makahiki harvest period. Near the enclosure is an alignment of basalt uprights typical of simple Central East Polynesian marae (temples), and early ‘shrine’ sites found in other geographically isolated regions of the Hawaiian archipelago. Here, we report on the first excavation of this shrine along with continued excavations at the Pālehua enclosure, with 14 new AMS radiocarbon dates from the shrine and the enclosure and six dates from previous excavations. Bayesian radiocarbon models with high agreement indices suggest construction of the Pālehua enclosure likely pre-dated construction of the shrine. Construction dates for the shrine site (mid-17th century to 19th century) are significantly later than those for similar structures elsewhere in the archipelago. This suggests that, rather than being replaced later in time by more elaborate forms, simple ‘marae-like’ shrines persisted alongside the development of monumental ceremonial architecture. These results carry implications not only for pre-contact activity at Pālehua, but also for chronologies of ceremonial architecture and religious practices across the Hawaiian archipelago.

Keywords: Radiocarbon dating; Hawaiian religion; monumental architecture; Hawaiian archaeology; marae

INTRODUCTION

The stone foundations of Hawaiian ceremonial architecture have long fascinated Pacific archaeologists, with their promise of insight into pre-contact Hawaiian archaic states with what we now know are centuries-old connections to other Polynesian islands (Hommon 2013; Kirch 2010). Prior to the advent of radiocarbon dating, archaeologists relied on formal comparisons in monumental architecture to develop relative chronologies of Hawaiian sociopolitical development and ritual practices (e.g., Stokes 1991; see Dye 1989 for a brief history). Of particular interest were the simple platforms with alignments of stone uprights first recorded by Emory (1928) on Nihoa and Mokumanamana (also known as Necker) Islands in the northwestern Hawaiian Islands, which closely resemble simple marae structures in the Society and Tuamotu Islands. These structures, also termed ‘shrines’ or ‘kuahu’ (Hiroa 1957: 527–8), consist of an altar that is often no more than an alignment of stone uprights, without the enclosed court typical of most Hawaiian heiau (temple) architecture. Observing that these structures shared more in common with Central East Polynesian temple sites than their Hawaiian counterparts, Emory went so far as to apply the East Polynesian term, ‘marae,’ to describe them rather than the Hawai‘i-specific term, heiau. Emory notes:

> The Necker maraes, with their continuous row of uprights along the back of the platform, are most like the maraes of the more isolated eastern end of the vast Tuamotu Archipelago. Although Necker was unknown to the historic Hawaiians, its ancient visitors certainly came from the main Hawaiian group, as the squid-lure sinkers and adzes found on the island are Hawaiian. Crude

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> replicas of the Necker maraes were discovered by the writer in 1937 at the quarries of the adze-makers on the 12,500 foot contour of Mauna Kea, the highest mountain on the island of Hawaii. At Puu o Umi on the slopes of neighboring Mauna Loa, a low, narrow platform, bearing uprights similar to the Necker marae, has been photographed. (See pl. V, fig. 1) But the Necker type of marae has been all but obliterated in Hawaii (Emory 1943: 13).

Emory's observations generated an enduring idea that these shrine sites represented an ancestral or archaic form of temple architecture brought to Hawai'i by early Polynesian voyagers.

These simple shrines were likely to have been built and used by individuals or families rather than for large-scale community celebrations such as the classic Makahiki sequence of ritual events that extend over a period of four lunar months (Hiroa 1957: 527–8; Valeri 1985). Emory (1943) further theorized that these purportedly archaic forms had previously existed in larger numbers, but were replaced in later time periods by more complex, walled and platform heiau forms. He and others tied this replacement to the arrival of Pā'ao, a Tahitian priest recorded in Hawaiian oral traditions (Emory 1928; Hiroa 1957; Stokes 1991). Pā'ao is said to have arrived in Hawai'i during the so-called 'voyaging period,' introducing significant transformations to Hawaiian sociopolitical and religious practices. This included human sacrifice and, with it, the walled heiau. That some of these shrines escaped destruction and replacement is argued to be a product of their location: today most are found in geographically isolated or marginal environments, including the islands of Nihoa and Mokumanamana (Emory 1928; Kikiloi 2012) and on Mauna Kea (McCoy & Nees 2014).

Advances in radiocarbon dating (especially the application of AMS dating), combined with methodological developments such as Uranium-series dating and Bayesian modeling, have generated increasingly precise chronologies for the construction and use of monumental architecture across the Hawaiian archipelago (Dye 2012, 2016; Kirch *et al.* 2015; Kirch and Ruggles 2019) as well as elsewhere in the Pacific (e.g., Kahn & Kirch 2011; Sharp *et al.* 2010). These methods have opened new windows for the archaeological study of Hawaiian ritual and religion that were previously thought to be outside the purview of archaeological investigation (see Hawkes 1954 and discussion in Flexner & McCoy 2016), including the Makahiki season (McCoy 2018) and its role in the development of the Hawaiian archaic states (Kirch 2010).

Uranium-series dating of coral artifacts provides even more precise results than AMS dating for ceremonial features, assuming these materials can be confidently tied to site construction and/or use. McCoy *et al.* (2009) applied U-series dating to a piece of branch coral found between two stone uprights and presumed to be a dedicatory offering at one such simple shrine at about 3700 m elevation on Mauna Kea. Their sample returned a date of AD 1441 ± 3 years. Kikiloi (2012) likewise used U-series dating on coral offerings to develop chronologies for simple shrine structures on the islands of Lehua, Nihoa, and Mokumanamana. Coral samples from two simple shrines on Lehua returned dates of AD 1470 ± 7 y and AD 1478 ± 6 y. A series of 36 dates from ceremonial architecture on Nihoa Island, from interior construction and surface contexts of both simple shrine sites and larger temples, provide a chronology of ritual architecture spanning from AD 1496 ± 6 y to AD 1606 ± 7 y. On Mokumanamana, two coral samples from a single ritual site yielded one date of AD 1420 ± 5 y, and one more problematic date of AD 677 ± 15 y. Kikiloi (2012) suggests that this early date may have come from a piece of 'heirloom' coral brought to Mokumanamana by voyagers from elsewhere in Polynesia. Taken together, these U-series dates suggest a consistent period of simple shrine construction in the 15th century, with probable continued use into the 1600s.

The Pālehua ceremonial complex in the upland Honouliuli District of O'ahu Island, Hawai'i (Fig. 1) contains an alignment of six upright stones (five still standing and one that has fallen) that we designated the 'shrine site,' (Fig. 2) following descriptions of similar architectural features by Emory (1928) and Hiroa (1957), as detailed above. The formal affinity shared by the Pālehua shrine and the simple shrines found on Mauna Kea and the northwestern Hawaiian Islands suggested that it too might be associated with an earlier period in Hawaiian pre-contact history. Within the Pālehua complex, the shrine is situated approximately 25 m northwest of a large, rectangular walled enclosure that was previously mapped and excavated in 2012 (Gill *et al.* 2015). Six AMS radiocarbon dates derived from plant charcoal and modeled using a Bayesian approach indicated that the enclosure was built no earlier than AD 1500, and no later than AD 1804, with a likely period of intensive site use in the mid-17th century. The alignment of the enclosure, along with its large and relatively simple walled architecture, led Gill *et al.* (2015) to hypothesize that it was used as an assembly area during annual Makahiki ('first fruits') ritual seasons. Astronomical reconstructions indicate that the enclosure aligns with the achronical rising of the Pleiades star cluster (called Makali'i in Hawaiian) as well as with the summer solstice sunrise at *c.* AD 1600 (Gill *et al.* 2015). Because the achronical rising of Pleiades is ethnohistorically well-attested as the major astronomical event that signaled the onset of the Makahiki season (Valeri 1985), it is most likely this phenomenon that determined the orientation of the enclosure. Solstice events are not noted in the Hawaiian ethnohistorical literature as having been of any significance (but see Kirch 2004, Kirch and Ruggles 2019 for evidence that solstice observation may have been important on Maui Island).

Here, we report on continued excavation at the Pālehua ceremonial complex, which includes new sampling from

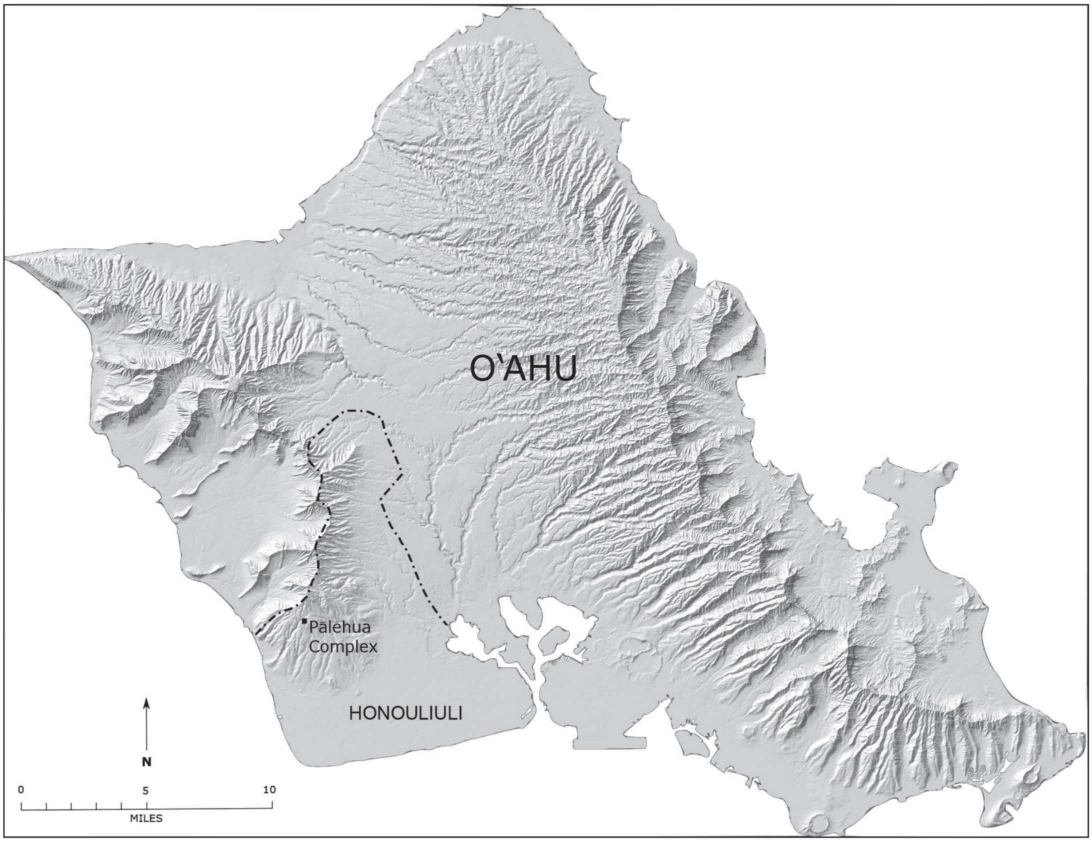

Figure 1. Map of O'ahu Island with the location of the Pālehua Complex labeled.

Figure 2. The shrine site prior to excavation with photo scale indicating grid north. Photograph by PVK.

the enclosure site combined with new excavation and dating of the adjacent shrine. We resumed investigations in order to collect suitable materials for AMS dating from both the shrine and the enclosure, in particular to develop a Bayesian chronological model for the construction and use of these features. We were especially interested in dating the construction of the possibly archaic Pālehua shrine, and to determine whether it pre-dated or was contemporaneous with the larger enclosure.

EXCAVATION OF THE PĀLEHUA COMPLEX

The primary focus of our 2018 excavations was the shrine, an alignment of five (possibly six) upright stones *c.* 25 m northwest of the main enclosure. As in the previous field season (Gill *et al.* 2015), our excavations were carried out in consultation with the local Hawaiian community and included the participation of Hawaiian cultural practitioners. Gill and colleagues focused exclusively on the enclosure site in their previous season, as they were concerned about subsurface testing in the shrine site due to its potential religious significance. However, when the team returned for renewed fieldwork in 2018, we were encouraged to excavate at the shrine after Kānaka Maoli (Native Hawaiian) community members expressed interest in ascertaining a chronology for the construction and use of this structure. To achieve this goal while keeping invasive excavation to a minimum, we limited our excavations to a small, 0.5 × 0.5 m test excavation (designated Unit A). This unit was laid out against the west face of two of the standing uprights with the goal of obtaining suitable dating material in good stratigraphic context. At the same time we opened a 1 × 1 m unit situated against the east wall of the main enclosure (designated Unit 50); this was the only wall of the four-sided enclosure that had not been tested in previous excavations (Fig. 3). We also excavated two 1 × 1 m test pits abutting a very rough alignment of boulders to the south of the enclosure (Units 101 and 102), but these excavations failed to yield any cultural materials and are not further described here.

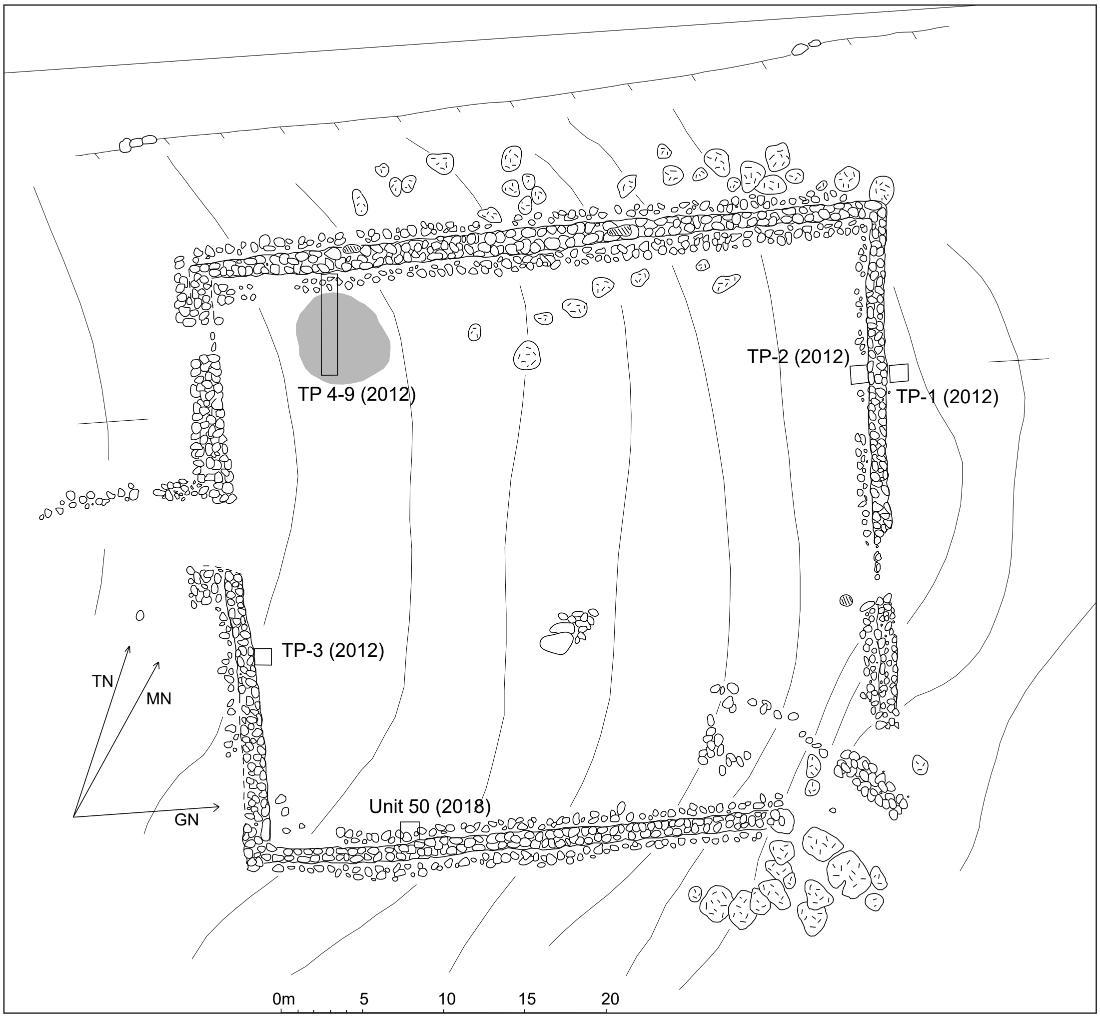

Figure 3. Plan map of the Pālehua enclosure showing grid north (GN) and relationship to true (TN) and magnetic north (MN), and locations of test units from 2012 and 2018 excavations.

Because the enclosure is aligned with a significant celestial marker and not on cardinal directions, for the purpose of our excavations we established a 'grid north,' which corresponds to the enclosure wall inland and upslope (mauka). All directions mentioned here are in reference to this grid north. We excavated all units by natural stratigraphy (layers), but used 5 cm arbitrary levels to further subdivide layers for precise vertical control. Excavated sediment was dry-screened through nested ¼" and ⅛" mesh. Significant finds included post-contact artifacts and charcoal scatters, which were point-plotted from the southwest corner of each unit whenever possible.

The Pālehua Shrine (Unit A)

The Pālehua shrine consists of an alignment of five standing upright basalt boulders on a small promontory created by natural boulder outcrops; a sixth basalt boulder of the same dimensions as the others lies on its side on the north end of the alignment, and seems to have been included in the original alignment but since toppled over. In front of these stones on the southeast side is a cleared, level area. We placed a 0.5 × 0.5 m test unit (Unit A) on the western side of this alignment, abutting two of the still-standing uprights (Fig. 4).

Unit A stratigraphy consisted of three layers. Layer I consisted of 2–3 cm of aeolian-deposited silt mixed with grassy vegetation and root mat. Layer II (~5–10 cm) was more compact with a higher clay content and less organic matter; the color of Layer II was 'very dark brown' (Munsell 7.5 YR 2.5/3). Layer II contained considerable charcoal, particularly in the eastern half of the unit near the stone uprights, where charcoal was concentrated in scattered pockets. While excavating Layer II, we removed a large root from underneath the more northerly stone. After clearing the disturbed sediment, we then excavated the remaining sediment adhering to the upright to reveal the rock face. During this latter process, we found and collected a concentration of *in situ* charcoal at the base of, and adhering to, the upright. We designated this charcoal concentration Feature 1 (Fig. 5). As we approached the base of Layer II, charcoal was no longer concentrated in small zones near

Figure 4. Plan map of the Pālehua shrine showing grid north (GN) and relationship to true (TN) and magnetic north (MN), and location of Unit A from 2018 excavations.

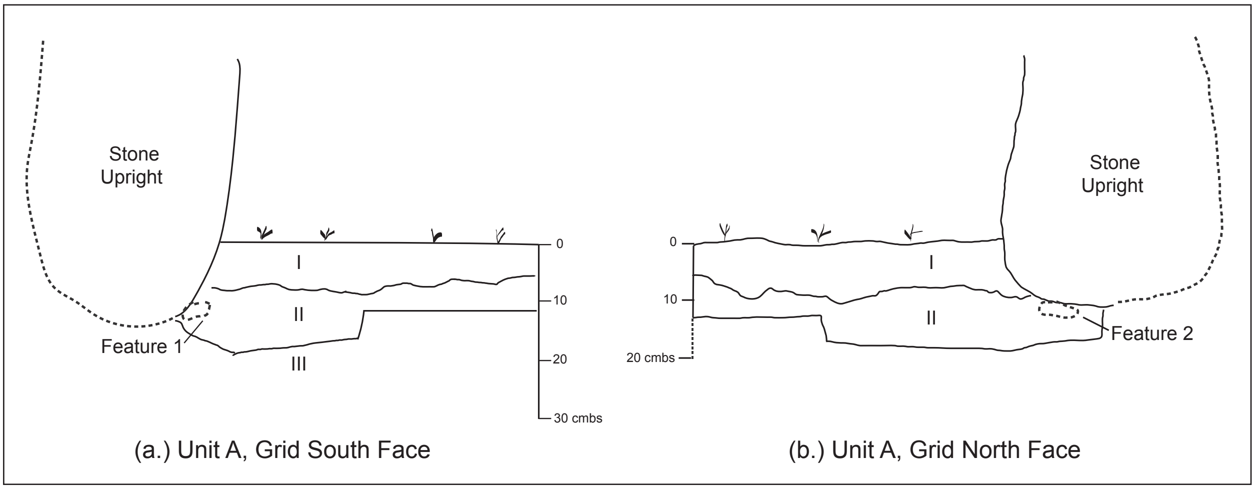

Figure 5. Stratigraphic profiles of Unit A at the end of excavations, with (a.) grid south face displaying the location of Feature 1 charcoal and (b.) grid north face displaying the location of Feature 2 charcoal.

the uprights; rather, it was scattered across the entire unit in much smaller quantities. After reaching the base of Layer II, we again removed the sediment adhering to the base of the upright stones and recovered a second concentration of *in situ* charcoal which we designated Feature 2 (Fig. 6). Layer III sediment was very compact and clayey, 'strong brown' (Munsell 7.5 YR 4/6) in color. We recovered some charcoal at the interface of Layers II and III, though only sporadically, in small quantities, and exclusively near the stone alignments; otherwise, Layer III appeared to be non-cultural. After excavating two levels (~10 cm) into Layer III, we were certain that we had excavated below the cultural

Figure 6. Grid east view of shrine site (Unit A) at the end of excavation, with photo scale pointing to the location of Feature 2 charcoal. Photograph by PVK.

deposit and closed the excavation. After reaching the bottom of the unit, we excavated directly underneath both of the now-exposed bases of the stone uprights to recover charcoal for AMS dating.

The primary cultural deposit of the shrine is Layer II, and we associate the construction of the stone alignment with this stratigraphic unit. We hypothesize that the dense concentrations of charcoal recovered near the uprights in Layer II may represent the remains of shrine offerings, while the scattered flecks of charcoal recovered at the interface between Layers II and III could represent an episode of controlled burning for forest clearance and agriculture, potentially indicating initial human activity within this landscape.

The Pālehua Enclosure (Unit 50)

The large rectangular walled structure that constitutes the Pālehua enclosure was previously excavated by Gill *et al.* (2015) in 2012. They placed a 6 × 1 m trench running from the interior of the west wall of the structure across a small pavement area, and three 1 × 1 m test units against the interior side of the south wall and the interior and exterior sides of the north wall. Our 2018 excavations added a single 1 × 1 m test unit (Unit 50) against the interior east wall of the structure to complete the representation from all four sides of the enclosure. The southeast corner of Unit 50 is located 8.75 m north of the interior southeast corner of the enclosure (see Fig. 3).

The enclosure walls were apparently intentionally deconstructed at some point in its use history, as the top 1–3 courses of stone were uniformly removed and laid next to the structure walls both inside and outside. Prior to excavation, we removed 10–15 of these large boulders that were presumably once part of the original wall construction. They had the fortunate effect of preventing surface vegetation growth in all but the westernmost portion of the unit. Thus, the overburden (Layer I) was minimal, apart from removing this vegetation and sweeping loose sediment from the unit surface. Layer II (~12 cm) was 'dark brown' (Munsell 7.5 YR 3/3) in color, as well as more clayey and with dense amounts of root matter. We reached the bottom of the structure wall in this layer. A diffuse boundary separated Layer II from Layer III, which became more compact, clayey, and 'dark reddish brown' (Munsell 2.5 YR 2.5/4), with no further cultural materials recovered. We excavated two levels in Layer III (~10 cm) and closed the excavation after determining that we had reached the end of the cultural deposit. We then sampled below the exposed rock facing, excavating separately underneath the two boulders that made up the enclosure wall on the east side of the unit. Only one of these samples yielded charcoal, which we labeled Feature 1. We then backfilled the unit and replaced the large boulders to their original locations alongside the structure walls.

We recovered a small number of post-contact artifacts during the excavation. At the top of Layer I, after removing the boulders, we found a post-contact ceramic sherd near the enclosure wall. This sherd may be temporally associated with the removal of boulders from the wall courses, or it may have been lifted up from the sediment due to root growth. We also found a second ceramic sherd and pieces of metal nails and wiring in Layers I and II. Of particular note was the presence of a metal nail in the east side of the wall at the base of the lowest wall course (see Table 1), which raises new questions about the enclosure and its use history.

A CHRONOLOGY OF ACTIVITY AT THE PĀLEHUA CEREMONIAL COMPLEX

Prior to selecting samples for dating, JH identified all carbonized plant materials collected from the shrine and enclosure test units. A total of 14 identified plant samples from both test units were subsequently selected for AMS radiocarbon dating. We selected specimens that represented both long- and short-lived taxa to generate a robust sample, and secondarily to compare results between taxa that have differing lifespans. Specimens were submitted to the Keck Carbon Cycle AMS Facility at the University of California, Irvine for radiocarbon dating (Southon *et al.* 2004). The dating results and associated botanical identifications are presented in Table 2. Figures 7 and 8 show new calibrated, unmodelled AMS radiocarbon dates plotted in stratigraphic order for the shrine and the enclosure sites, respectively.

Table 1. *List of post-contact artifacts found during 2018 excavation of the enclosure site.*

Site	Unit	Level	Layer	Description
Enclosure	Unit 50	1	I	Ceramic sherd
Enclosure	Unit 50	2	I	Ceramic sherd
Enclosure	Unit 50	2	I	Metal fragments, possibly wiring
Enclosure	Unit 50	3	II	Ceramic sherd with hand-painted design, possibly Lokelani plateware manufactured in Staffordshire, England
Enclosure	Unit 50	3	II	Ceramic sherd with transfer-print design
Enclosure	Unit 50	3	II	Metal nail

Table 2. *List of identified carbonized plant remains submitted for AMS radiocarbon dating, with both radiocarbon age (BP) and dates calibrated to 2σ (cal AD). Calibrations were made with OxCal version 4.3, using the IntCal13 atmospheric calibration curve (Reimer* et al. *2013).*

Sample ID	Site	Context	Material	δ^{13}C	^{14}C Age (BP)	cal AD (2σ)	Probabilities
UCIAMS-203602	Shrine (Unit A)	Layer II	*Euphorbia* cf. *celastroides* ('Akoko)	–10.1	200 ± 15	1656–1937	1656–1683 (22.7%), 1738–1750 (3.0%), 1762–1804 (44.4%), 1937 (25.2%)
UCIAMS-203603	Shrine (Unit A)	Layer II	cf. *Acacia koa* (Koa)	–23.8	180 ± 15	1666–1929	1666–1684 (19.4%), 1734–1785 (46.7%), 1795–1807 (8.3%), 1929 (21.0%)
UCIAMS-203604	Shrine (Unit A)	Layer II	*Euphorbia* cf. *celastroides* ('Akoko)	–9.6	210 ± 15	1651–1939	1651–1679 (29.3%), 1764–1800 (50.3%), 1939 (15.8%)
UCIAMS-203605	Shrine (Unit A)	Layer II	*Euphorbia* cf. *celastroides* ('Akoko)	–10.1	220 ± 15	1651–1939	1651–1679 (29.3%), 1674–1800 (50.3%), 1939 (15.8%)
UCIAMS-203606	Shrine (Unit A)	Feature 1	*Dodonaea viscosa* ('A'ali'i)	–23.7	235 ± 15	1647–1797	1647–1668 (65.5%), 1783–1797 (29.9%)
UCIAMS-203607	Shrine (Unit A)	Feature 1	Acacia Koa (Koa)	–25.3	185 ± 15	1665–1934	1665–1648 (20.1%), 1736–1806 (52.4%), 1934 (22.9%)
UCIAMS-203608	Shrine (Unit A)	Feature 2	*Euphorbia* cf. *celastroides* ('Akoko)	–11.1	220 ± 15	1648–1943	1648–1670 (40.6%), 1780–1800 (48.7%), 1943 (6.1%)
UCIAMS-203609	Shrine (Unit A)	Feature 2	*Dodonaea viscosa* ('A'ali'i)	–24.2	240 ± 15	1646–1796	1646–1667 (73.5%), 1783–1796 (21.9%)
UCIAMS-203610	Shrine (Unit A)	Feature 2	Indeterminate Hardwood	–25.1	195 ± 15	1661–1935	1661–1684 (20.7%), 1736–1805 (49.4%), 1935 (25.3%)
UCIAMS-203611	Enclosure (Unit 50)	Layer II	Indeterminate Hardwood	–24.1	165 ± 15	1666–1925	1666–1690 (16.3%), 1728–1784 (51.4%), 1796–1810 (10.6%), 1925–1950 (17.1%)
UCIAMS-203612	Enclosure (Unit 50)	Layer II	*Chenopodium oahuense* ('Āweoweo)	–26.3	195 ± 15	1661–1936	1661–1683 (21.1%), 1737–1756 (6.5%), 1761–1804 (40.9%), 1936 (26.9%)
UCIAMS-203613	Enclosure (Unit 50)	Layer II	*Acacia koa* (Koa)	–24.2	160 ± 15	1667–1947	1667–1691 (15.6%), 1728–1782 (50.9%), 1796–1811 (11.3%), 1923–1947 (17.6%)
UCIAMS-203614	Enclosure (Unit 50)	Feature 1	*Acacia koa* (Koa)	–22.9	195 ± 15	1661–1936	1661–1683 (21.1%), 1737–1756 (6.5%), 1761–1804 (40.9%), 1936 (26.9%)
UCIAMS-203615	Enclosure (Unit 50)	Feature 1	cf. *Acacia koa* (Koa)	–23.3	150 ± 15	1668–1945	1668–1696 (15.2%), 1726–1780 (40.6%), 1796–1815 (11.8%), 1836–1877 (7.7%), 1916–1945 (20.0%)

Botanical Identifications and Sampling Considerations

We submitted charcoal specimens from short-lived (*Chenopodium oahuense*, 'āweoweo), probable short-lived (*Euphorbia* cf. *celastroides*, 'akoko and *Dodonaea viscosa*, 'a'ali'i) and long-lived (*Acacia koa*, koa) taxa. 'Akoko and 'a'ali'i both occur as small trees or shrubs, and are not at risk for any great inbuilt age. In this area, 'akoko are usually small shrubs and more likely to die due to catastrophic events prior to senescence (Bruce Koebele, pers. comm.), and the lifespan for 'a'ali'i in this context can be up to several decades. Koa trees, in contrast, can live far longer and thus the wood has higher risk of having significant inbuilt age (Allen & Huebert 2014).

The foregoing concerns have been the subject of several recent publications (see Allen & Huebert 2014; Rieth & Athens 2013), and some key issues are summarized here. First, while it is preferable to use identified, short-lived plant parts or species with short lifespans for radiocarbon dating, sometimes these materials are not available and questions arise as to what (or whether) other specimens can produce a useful date. Broadly, the temporal scale of the research question can serve as a guide for the degree of precision needed. To understand a discrete event, for example the use of a hearth or the construction of a feature, short-lived plant parts would be desirable. However, when studying processes of societal change that span centuries, it is acceptable to include some dates in a model which are from material that might have an inbuilt age of a few decades or more. Such 'medium-lived' taxa have maximal ages that are not long-lived on a human scale, which is roughly two to three generations, or approximately 50–75 years.

Dating wood from potentially very long-lived trees remains problematic, especially in Polynesian contexts where a century or more of inbuilt age can have a significant impact on interpretations. This is particularly true for the relatively short chronologies of the Eastern Polynesian archipelagoes (Allen & Wallace 2007). In our study, however, the dates on short- and potentially long-lived materials from the same contexts were relatively consistent. And, surprisingly, the results from potentially old wood tended

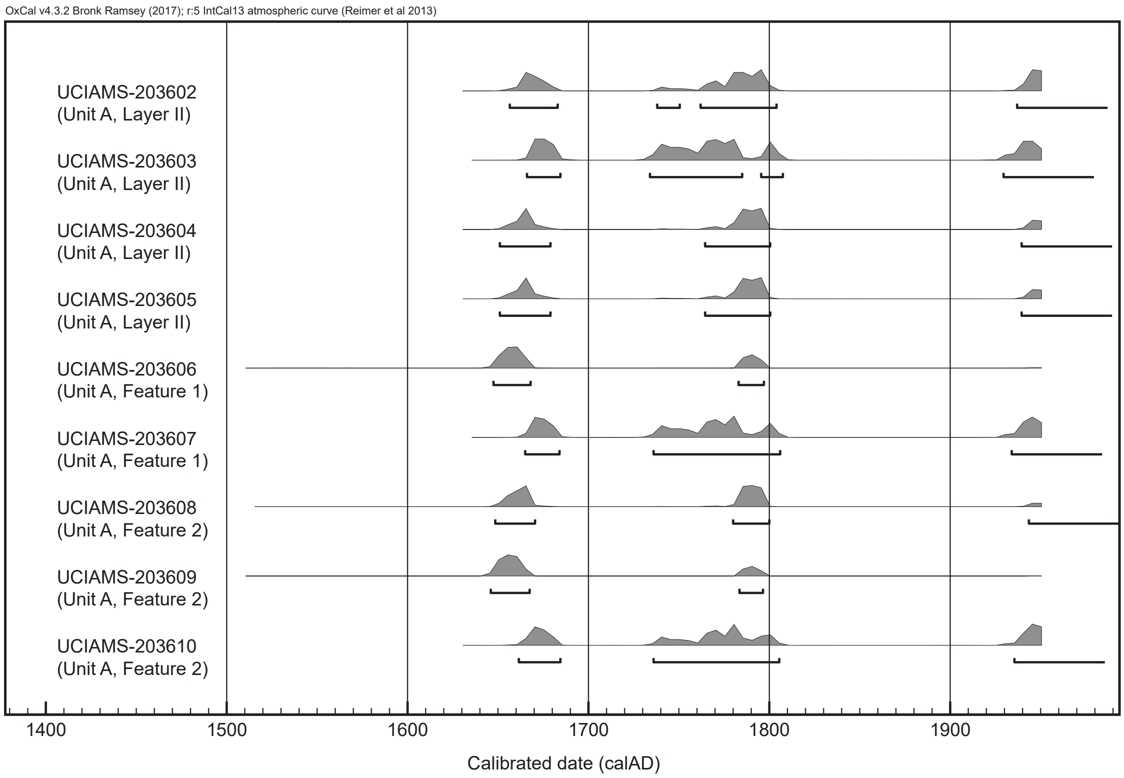

Figure 7. OxCal plot of new AMS radiocarbon dates from the shrine site (Unit A) in stratigraphic order.

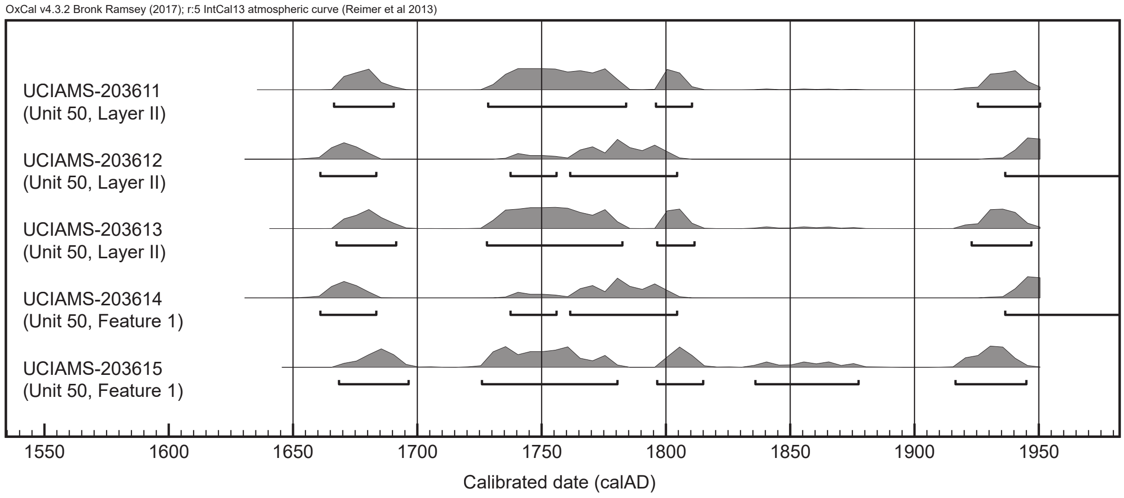

Figure 8. OxCal plot of new AMS radiocarbon dates from the enclosure site (Unit 50) in stratigraphic order.

to push our models *later* in time.

A second consideration is the relationship between sample context and target event, and how closely the material can be linked to a specific human activity. For example, it can be more useful to date charcoal from medium-lived taxa *in situ* in a hearth than to date twigs from general occupation debris, when the aim is to date a cultural stratum or a structure. Nutshells in charcoal-rich burn deposits would provide a precise date for a fire associated with anthropogenic burning, while charred fragments of pandanus drupes in soils would have uncertain association with a single event.

Traditional uses of wood can also provide useful supporting information. ʻAkoko, for example, was once valued by Hawaiians for fuel wood (Rock 1913: 243–262) and olomea (*Perrottetia sandwicensis*) was used as a fire plow (Malo 1951: 21). These taxa would be expected (and indeed the former is quite common in archaeological contexts in

Hawaiʻi[1]) in hearth features, associated activity areas, and midden deposits. Other taxa such as ʻāweoweo have less certain associations when found outside of combustion features, as the plants have soft wood and were mainly used as a potherb (Malo 1951: 23). ʻĀweoweo grows rapidly and often has dry, brittle branches which would make it an expedient source of fuel, but it is also very susceptible to ignition in vegetation fires, and the lightweight charcoal could be blown around by wind. Our concerns regarding such associations for the shrine and the enclosure are discussed below.

Bayesian Modelling

We applied a Bayesian statistical modeling approach using OxCal Online (Bronk Ramsey 1995) and applying the IntCal13 atmospheric calibration curve for the Northern Hemisphere (Reimer *et al.* 2013). We chose not to follow the previous modeling conventions for the Pālehua enclosure (Gill *et al.* 2015), which constrained the early and late bounds of the model with two floating parameters: the first (φ1) used 1050 ± 100 BP as an estimate for the initial Polynesian colonization of the Hawaiian Islands, based on Athens *et al.* (2014). We elected to remove this constraint from our model after several trial runs, as this date is much earlier than we expected to see activity in the Pālehua complex, and its inclusion did not significantly impact our results or interpretations. The second parameter (φ2) constrained the later end of the model at 90 ± 25 BP, estimated to represent the beginning of the post-contact ranching period on Oʻahu. To our knowledge, there is no archaeological or written historical evidence that suggests continued use of the sites at Pālehua by Native Hawaiians after this time (Von Holt 1953). We elected not to incorporate this constraint into the present models, as our 2018 excavations of the enclosure recovered several post-contact artifacts which may relate to this ranching period or later.

Bayesian radiocarbon modeling requires an understanding of relative site chronology and stratigraphic relationships between individual contexts. As we were primarily interested in estimating construction dates for the two structures, we carefully considered the relative positioning between depositional contexts, coordinate locations of individual samples, and abutting site walls to develop a relative chronological model based on the inferred stratigraphic relationships of dated samples for the shrine (Unit A) and the enclosure (Unit 50). Given this model of inferred stratigraphic relationships between archaeological features, contexts, and AMS dated materials, OxCal performs a Markov chain Monte Carlo (MCMC) analysis to determine the highest posterior densities (HPD) at 95% and 68% probabilities. The OxCal scripts we used to conduct these analyses are provided in the Supplementary Information, and our results are presented in Tables 3–6.

The Pālehua Shrine

The shrine excavation yielded radiocarbon dates from three separate contexts. Layer II is the primary cultural deposit, with Features 1 and 2 representing sampling loci where charcoal was recovered against the side and underneath the basalt stone uprights (see Fig. 5). The charcoal from Features 1 and 2 was recovered from sediment adhering directly to the uprights and likely associated with the initial setting in of the stones. Sediment from Layer II would then have accumulated against the uprights after they were set in place. Therefore, we can establish Features 1 and 2 as a *terminus post quem* for the construction of the shrine, and Layer II as a *terminus ante quem*, bracketing the construction of the shrine at the interface between Features 1/2 and Layer II.

We present two Bayesian radiocarbon models for the shrine site chronology. Both models assume that we can bracket wall construction between the deposition of Features 1 and 2 charcoal, and Layer II. Model 1 (Table 3, Fig. 9) incorporates all radiocarbon dates from Unit A, and its output brackets the construction of the shrine between AD 1661–1800 (95%) or 1787–1797 (68%). However, the agreement indices ($A_{model} = 49.8$ and $A_{overall} = 53.3$) for Model 1 fail to meet the recommended minimum threshold ($A = 60$), indicating that the statistical model is not consistent with the age measurements. To test whether this low agreement index results from the inclusion of the old or indeterminate wood samples – because these provide less precise age estimates than dates derived from identified short-lived species – we created Model 2 (Table 4, Fig. 10). Model 2 has the same structure as the previous model, but omits those radiocarbon dates ($n = 3$) that could not be identified as a short-lived or probable short-lived species. The agreement indices for this model ($A_{model} = 113$ and $A_{overall} = 115.1$) significantly exceed the recommended agreement threshold. Model 2 brackets shrine construction between AD 1655–1797 (95%) or 1657–1668 (68%).

Regardless of which model is applied, conservative estimates for the shrine construction all fall within the range of AD 1655–1811, with a bimodal probability curve exhibiting peaks at *c.* AD 1650 and AD 1800. Which of these peaks are favored largely depends on whether or not the unidentified or old wood samples are included in the model. Excluding the old wood samples pushes the date of shrine construction *earlier* and provides a higher agreement index, while including these samples favors a later construction date with lower, and likely inadequate, agreement indices.

The Pālehua Enclosure

Previous analysis of the enclosure site by Gill *et al.* (2015: 256) bracketed the enclosure's construction between the

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[1] JH personal observations, and records of the Wood Identification Laboratory, International Archaeological Research Institute, Inc. (IARII), Honolulu

Table 3. *Results of OxCal Bayesian radiocarbon modeling for the shrine site which incorporates all radiocarbon dates obtained from Unit A excavations. Agreement indices for this model are reported as* $A_{model} = 49.8$ *and* $A_{overall} = 53.3$*, which do not meet the minimum threshold (A = 60) for model consistency.*

Name	Unmodelled (BC/AD)						Modelled (BC/AD)							
	from	to	%	from	to	%	from	to	%	from	to	%	A	C
Sequence Shrine Unit A														
Boundary Start Shrine							1662	1794	68.2	1651	1798	95.4		96.8
Phase Features 1&2														
R_Date UCIAMS-203609 Fea2	1648	1664	68.2	1646	1796	95.4	1783	1795	68.2	1657	1799	95.4	57	98.6
R_Date UCIAMS-203608 Fea2	1660	1796	68.2	1648	—	95.4	1783	1795	68.2	1658	1799	95.4	113.8	98.5
R_Date UCIAMS-203610 Fea2	1664	—	68.1	1661	—	95.4	1783	1795	68.2	1658	1800	95.4	88.6	97.9
R_Date UCIAMS-203606 Fea1	1649	1793	68.2	1647	1797	95.4	1783	1795	68.2	1657	1799	95.4	75.9	98.5
R_Date UCIAMS-203607 Fea1	1668	—	68.2	1665	—	95.4	1782	1795	68.2	1658	1800	95.4	48.1	97.6
Boundary Transition Features/LII							1787	1797	68.2	1661	1800	95.4		98.1
Phase Layer II														
R_Date UCIAMS-203605 LII	1660	1796	68.2	1648	—	95.4	1789	1799	68.2	1661	1800	95.4	100.6	98.7
R_Date UCIAMS-203604 LII	1660	—	68.2	1651	—	95.4	1789	1799	68.2	1662	1801	95.4	118	98.7
R_Date UCIAMS-203602 LII	1663	—	68.2	1656	—	95.3	1664	1800	68.2	1662	1803	95.4	114	98.6
R_Date UCIAMS-203603 LII	1668	1949	68.2	1666	—	95.4	1790	1802	68.2	1661	1805	95.4	53.3	98.1
Boundary End Shrine							1665	1805	68.2	1661	1811	95.4		98

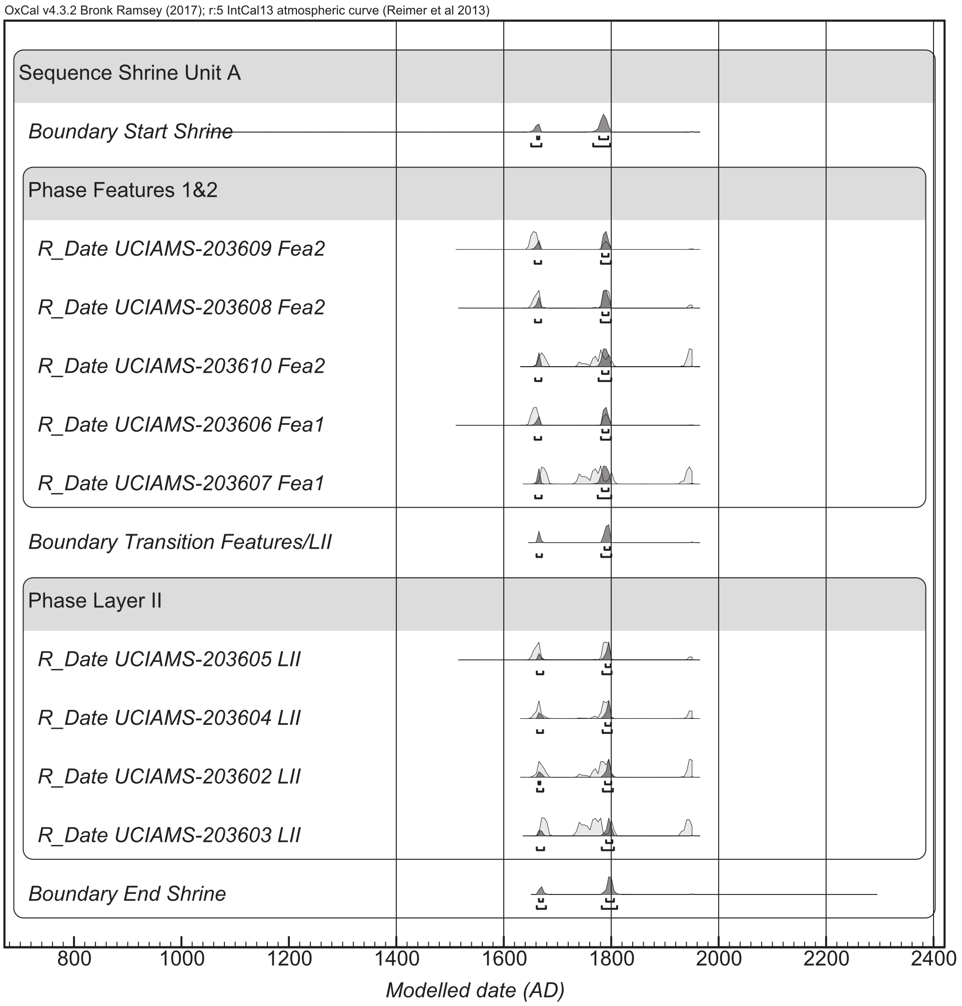

Figure 9. Shrine Model 1: OxCal Bayesian radiocarbon model of all dates from the shrine site (Unit A).

Table 4. *Results of OxCal Bayesian radiocarbon modeling for the shrine site (Unit A) which excludes all dates derived from unidentifiable or old wood charcoal. Agreement indices for this model are reported as $A_{model} = 113$ and $A_{overall} = 115.1$, which meet the minimum threshold ($A = 60$) for model consistency.*

Name	Unmodelled (BC/AD)						Modelled (BC/AD)							
	from	to	%	from	to	%	from	to	%	from	to	%	A	C
Sequence Shrine Unit A														
Boundary Start Shrine							1650	1790	68.2	1640	1798	95.4		96.4
Phase Features 1&2														
R_Date UCIAMS-203609 Fea2	1648	1664	68.2	1646	1796	95.4	1653	1792	68.2	1649	1795	95.4	97.8	97.3
R_Date UCIAMS-203608 Fea2	1660	1796	68.2	1648	—	95.4	1654	1791	68.2	1651	1798	95.4	101.2	97.3
R_Date UCIAMS-203606 Fea1	1649	1793	68.2	1647	1797	95.4	1653	1792	68.2	1650	1795	95.4	107.9	97.2
Boundary Transition Features/LII							1657	1668	68.2	1655	1797	95.4		97.5
Phase Layer II														
R_Date UCIAMS-203605 LII	1660	1796	68.2	1648	—	95.4	1660	1796	68.2	1656	1799	95.4	108.1	97.9
R_Date UCIAMS-203604 LII	1660	—	68.2	1651	—	95.4	1660	1796	68.2	1656	1799	95.4	115.6	97.8
R_Date UCIAMS-203602 LII	1663	—	68.2	1656	—	95.3	1661	1796	68.2	1656	1800	95.4	105.8	97.6
Boundary End Shrine							1661	1798	68.2	1657	1805	95.4		96.5

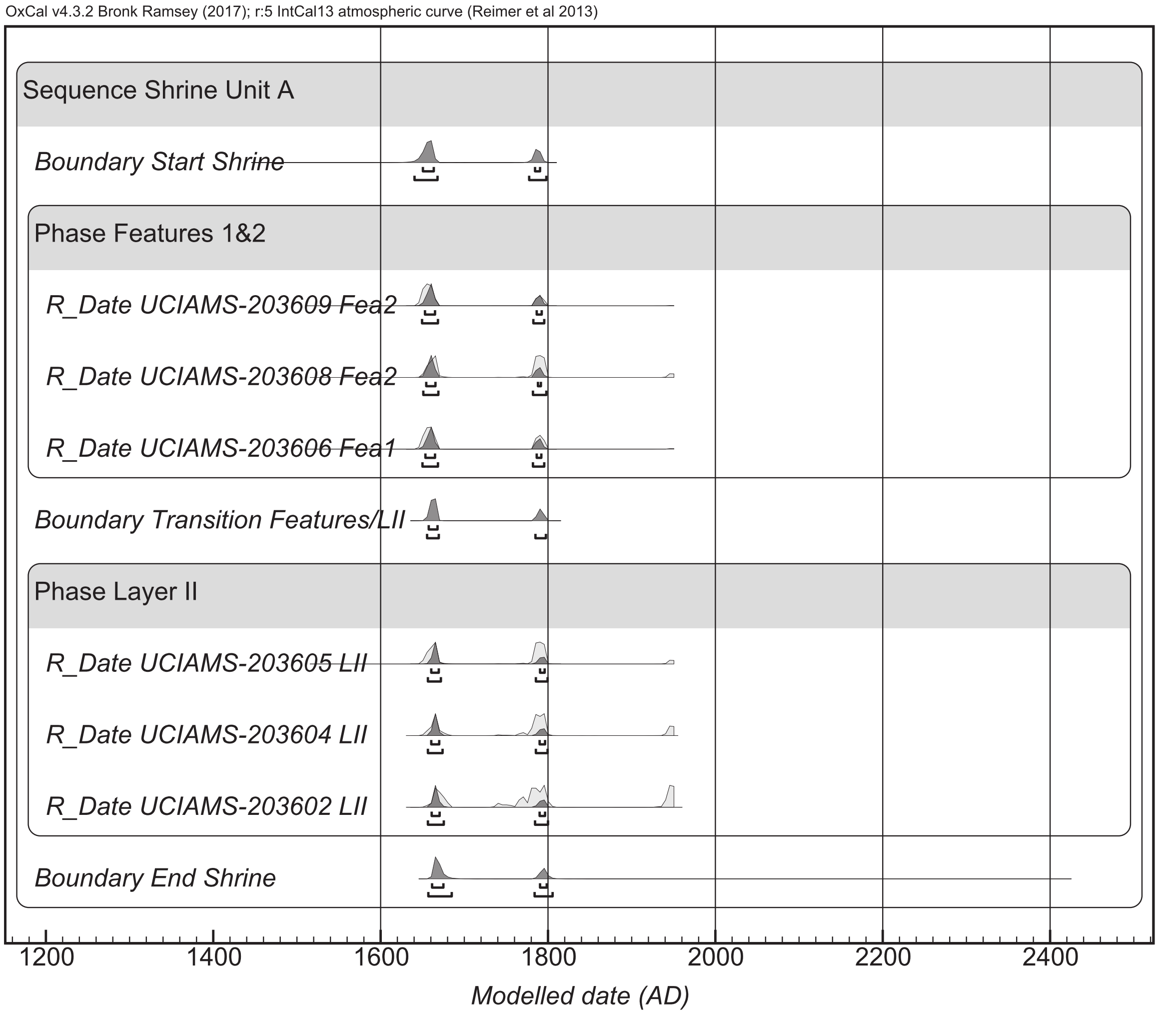

Figure 10. Shrine Model 2: OxCal Bayesian radiocarbon model of dates from shrine site (Unit A), excluding indeterminate and old wood samples.

end of TP-3, Layer IV (β1) and TP-3, Layer III (α2). This model determined that the enclosure was not constructed earlier than AD 1500 and not later than AD 1804. This previous model was created with the bCal Bayesian calibration program (Buck *et al.* 1999), and Gill *et al.* did not report detailed instructions for model replication nor agreement indices to evaluate consistency. We attempted to reproduce their previous radiocarbon model in OxCal with the radiocarbon dates from Gill *et al.* (2015), assuming TP-3, Layer IV > TP-3, Layer III > Pavement > TP-2, Layer II (see Supporting Information). However, this model produced an unacceptably low agreement index ($A_{model} = 7.4$ and $A_{overall} = 20.2$), indicating little consistency between model and measured ages.

Given the low agreement index of the previous model, we revisited the stratigraphic interpretations of the previous excavation to construct an alternative model. Gill *et al.* (2015) note that 'Similarly, Layer III in TP-3 (θ2) and the pavement exposed in TP-5 to TP-9 (θ3, θ4 and θ5) both post-date wall construction; in our model we assume them to be penecontemporaneous, representing the main period of use of the enclosure, as they appear to bear the same stratigraphic relationship to the enclosure wall' (226). On this basis, we grouped the dates from Layer III and the pavement into a single phase, forming Enclosure Model 1 (Table 5, Fig. 11). This model exceeds the agreement index threshold ($A_{model} = 91.3$ and $A_{overall} = 91.7$), and narrows the age estimate for the enclosure's construction to an earlier range of between AD 1468–1648 (95%) and AD 1490–1644 (68%).

Our 2018 excavation of the enclosure's east wall (Unit 50) yielded two contexts with charcoal for AMS dating. Layer II represents the primary cultural deposit, and Feature 1 represents a charcoal sampling locus taken underneath the foundation course at the end of the excavation. It would be tempting to assume that the charcoal recovered from Feature 1 pre-dates the construction of the enclosure. However, given the natural inward slope of many of the boulders used in the foundation course, it is possible that despite excavating beneath the visible base of the stone face, the charcoal recovered may be adjacent to, rather than directly underneath, the stone. It was not possible to safely verify this without removing the basal course of the wall. As we cannot assume that the charcoal recovered from Feature 1 was deposited prior to wall construction, the additional dates from our 2018 excavations can only provide a *terminus ante quem* for enclosure construction. However, as the TP-3, Layer IV sample is positioned within a context that is stratigraphically below the basal course of the structure, we can incorporate this sample into our Unit 50 model as a *terminus post quem* for enclosure construction. Given the differences in stratigraphy between the 2012 and 2018 enclosure units, we cannot confidently correlate our Unit 50 stratigraphy with the previous excavation's test units. Modeled dates for the Unit 50 excavations (Enclosure Model 2; Table 6, Fig. 12) estimate enclosure construction between AD 1504–1770 (95%) and AD 1597–1764 (67%). As 4 out of our 5 radiocarbon dates from Unit 50 are derived from old wood (koa), it was not possible to eliminate all unidentified or old wood dates from our model. However, even with these samples included, agreement indices for this model ($A_{model} = 68.8$ and $A_{overall} = 70.5$) meet the recommended

Table 5. *Results of OxCal Bayesian radiocarbon modeling for the enclosure site using the radiocarbon dates acquired from 2012 excavations by Gill* et al. *(2015), and pooling the radiocarbon measurements from Layer III and the Pavement into a single context. Agreement indices for this model are reported as $A_{model} = 91.3$ and $A_{overall} = 91.7$, which meet the minimum threshold ($A = 60$) for model consistency.*

Name	**Unmodelled (BC/AD)**						**Modelled (BC/AD)**							
	from	**to**	**%**	**from**	**to**	**%**	**from**	**to**	**%**	**from**	**to**	**%**	**A**	**C**
Sequence Enclosure Old														
Boundary Start Enclosure							1365	1619	68.2	1027	1633	95.4		96.5
Phase Layer V														
R_Date Beta-377882 LV	1441	1486	68.2	1430	1620	95.4	1443	1617	68.2	1435	1629	95.4	81.5	98.2
Boundary Transition LV/LIII							1490	1644	68.2	1468	1646	95.4		99.0
Phase Layer III														
R_Date Beta-326899 LIII	1668	—	68.2	1659	—	95.4	1655	1693	68.2	1647	1809	95.4	98.5	99.8
R_Date Beta-32901 Pav	1518	1640	68.2	1483	1646	95.4	1584	1652	68.2	1524	1657	95.4	96.5	99.6
R_Date Beta-32900 Pav	1525	1664	68.2	1514	1799	95.4	1633	1664	68.2	1524	1793	95.4	124.5	99.8
R_Date Beta-371023 Pav	1647	—	68.2	1642	—	95.4	1646	1675	68.2	1638	1800	95.4	107.2	99.8
Boundary Transition LIII/LII							1663	1823	68.2	1657	1886	95.4		99.2
Phase LII														
R_Date Beta-326898 LII	1700	1915	68.3	1694	1919	95.4	1694	1909	68.2	1687	1964	95.4	78.4	98.6
Boundary End Enclosure							1696	1969	68.2	1686	2220	95.4		97.2

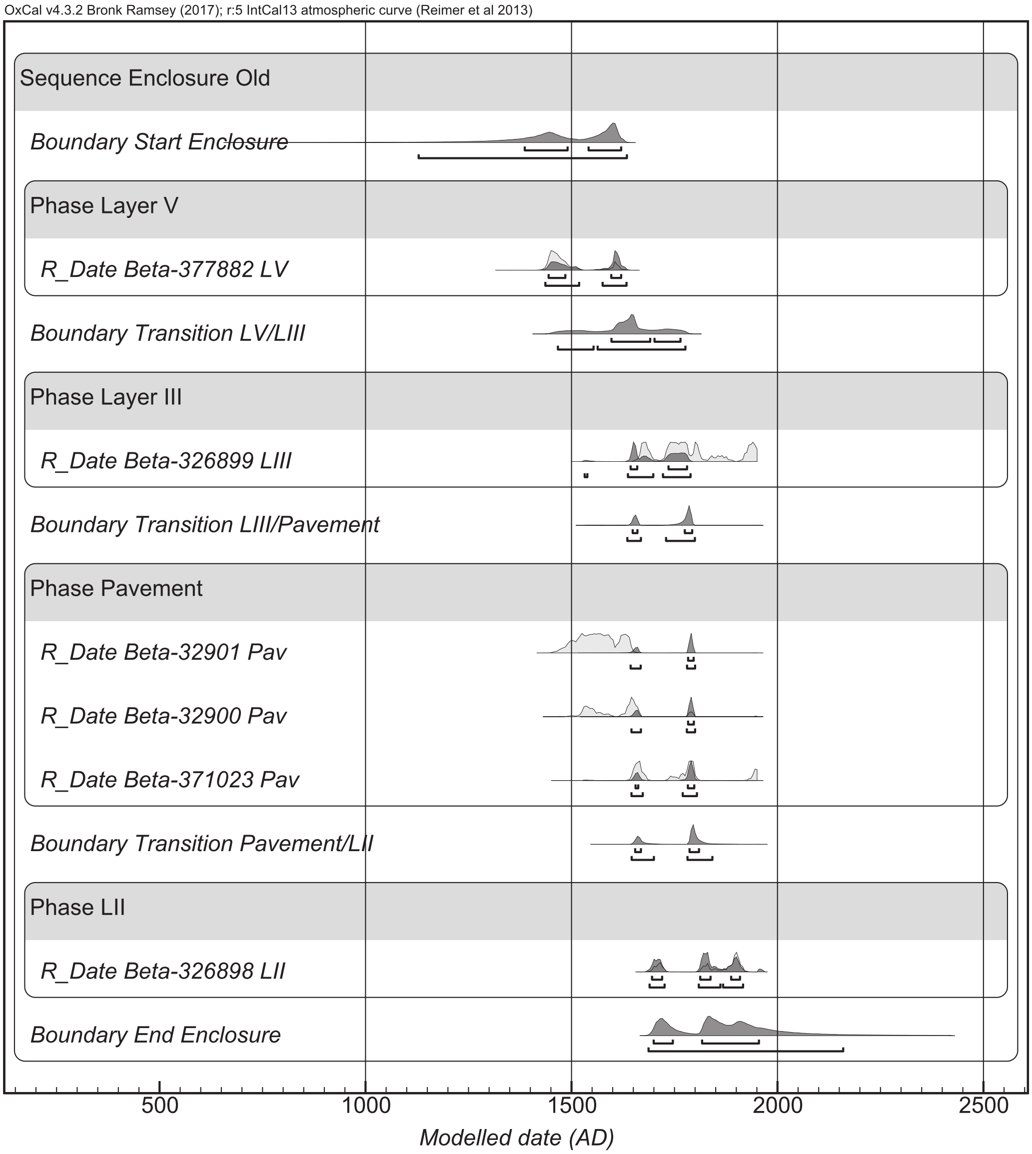

Figure 11. Enclosure Model 1: OxCal Bayesian radiocarbon model of Gill *et al.*'s (2015) previous dates from the enclosure site, with radiocarbon dates from Layer III and the Pavement grouped together as a single context.

minimum threshold (A = 60).

Our interpretations assume that (1) deposition of TP-3, Layer IV predates enclosure construction and (2) the enclosure was built in its entirety in a single construction phase. Gill *et al.* (2015) report that the flecks of charcoal recovered from Layer IV likely derive from forest clearance or other agricultural activities that took place prior to the enclosure's construction. As such, this early context is representative of initial activity in upland Honouliuli, though not necessarily at the Pālehua enclosure site specifically. The 15th century construction dates provided by Enclosure Model 2 may be reflective of this earlier off-site activity. When we compare the 2012 Enclosure Model 1 with the 2018 Enclosure Model 2, an age estimate of AD 1504–1648 for the construction of the enclosure appears most likely.

DISCUSSION

Our revised Bayesian radiocarbon model for the Pālehua complex provides evidence for human activities in the upland Honouliuli region as early as the mid-15th century. The earliest date from this sequence was obtained from windswept flecks of *Chenopodium oahuense* charcoal recovered from TP-3 Layer IV in 2012 (Gill *et al.* 2015), likely deposited at the site as a result of anthropogenic burning. While this evidence can be tied to Hawaiian presence in the area, initial activity at the Pālehua complex itself may have occurred later. Our new models for the enclosure site point to a likely construction date of *c.* AD 1504–1648. This predates the construction of the shrine site, which occurred no earlier than AD 1650. Activity at the shrine site appears

Table 6. *Results of OxCal Bayesian radiocarbon modeling for the enclosure site using the radiocarbon dates acquired from our 2018 excavations of Unit 50, with the previously excavated sample from Layer IV (Beta-377882) serving as a terminus post quem. Agreement indices for this model are reported as* $A_{model} = 68.8$ *and* $A_{overall} = 70.5$*, which meet the minimum threshold (A = 60) for model consistency.*

Name	**Unmodelled (BC/AD)**						**Modelled (BC/AD)**							
	from	**to**	**%**	**from**	**to**	**%**	**from**	**to**	**%**	**from**	**to**	**%**	**A**	**C**
Sequence Palehua Enclosure														
Boundary Start Enclosure							1379	1619	68.2	1081	1634	95.4		97.3
Phase Layer IV														
R_Date Beta-377882 LV	1441	1486	68.2	1430	1620	95.4	1444	1620	68.2	1437	1633	95.4	69.4	99.4
Boundary Layer IV/Fea1 Transition							1604	1752	68.2	1504	1770	95.4		98.8
Phase Feature1														
R_Date UCIAMS-203614 Fea1	1664	…	68.1	1661	…	95.4	1662	1750	68.2	1658	1785	95.4	75.5	99.4
R_Date UCIAMS-203615 Fea1	1680	1939	68.2	1668	1945	95.3	1670	1749	68.2	1666	1776	95.4	96.5	98.2
Boundary Feature/Layer II Transition							1672	1779	68.2	1668	1803	95.4		96.7
Phase Layer II														
R_Date UCIAMS-203612 LII	1664	…	68.1	1661	…	95.4	1745	1802	68.2	1672	1953	95.3	77.5	97.5
R_Date UCIAMS-203611 LII	1675	1941	68.2	1666	1950	95.4	1745	1805	68.2	1671	1945	95.5	104.8	97.6
R_Date UCIAMS-203613 LII	1678	1940	68.2	1667	1947	95.4	1745	1806	68.2	1671	1944	95.4	103.7	97.6
Boundary End							1678	1820	68.2	1671	1974	95.5		95.5

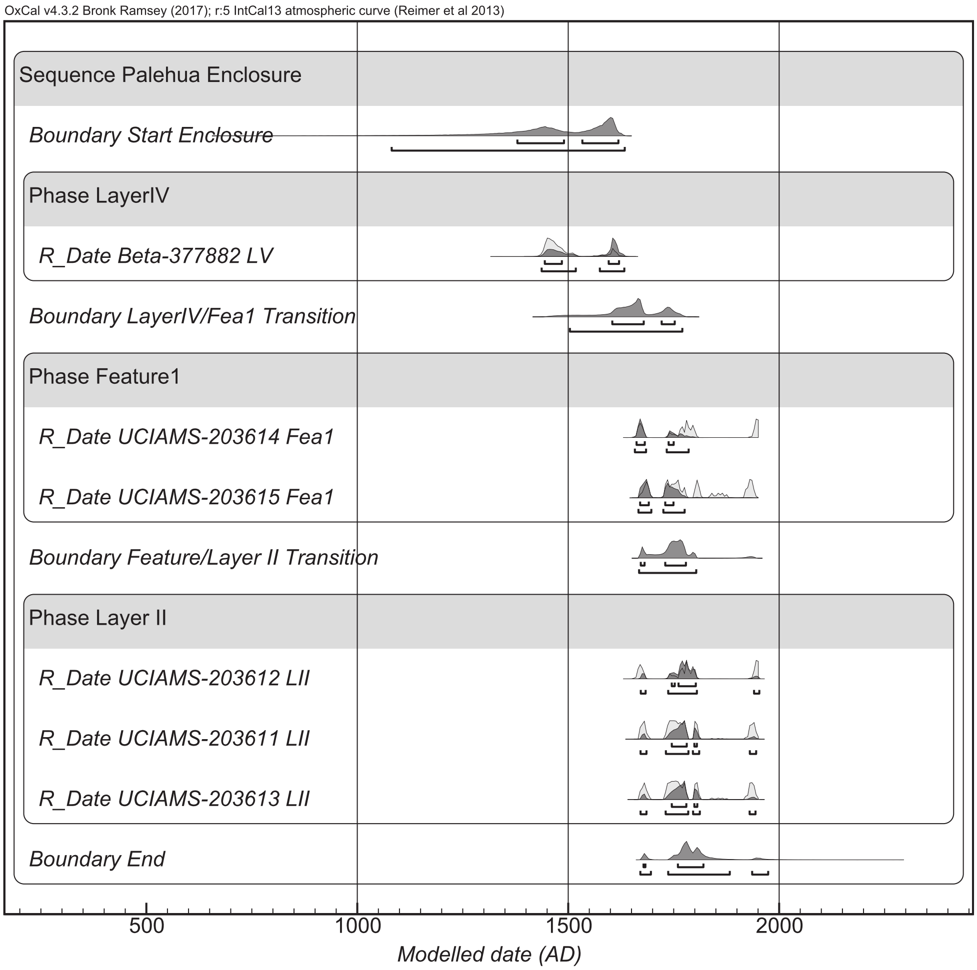

Figure 12. Enclosure Model 2: OxCal Bayesian radiocarbon model of new dates from the enclosure site (Unit 50), incorporating the TP-3 Layer IV radiocarbon date from Gill *et al.* (2015) as a TPQ for enclosure construction.

to have ceased by *c.* AD 1811, whereas our chronological models for the enclosure site do not provide a similarly clean cut-off point for activity. The post-contact artifacts found during the 2018 excavation of the enclosure also point to continued use until – and possibly through – the historic ranching period.

A 16th or 17th-century date for the construction of the enclosure site remains consistent with previous interpretations of Pālehua's chronology, as well as with chronologies for major sociopolitical transformations and ceremonial architecture elsewhere in the archipelago. For example, Uranium-series dating of coral offerings deposited at heiau sites in the Kahikinui District (leeward Maui Island) indicates that most of the ceremonial architecture in this region was constructed during the Late Expansion Period, *c.* AD 1550–1700 (Kirch *et al*. 2015; though see Dye 2016). It is also during this time that the Makahiki period is believed to have been formalized across the islands as a ritualized form of tribute extraction (Kirch 2010; McCoy 2018).

Our new chronological model for the Pālehua shrine indicates this feature was constructed no earlier than AD 1650, and possibly as late as AD 1800. This date is significantly later than might be expected given the shrine's formal similarity to the supposedly 'archaic' marae shrines elsewhere in the archipelago, which were presumed to be associated with an early colonization phase. However, the assumption that these structures date exclusively to an early phase in Hawaiian history is a legacy of an early 20th century culture historical approach that – in the absence of radiometric dating – relied on limited formal comparisons of architectural types to infer cultural sequences (e.g., Emory 1928, 1943).

Radiometric dates available for similar 'archaic' shrines in the northwestern Hawaiian Islands and Mauna Kea indicate consistently early construction dates in the mid- to late-15th century (Kikiloi 2012; McCoy *et al*. 2009). While these dates are earlier than those for the Pālehua shrine, they are not early enough to be tied to the first Polynesian arrivals to Hawai'i. Instead, their construction corresponds to the early Expansion Period, a time of population growth and movement into more marginal regions, which include the northwestern Hawaiian Islands and establishment of adze quarries on the higher slopes of Mauna Kea. Thus rather than a direct association with early voyagers from other Polynesian islands, the appearance of these structures was more likely affiliated with permanent Hawaiian population movements into new regions. Our research neither supports nor contradicts previous suggestions (e.g., Hiroa 1957: 527–8; McCoy & Nees 2014) that these structures reflect specialized, small-scale religious activities occurring within families and outside of highly-structured, public celebrations. However, the close proximity of the shrine and the enclosure, as well as a likely contemporaneity of use, suggest that both may also have played a role in larger ceremonies. It is also still possible that a greater number of these structures once existed across the archipelago, but were eventually destroyed or replaced. However, the contemporaneous timelines of the shrine and the Pālehua enclosure with its putative Makahiki associations suggests that smaller shrine sites were not entirely replaced over time by more elaborate walled heiau structures. Rather – at least within this region – the onset of large-scale state celebrations took place *alongside* the persistence of smaller shrines, the latter possibly as a locus for smaller, private ceremonial activities.

Our Bayesian radiocarbon model of the Pālehua complex also points to a divergence in post-contact use of the shrine versus the enclosure. The official end to the Hawaiian state religion began in 1819 with the death of Kamehameha I and the overthrow of the kapu system ('Ai Noa) by his heir Kamehameha II (Liholiho) and former wives, Ka'ahumanu and Keōpūolani. This was followed shortly thereafter by the arrival of Christian missionaries in 1820. Many material traces of Hawaiian ritual and religious activity were destroyed during this time, including heiau sites and their associated structures and paraphernalia. Though this sealed the fate of the official state religion, private religious practices may have continued clandestinely. There is no evidence for activity occurring at the shrine after the official end of the Hawaiian state religion (AD 1819), and it seems likely that this cessation of site use is connected to the 'Ai Noa and conversion to Christianity.

We can contrast the above chronology of the Pālehua shrine with that of the enclosure, which apparently continued to be used through the late 19th century and start of the ranching period on O'ahu (*c.* AD 1860). The post-contact artifacts we recovered during excavation were found exclusively within the enclosure site (Table 1). Among these are fragments of metal nails and wiring, which may have been used to build fencing around the enclosure during the ranching period, as well as a small number of ceramic sherds which carry both hand-painted and transfer print designs. The partial floral designs of the hand-painted ceramics resemble the 'Lokelani Rose' plateware design, which was popular in Hawai'i during the late 19th century, manufactured in Staffordshire, England and imported by W.W. Dimond & Co., Ltd. (Kirch 1992: 109). Similar ceramics were also found in mid-19th century archaeological deposits from sites in Leeward Kohala, Hawai'i Island (Flexner *et al*. 2018). However, at some point in this use history, the uppermost 1–3 courses of the enclosure walls were removed. This suggests an intentional deconstruction of the site, which we tentatively attach to a transformation in site function from a ritually-significant gathering place to a purely secular space in the post-contact period.

CONCLUSION

Our revised model of the Pālehua complex provides a chronology of public and private ritual activities that may have begun as early as the mid-15th century and extended into at least the early 19th century. Even the most conservative interpretation of the Pālehua shrine chronology suggests an unexpectedly late construction date, at least two centuries later than Uranium-series dates from other marae-like shrines found within the Hawaiian archipelago; the latter are likewise at least two centuries later than current estimates for initial arrival to the Hawaiian Islands (Athens *et al.* 2014). This growing body of radiometric data for Hawaiian ritual sites indicates that simple shrine structures are not uniquely – and perhaps not at all – 'archaic' forms, but rather continued to play an important role in Hawaiian religious practices until the early 1800s.

These results carry implications not just for Hawaiian ceremonial architecture, but also for other large-scale culture historical narratives across the Pacific. Typologically-based assumptions about surface architectural patterns can be 'ground-truthed' with the latest chronometric methods, often resulting in localized, high-resolution insights that challenge or further refine previous interpretations. For example, radiocarbon dating of marae complexes in the 'Opunohu Valley, Society Islands (French Polynesia) has expanded and revised previous interpretations of settlement patterns and sociopolitical development in this region (Kahn 2011; Kahn and Kirch 2011). Increasingly precise radiometric chronologies of architectural remains thus offer a key line of evidence towards understanding both spatial and temporal variation in sociopolitical, economic, and ceremonial practices. However, many ceremonial architectural features in Hawai'i and across the Pacific lack secure radiocarbon dates from short-lived taxa. This is a product of numerous factors, including time and cost constraints, preservation concerns, architectural destruction and/or rebuilding, and – crucially – the feasibility and appropriateness of excavating structures with ritual significance. Many Hawaiian archaeological sites continue to be actively used and maintained by Kānaka Maoli communities (Kawelu *et al.* 2015; Mossman 2017); it is critical that archaeologists work closely with these communities to ensure respectful treatment of these structures and associated beliefs and practices. At the same time, archaeological science can provide new lines of evidence for reevaluating previous assumptions and adding local and historical nuance to broad-sweeping archaeological narratives, particularly when working in tandem with Kānaka Maoli stakeholders and oral histories.

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