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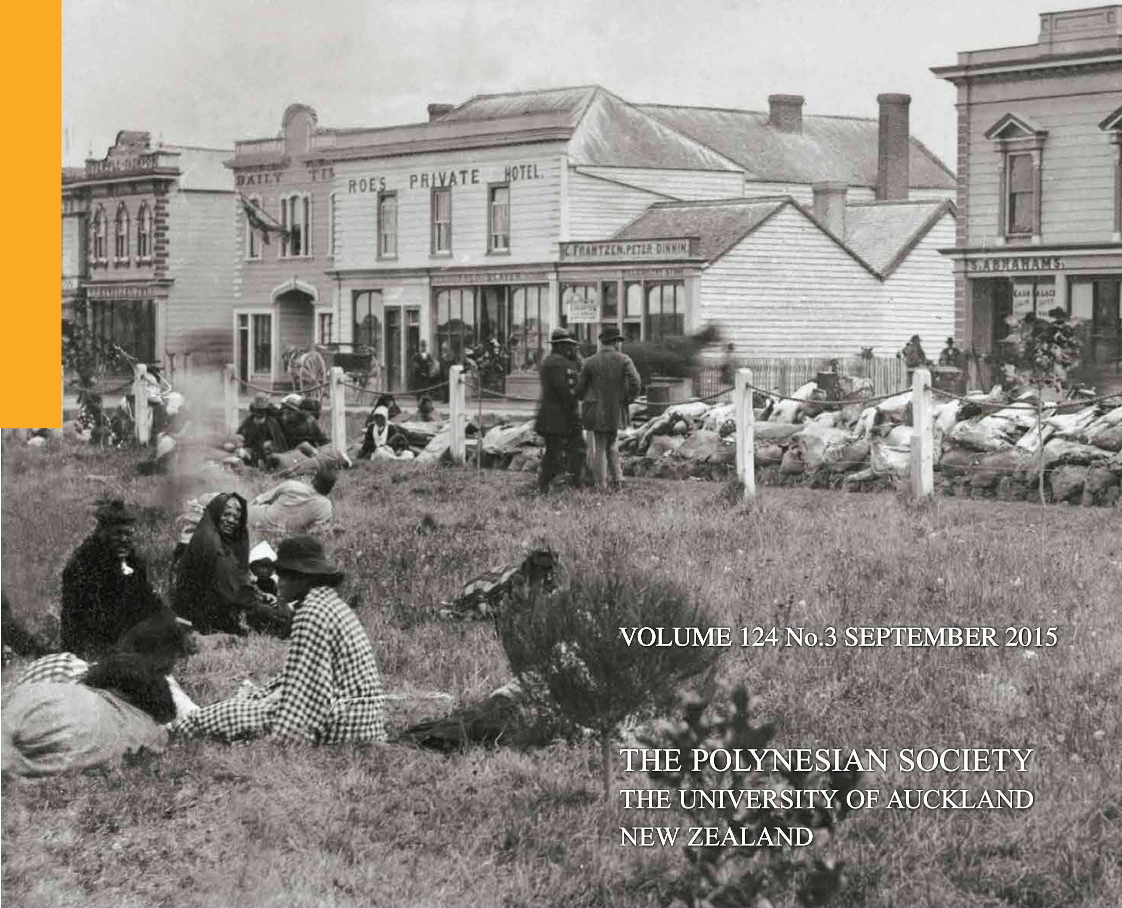
The Journal of the Polynesian Society



VOLUME 124 No.3 SEPTEMBER 2015

THE POLYNESIAN SOCIETY
THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

IDEOLOGY, CEREMONY AND CALENDAR IN PRE-CONTACT HAWAI‘I: ASTRONOMICAL ALIGNMENT OF A STONE ENCLOSURE ON O‘AHU SUGGESTS CEREMONIAL USE DURING THE MAKAHIKI SEASON

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The Polynesians had extensive knowledge of astronomical phenomena, knowledge that played significant social, ideological and political roles. Such knowledge was prized throughout Polynesia because of its importance in ocean voyaging, but also owing to its role in a ritual-calendrical cycle that was carried from ancestral homelands in the central Pacific out to islands scattered over many thousands of kilometres (Kirch and Green 2001). In the Hawaiian Islands in particular, a rich ethnohistoric record attests to the prominent place of astronomy within religious, navigational and calendrical traditions (Kepelino 1932, Makemson 1941, Ruggles 1999a). Although some archaeologists have investigated the orientation and positioning of temples and other structures in Hawai‘i and elsewhere in Polynesia (e.g., Hommon 2013: 105, Kirch 2004a, 2004b, Ruggles 2014a, 2014b), the interpretation of sites in an archaeoastronomical context is a relatively neglected area of investigation.

In this article we report on mapping, test excavations and archaeoastronomical analysis of a 1,577 m^2 walled enclosure in the uplands of Honouliuli, O‘ahu Island, Hawai‘i (Fig. 1). Multiple lines of evidence—astronomical orientation, ethnography and carbon dating—converge to indicate that this enclosure had a ceremonial use associated with the annual Makahiki harvest season, a four-month ritual period whose onset was determined by observation of the rising of the Pleiades star cluster, upon which the enclosure is aligned. During the late period of Hawaiian history (AD 1650–1819) the Makahiki was institutionalised as a means of tribute collection by the emerging archaic state hierarchy (Hommon 2013, Kirch 2010).

Journal of the Polynesian Society, 2015, 124 (3): 243-268;
DOI: http://dx.doi.org/10.15286/jps.124.3.243-268

THE MAKAHIKI SEASON IN PRE-CONTACT HAWAI'I

The Hawaiian lunar calendar was divided into two parts: a period of four lunar months collectively called the "Makahiki" and dedicated to Lono, deity of dryland agriculture, and a longer period of eight lunar months when the main temple rituals associated with the war god Kū were performed by the king and high priest (Handy and Handy 1972: 327-88, Kamakau 1964: 19-21, Kirch 2010: 61-64, Malo 1951: 141-59, Valeri 1985). The Makahiki commenced once the Pleiades (Makali'i, literally 'Little Eyes' in Hawaiian), rising progressively earlier each night, became visible above the horizon in the ENE immediately after sunset, an event known as the acronychal (or acronical) rise (see Kirch and Green 2001: 262 and Hommon 2013: 100). During the Makahiki season war was prohibited and dryland sweet potato and other crops were harvested. In a highly ritualised process that occurred toward the end of the Makahiki, the priests of Lono collected tribute from the commoners. One key element of the process was the clockwise circuit around the island of the *akua loa* 'long god' and the accompanying collection of starch staples, pigs, dogs, cloth, capes, fishlines, feathers and other items of food and prestige goods, tribute which was used to support the chiefly class (Hommon 2013, Kirch 2010, 2012). The English navigator Captain James Cook famously arrived in Hawai'i during the Makahiki season of 1778, and again in 1779, a fact that played into the treatment he received from the Hawaiian priests and chiefs (Kirch 2012: 250, Sahlins 1995).

Ethnohistoric descriptions reveal that the Makahiki circuit conducted by the Lono priests carrying the *akua loa* representation of Lono was marked not only by the collection of tribute within each territorial unit (*ahupua'a*), but also by large gatherings of people from each community as the procession of priests and warriors passed through. As Handy and Handy (1972: 357-58) wrote: "The evening before the feeding of Lono by the *mo'i* [king], the people gathered in every village and district throughout the island and engaged first in boxing, and then in other games and dancing." The 19th-century Hawaiian sage David Malo noted: "During the Makahiki season, when the Makahiki god made his rounds, the people of different districts *gathered at one place* and held boxing matches" (1951: 232, *emphasis added*). Another Native Hawaiian scholar, Samuel Kamakau, noted that "a place had been made ready" before the arrival of the Makahiki gods, where sporting matches were performed after the tribute offerings were made (1964: 20). These references suggest the presence of particular locales where Makahiki rituals and celebrations were performed annually; they raise the possibility that such assembly places might be archaeologically identifiable on the Hawaiian landscape.

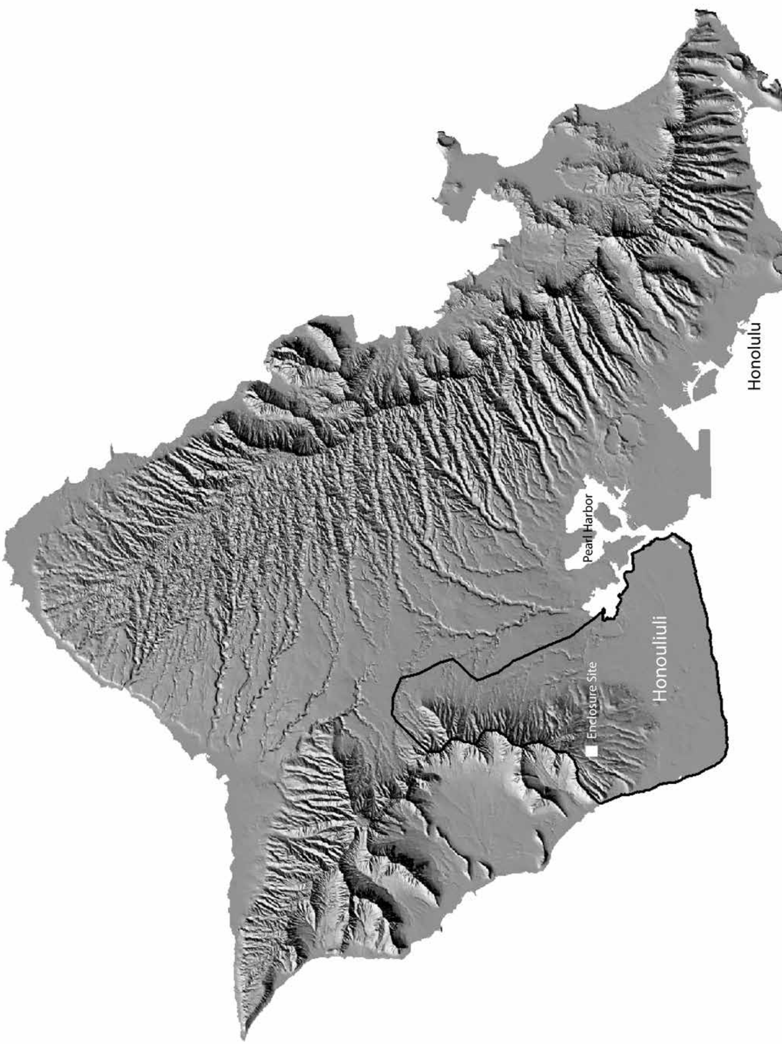

Figure 1. Map of Oʻahu Island, with location of enclosure marked.

THE HONOULIULI UPLAND ENCLOSURE

Near the southern terminus of the Wai'anae mountains of western O'ahu Island, at an elevation of approximately 510 m, a substantial square, dry stone masonry walled enclosure with an area of 1,577 m^2 occupies a shallow swale on a ridge that slopes gently towards the west (Fig. 1.) This upland area of Honouliuli Ahupua'a is today commonly referred to as Pālehua. This is the leeward, and therefore drier, part of O'ahu, an area that was restricted to dryland farming, primarily of sweet potato. It is likely that the broad ridge descending below the enclosure was used for such dryland farming before being put into pineapple plantation cultivation in the early 20th century. The enclosure commands a sweeping view west over the Pacific Ocean; from nearby higher ground there is an expansive view of southern O'ahu Island (Fig. 2).

Prior to the work described here, the Pālehua area was the subject of several archaeological surveys which briefly identified and described the enclosure, giving it the temporary designation CSH-3 (Tulchin and Hammatt 2007, 2008), but no archaeological excavation or precise mapping of the

Figure 2. View of Honouliuli enclosure, looking west.

enclosure had been undertaken. The site does not appear in McAllister's classic study of O'ahu archaeology, which included most known *heiau* 'temples or places where rituals were performed' (McAllister 1933; see also Sterling and Summers 1978), and we have found no reference to the site in any historical accounts. Field research took place over eight days during May 2012. The main enclosure and adjacent shrine were mapped with plane table and alidade, as well as with a Trimble GeoXT GPS unit. Excavations were carried out to obtain samples for radiocarbon dating and to gain information on the possible uses of the enclosure.

The site is known to the local Hawaiian community and is considered a significant cultural site, regarded by some as a place where martial arts (*lua*) were practiced; there is, however, no known ethnohistoric documentation for this claim. School and community groups visit the enclosure and contribute to its upkeep and preservation. Our research was carried out in close consultation with the local Hawaiian community, and included the participation of Hawaiian cultural practitioners.

Figure 3 is a plan of the main enclosure based on plane table and alidade survey at 1:200. The enclosure is nearly square, with dimensions of 38 by 41.5 m. The walls are well constructed of subrounded basalt boulders (most ranging in size from c. 30-80 cm in diameter), with clear interior and exterior faces varying between 1-1.5 m apart. The relatively uniform size of the boulders suggests that they were carefully selected from the surrounding landscape for this purpose. One to three wall courses are intact, but an additional one to perhaps three courses are represented by fallen stones lying alongside both the inner and outer faces, so that the original wall height was probably about 1 m or slightly higher. The uniform removal of these upper courses around the entire enclosure suggests intentional deconstruction of the wall at some point.

Gaps in the enclosure's walls on the upslope (ENE) and downslope (WSW) sides were made by a bulldozer, probably as part of a dirt road, during the historic ranching period; similarly, a gap in the southeast corner was accidentally bulldozed during a fire-fighting operation. However, a narrower gap in the wall about 2 m wide near the west corner may be a formal entryway into the enclosure.

Aside from a few naturally outcropping basalt boulders, the enclosure's interior is devoid of any surface features, consisting of a gently sloping soil surface which would have been well suited as a seating or assembly area for dozens or possibly more than 100 people. The ground surface drops about 3 m from the upslope (ENE) to the downslope (WSW) wall.

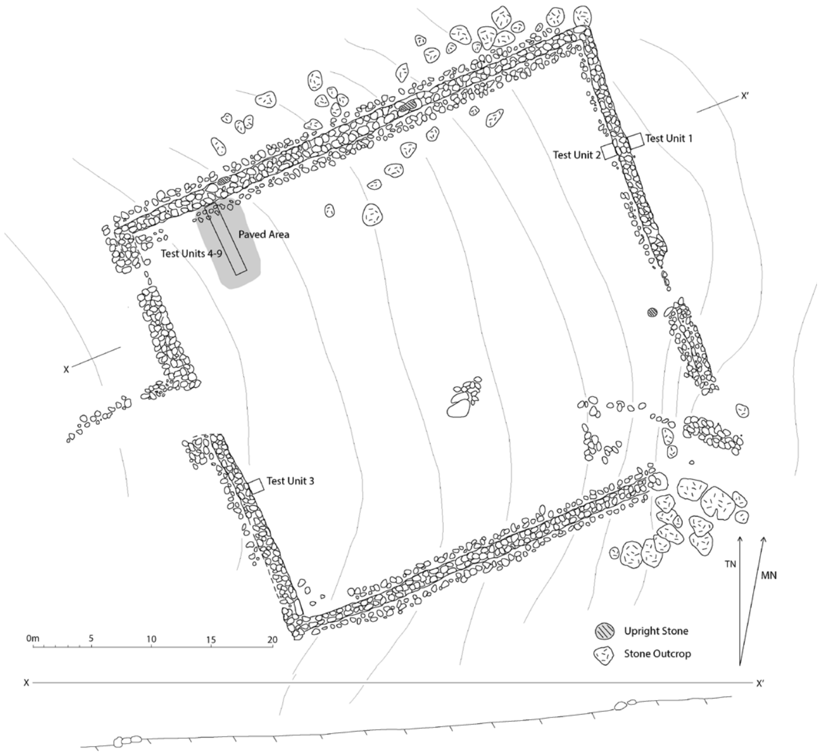

Figure 3. Plan of the enclosure site.

OTHER FEATURES

Approximately 25 m to the NW of the enclosure an artificial alignment of five upright basalt boulders runs WSW–ENE (roughly parallel to the enclosure walls) between a pair of much larger natural outcrop boulders. The upright boulders range from 35-60 cm in height. A cleared, level space fronts the row of uprights to the SSE, as seen in Figure 4. Such rows of uprights are typical of simple *marae* 'temples or shrines' found in various Polynesian islands (Emory 1943). In the Hawaiian Islands, such rows of uprights are rare, although they are known to occur on the remote islands of Nihoa and Necker in the northwestern Hawaiian Islands (Emory 1928), as well as in association with the high-altitude adze quarry site on Mauna Kea (McCoy *et al.* 2009). We interpret this row of uprights as a shrine which may have been related to

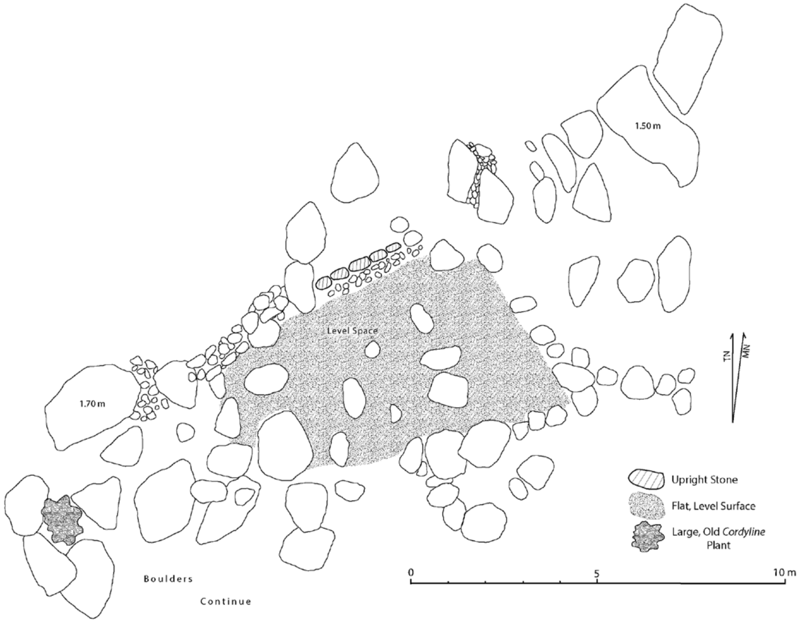

Figure 4. Plan of the small shrine site with row of five upright stones.

the larger, nearby enclosure. We did not excavate at this shrine structure in deference to concerns expressed by our Native Hawaiian collaborators who did not wish to see this structure disturbed by subsurface investigations. It is mentioned here as one of several sites in the area and because of its potential religious significance; however, its relationship to the previously described enclosure remains to be determined.

Other features in the vicinity of the enclosure include short sections of stone wall and possible pre-contact burials represented by spaces between natural boulders filled by compacted small stones. In addition, the enclosure sits at the uphill terminus of Maka‘iwa Gulch, which contains stone platforms and paved areas, as well as possible post-contact and pre-contact burial sites. Within a few hundred metres to the NE of the enclosure the remains of other stone structures, possibly house sites, have been identified. Given the number of such nearby features, it is likely that other sites also existed in this area in the past, but were destroyed by the decades of plantation agriculture and ranching on the mountainside.

THE 2012 EXCAVATIONS

We dug nine 1 m^2 sondages, designated as TP (Test Pits) 1 through 9. Our excavations were situated so as to relate the surface architecture to any subsurface stratigraphy and to obtain dateable materials in contexts that would allow for an estimation of the age and use of the enclosure, following the approach advocated by Dye (2009). Excavation proceeded in 5 cm arbitrary levels within stratigraphic layers, with all artefacts plotted manually in three dimensions. Sediment was dry screened through nested ¼ inch (6.4 mm) and ⅛ inch (3.2 mm) sieves. Four of the nine test pits were placed against the walls of the enclosure, with the others located in the area of a suspected pavement (Fig. 3). We recorded excavation data on pre-printed forms and through photography, but also employed the beta version of a "Codifi" electronic database, developed by the Center for Digital Archaeology at the University of California, Berkeley and adapted specifically for this project. This database, using a FileMaker Go iPad application, allowed us to take pictures and short movies of the test units and other aspects of the excavation using a third-generation iPad, uploading them directly into the database and adding descriptive information in real time.

Test Pits 1 and 2

The first two 1 m^2 units were excavated on either side of the upslope, ENE wall of the enclosure, in an effort to expose the wall base and obtain charcoal for radiocarbon dating. TP-1, on the upslope side, revealed an accumulation of sediment c. 25 cm thick which partially buried the lowest course of wall stones. In TP-2, against the interior wall face, 10 cm of recent, reddish-brown clayey sediment (Layer I) containing a considerable quantity of non-carbonised candlenut (*kukui*) endocarps overlapped the base course of the wall. Beneath this, the sediment adjacent to the wall base became slightly more compact with flecks of charcoal (Layer II); a charcoal sample from 12 cm below the surface was extracted for radiocarbon dating (Beta-326898, see "Dating the Construction of the Enclosure" below). A small bead of *Conus* shell was found in Layer II near the base of the wall.

Test Pit 3

This 1 m^2 unit was excavated against the interior face of the enclosure's WSW wall, on the downslope side of the enclosure where sedimentation against the wall appeared to be greatest. Our aim was to determine the depth of the wall base and to recover dateable charcoal in association with the base of the wall which would inform on timing of the enclosure's construction. The stratigraphic section of TP-3 (Fig. 5) shows an accumulation of between

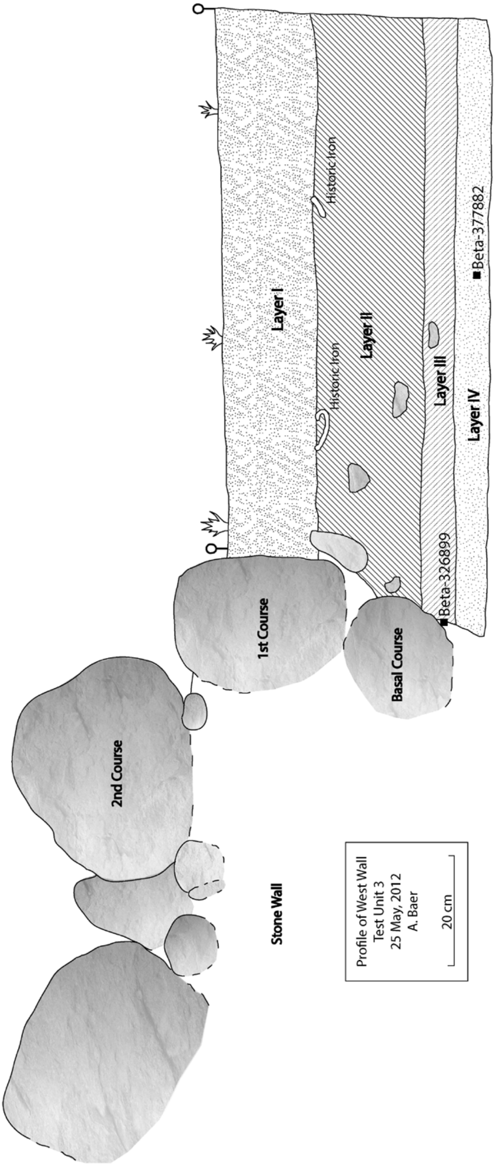

Figure 5. Stratigraphic profile of excavation unit TP-3.

45-48 cm of sediment against the wall face (much greater than at TP-1 and TP-2), burying the lowest boulder course, and consisting of four distinct stratigraphic units. Layer I is a compact, reddish-brown silty clay. At the interface between Layer I and Layer II were two pieces of rusted iron which were deposited on a surface represented by the top of Layer II and prior to the accumulation of Layer I, indicating that the stratigraphic boundary between Layers I and II dates to the historic, ranching period. Layer II was similar in colour to Layer I and also consisted of silty clay, but with larger and more angular peds; it lacked any historic period artefacts. Layer III also consisted of silty clay but with a considerable amount of basalt cobbles and with charcoal flecking throughout; this thin deposit accumulated against the base of the enclosure wall and from it we obtained a sample of charcoal immediately adjacent to the wall base (Beta-326899). Underlying the wall is Layer IV, a dense, hard-packed clay with flecks of charcoal presumably deriving from land clearance or agricultural activities prior to construction of the enclosure; one small concentration of charcoal in Layer IV at 50 cm depth below surface was sampled for radiocarbon dating (Beta-377882). Layer IV represents the original land surface upon which the enclosure was constructed.

Test Pits 4 Through 9

Near the western corner of the enclosure we observed the tops of a few exposed, rounded stones suggesting the presence of a stone pavement (Fig. 6). In addition, during mapping a large piece of branch coral (*Pocillopora* sp.) was found on the surface in this area; such branch coral was used as ritual offerings on Hawaiian temples (Kirch and Sharp 2005). Test Pit 4 confirmed the presence of the paving, shallowly buried under a few centimetres of sediment. We then extended the excavation as a trench (TP-5 to TP-9) to the NNW wall of the enclosure. Small pieces of coral were found throughout the paving. Dateable charcoal was recovered from beneath the top layer of paving stones (samples Beta-326901 and Beta-371023), as well as from sediment immediately adjacent to the inner face of the enclosure wall (Beta-326900). Our excavation was too limited to reveal the full extent of the pavement, but we were able to determine that it does not extend under the NNW wall, and therefore does not predate the enclosure. It is likely that the pavement represents the foundation for some kind of structure (possibly a thatched house) situated within the enclosure.

Figure 6. Area of pavement, TP-4 through TP-9.

DATING THE CONSTRUCTION OF THE ENCLOSURE

Six charcoal samples from Test Pits 2, 3, 5 and 9 were submitted to the International Archaeological Research Institute, Inc. (IARII) in Honolulu for botanical identification, with the aim of selecting charcoal from short-lived, native Hawaiian shrubby species for dating and avoiding old-growth wood (see Bayman and Dye 2013: 32). Identified charcoal samples were AMS radiocarbon dated by Beta Analytic, Inc. Table 1 presents the results of ^{14}C dating, with calibrations using the IntCal13 curve (Reimer *et al*. 2013) at 2σ ranges (95.4% probability). Figure 7 is an Oxcal plot (Bronk Ramsey 2009) of the calibrated probability distributions for the six samples organised by stratigraphic phases.

Interpretation of a suite of radiocarbon ages deriving from the last few centuries poses challenges due to the complex probability distributions that result from multiple intercepts of the radiocarbon ages with the calibration curve. To help interpret the radiocarbon dates reported in Table 1 we applied a

Table 1. Results of radiocarbon dating. Calibrations made with Oxcal version 4.2.3 (Bronk Ramsey *et al*. 2013), using the IntCal13 atmospheric calibration curve (Reimer *et al*. 2013).

Sample number	Provenience (all depths below surface)	Botanical taxon / Hawaiian name	Measured radiocarbon age BP	$^{13}C/^{12}C$ ratio (o/oo)	Conventional radiocarbon age BP	Calibrated age ranges AD (2 σ – 95.4 % probability)
Beta-326898	TP-2E, Level 2; 12 cm; Layer II	cf. *Chamaesyce* sp. / *'Akoko*	102.4 ± 0.4 pMC	-10.4	50 ± 30	1694-1782 (21.8%) 1812-1919 (73.6%)
Beta-377882	TP-3, Level 9; 50 cm; Layer IV (small concentration of charcoal 40 cm from N face of unit)	*Chenopodium oahuense* / *'Āheahea*	440 ± 30	-26.6	410 ± 30	1430-1522 (82.2%) 1578-1583 (0.5%) 1591-1620 (12.1%)
Beta-326899	TP-3E, Level 9; 48 cm; Layer III (associated with wall base stone)	*Chenopodium oahuense* / *'Āheahea*	160 ± 30	-24.6	170 ± 30	1695-1699 (17.3%) 1721-1818 (50.5%) 1833-1880 (8.0%) 1916...(19.6%)
Beta-326901	TP-5, Level 2; 12 cm (within pavement)	cf. *Chamaesyce* sp. / *'Akoko*	90 ± 30	-10.7	320 ± 30	1483-1646 (95.4%)
Beta-371023	TP-5, Level 2; 12 cm (within pavement)	*Cocos nucifera* / *Niu* (coconut)	200 ± 30	-23.6	220 ± 30	1642-1684 (36.7%) 1735-1806 (44.7%) 1933... (14.0%)
Beta-326900	TP-9, Level 4E; 20 cm (adjacent to base wall stones)	cf. *Pittosporum* / *Hō'awa*	240 ± 30	-23.2	270 ± 30	1514-1599 (42.8%) 1617-1669 (46.4%) 1781-1799 (6.2%)

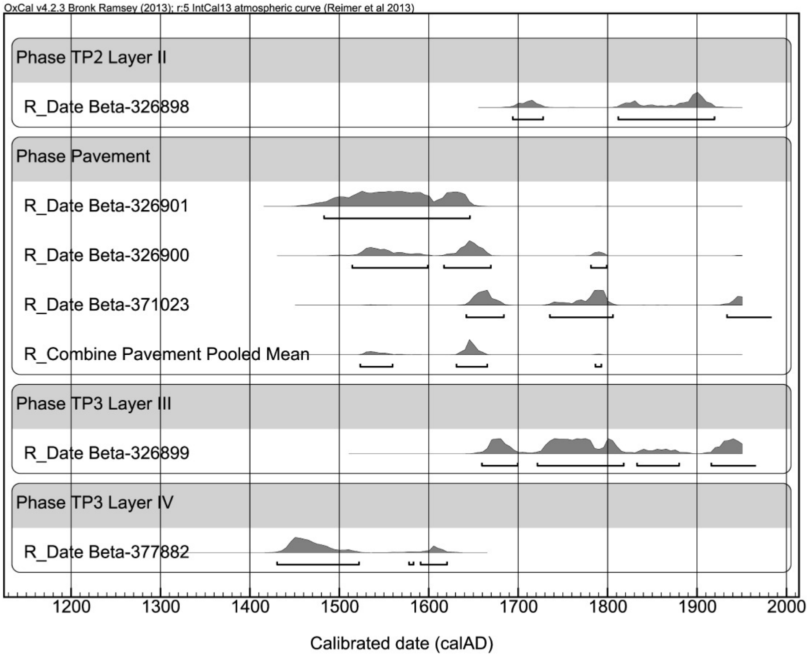

Figure 7. Oxcal plot of the six radiocarbon dates from the enclosure (see text for discussion).

Bayesian statistical approach using the BCal program (Buck *et al.* 1999). We first constructed a chronological model based on the inferred stratigraphic relationships of our six dated samples. Stratigraphically, the oldest context is Layer IV in TP-3 which underlies the enclosure wall and provides a *terminus post quem* (the limit after which) for the wall, while Layer III in TP-3 abuts the base of the wall and provides a *terminus ante quem* (the limit before which) for wall construction. Using the standard symbology of BCal in which α and β represent the maximum and minimum ages (start and end dates) for their particular contexts, we can express the relationship between the Layers IV and III and the enclosure wall as follows: $\alpha_1 \geq \beta_1 \geq \text{wall} \geq \alpha_2 \geq \beta_2$, where α_1 and β_1 refer to lower and upper boundary parameters of Layer IV and α_2 and β_2 refer to lower and upper boundary parameters of Layer III. Sample Beta-377882, in Layer IV, provides an estimate (θ_1) of an (unknown) date γ_1 in the range α_1 to β_1, while sample Beta-326899, in Layer III, provides an estimate (θ_2) of some γ_2 in the range α_2 to β_2. The relationship $\gamma_1 \geq$ wall $\geq \gamma_2$ allows us to derive the prior model $\theta_1 \geq$ wall $\geq \theta_2$. Similarly, Layer III in TP-3 (θ_2) and the pavement exposed in TP-5 to TP-9 (θ_3, θ_4 and θ_5) 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. The age of the pavement context (θ_3, θ_4 and θ_5) is estimated by radiocarbon samples Beta-326901, -326900 and -371023. Finally, the shallow context of Layer II in TP-2 (θ_6) is modelled as being the latest phase in the site chronology and its age is estimated by Beta-326898. We further constrained the model with two floating parameters: φ_1 is the best current estimate for the date of initial Polynesian colonisation of the Hawaiian Islands, set at 1050 ± 100 BP (Athens *et al.* 2014), while φ_2 is the beginning of the post-contact ranching period on O'ahu, set at 90 ± 25 BP, by which time the Pālehua area was known to have been abandoned by Native Hawaiians (Von Holt 1985). In our model, these floating parameters set lower and upper bounds on the possible time frame for the construction and use of the enclosure.

Based on this Bayesian model of the inferred stratigraphic relationships between our sample contexts, BCal calculates the highest posterior density (HPD) regions at 95% and 67% probabilities for the various parameters as reported in Table 2. Most importantly, construction of the enclosure wall is bracketed by β_1 (509-372 BP at 95%) and α_2 (442-146 BP at 95%). The radiocarbon date from TP-3, Layer III (parameter θ_2) indicates that this deposit accumulated against the inner face of the enclosure wall between 290-249 or 229-135 BP. While the three dates from the pavement area all have multiple intercepts, parameters θ_3 to θ_5 all have HPD regions that range between 422-150 BP with pronounced peaks at around 300 BP, strongly supporting an interpretation of main site use in the mid-17th century AD Continued use of the site into the early post-contact period is suggested by the date from TP-2 (θ_6), with 95% HPD regions of 135-113, 108-98 and 83-31 BP.

In sum, the six radiocarbon age determinations from the enclosure, when modelled with a Bayesian approach, yield an internally consistent chronology. From our BCal analysis we infer that the enclosure was constructed not earlier than AD 1500 and not later than AD 1804. The main period of site use involving the pavement area dates to the mid-17th century, although use of the site may have continued into the early 19th century.

Table 2. Highest Posterior Density (HPD) estimates for modelled stratigraphic groups.

Stratigraphic model group	Event	HPD 95% (BP)	HPD 67% (BP)
TP-3, IV	α1	978-964, 927-917, 01-889, 887-871, 869-451	657-644, 635-470
	θ1	517-453	508-479
	β1	509-372	496-434
TP-3, III	α2	442-146	333-261, 249-189
	θ2	290-249, 229-135	282-266, 215-193, 191-170
	β2	272-243, 218-66	190-103
Pavement	α3	466-314	429-385, 375-363, 348-327
	θ3	415-299	367-350, 336-305
	θ4	422-391, 389-376, 372-357, 331-283, 166-155	320-285
	θ5	308-268, 213-196, 188-150	303-276
	β3	272-243, 218-66	190-103
TP-2, II	α4	179-35	95-46
	θ6	135-113, 108-98, 83-31	70-37
	β4	103-86, 83-1	103-86, 83-1

ORIENTATION OF THE ENCLOSURE

Initial estimates of the orientations of the enclosure walls and other potentially meaningful alignments at the site were obtained by Kirch using a Suunto compass-clinometer and confirmed by GPS readings. Ruggles then visited the site independently on 13 January 2013 in order to carry out an accurate archaeoastronomical survey using a Leica TCR1205 Total Station. The instrument was set up close to the centre of the enclosure and due north was accurately determined by a series of timed observations of the sun—a standard procedure in archaeoastronomy (Ruggles 1999b: 164-71). Sequences of surveyed points along segments of intact wall facing were used to obtain best estimates of the intended orientation of the walls. Segments of intact wall facing were identified along the inner faces of all four walls and on parts of the outer faces of all but the WSW wall. Historically introduced *Eucalyptus*

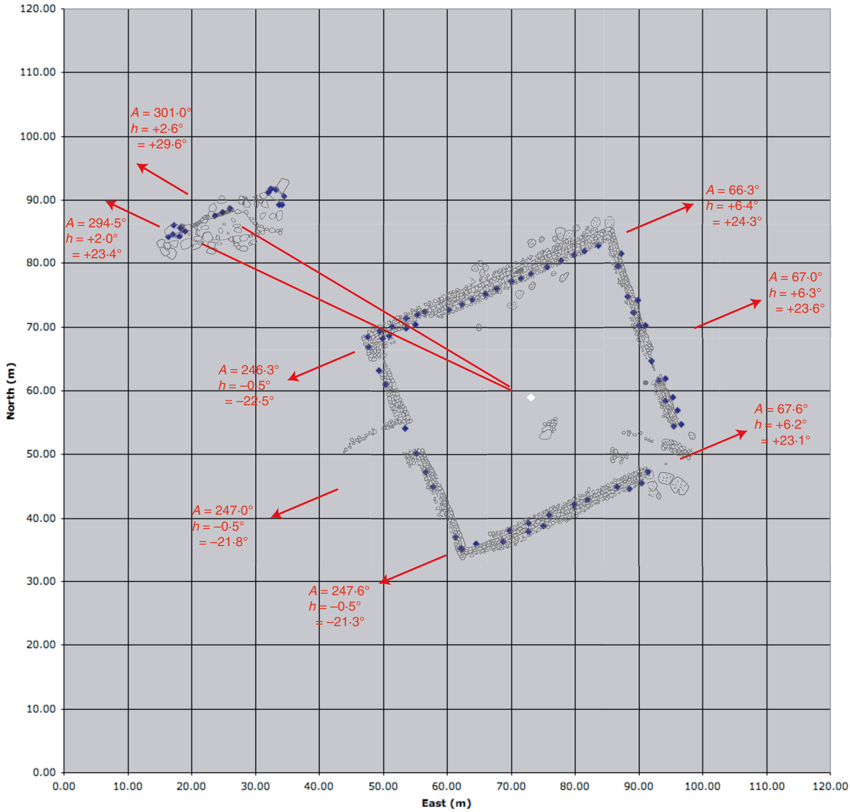

Figure 8. Points on intact wall facings fixed in the archaeoastronomical survey, plotted on a grid oriented in the true cardinal directions with the survey station at (70, 60). The annotations indicate the azimuth (A), horizon altitude (h) and declination (δ) in potentially significant directions.

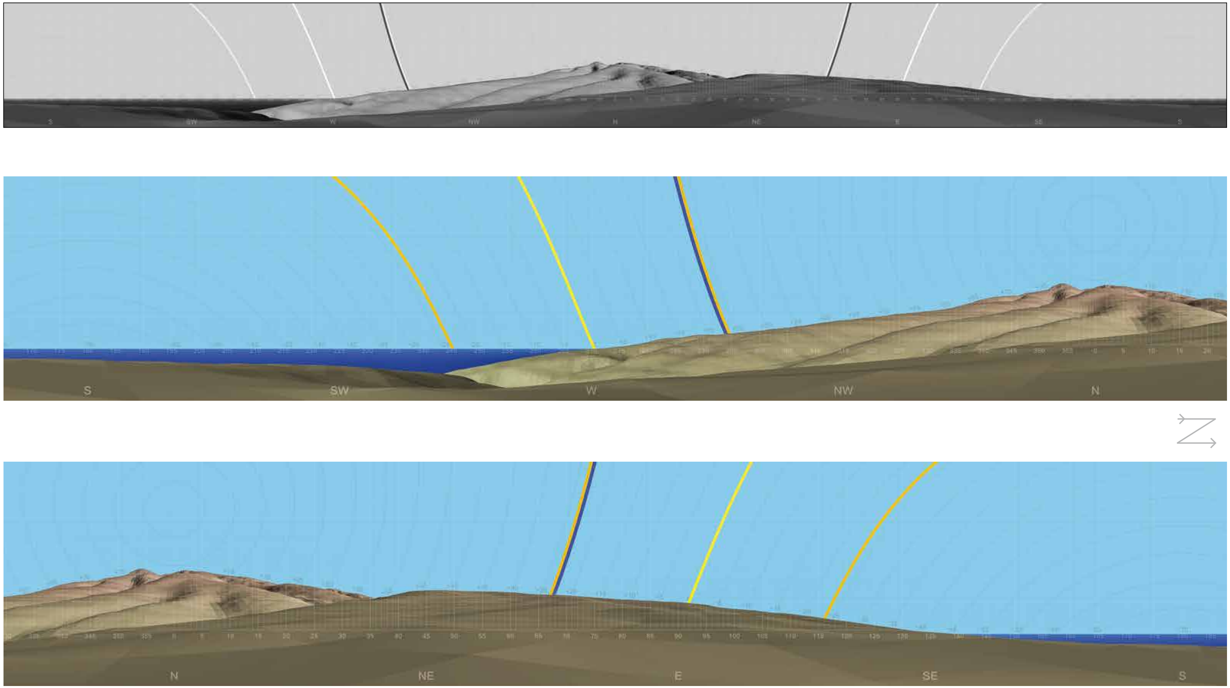

Figure 9. The distant horizon profile, generated digitally from DTM data by Andrew Smith. The darker yellow lines indicate the rising and setting paths of the sun at the solstices. The lighter yellow lines indicate the rising and setting paths of the sun at the equinoxes. The blue lines adjacent to the June solstice rising and setting lines indicate the rising and setting paths of the Pleiades. All paths are calculated for AD 1600.

trees obscure the distant horizon in most directions, but Andrew Smith of the University of Adelaide kindly generated a digital horizon profile from the 1: 24000 USGS Digital Terrain Model (DTM) data using the latest version of his program specifically developed for this purpose (e.g., Pimenta *et al*. 2009). This permitted us to visualise the visible distant horizon in the absence of tall exotic vegetation and to reliably estimate horizon altitudes in particular directions. Ground-truthing (checking or verifying) at the site established that the relevant distant profiles would not have been obscured by local areas of higher ground too small to be resolved using the DTM data. Astronomical declinations were calculated using Ruggles's GETDEC program (Ruggles 1999b: 169; see www.cliveruggles.net).

The spatial distribution of the surveyed points is shown in Figure 8, annotated with the azimuths, altitudes and declinations in potentially significant directions. The digitally generated horizon profile is shown in Figure 9.

Enclosure Alignment to the ENE

For the inner face of the NNW wall, the best-fit azimuth based on 17 measured points, well-spaced along the wall, is 66.3°/246.3°, as determined by least-squares fitting using perpendicular offsets (see http://mathworld.wolfram.com/LeastSquaresFittingPerpendicularOffsets.html). The horizon to the ENE has an altitude of +6.4° (Fig. 10), which corresponds to a declination of +24.3°. Nine measurable points were identified along the inner face of the SSE wall, yielding a best-fit azimuth of 67.6°/247.6° and a corresponding ENE declination of +23.1°. Taking the best estimate of the intended orientation as the mean of the azimuths of the two walls, i.e., 67.0°, the corresponding ENE declination is +23.6°.

The data from the outer faces of the two walls are less reliable. The outer face of the NNW wall could only be identified within c. 10 m of the WSW end; six measurable points here yield a best-fit azimuth of 65.7°, reflecting a slight convexity in the wall as a whole that is also evident from the inner face points. The outer face of the SSE wall could not be identified with certainty. Five widely spaced plausible points yield a best-fit azimuth of +67.0°, but the points on the inner face certainly provide the more reliable estimate of the intended azimuth of this wall.

The declination of the centre of the June solstice sunrise around AD 1600 was +23.5°; it has decreased very slightly, by about 0.05°, in the intervening 400 years owing to the changing tilt of the earth's axis with respect to the plane of its orbit around the sun, that is, the obliquity of the ecliptic. The apparent diameter of the sun being close to 0.5°, the path of the June solstice sun across the sky, corresponds to the strip between declinations +23.25° and

+23.75°, as can be seen in Figure 10. It is clear, then, that the enclosure was accurately aligned upon the rising sun at the June solstice.

However, this direction is also close to the rising point of the Pleiades. The seven stars in this cluster span a declination range of 0.6°, so that the apparent width of the cluster as it passes across the sky is similar to that of the sun (or moon). In AD 1500 the declination range covered by the Pleiades was +22.3° to +22.9°, but this changes significantly over the centuries owing to the changing orientation of the earth's axis with respect to the distant stars

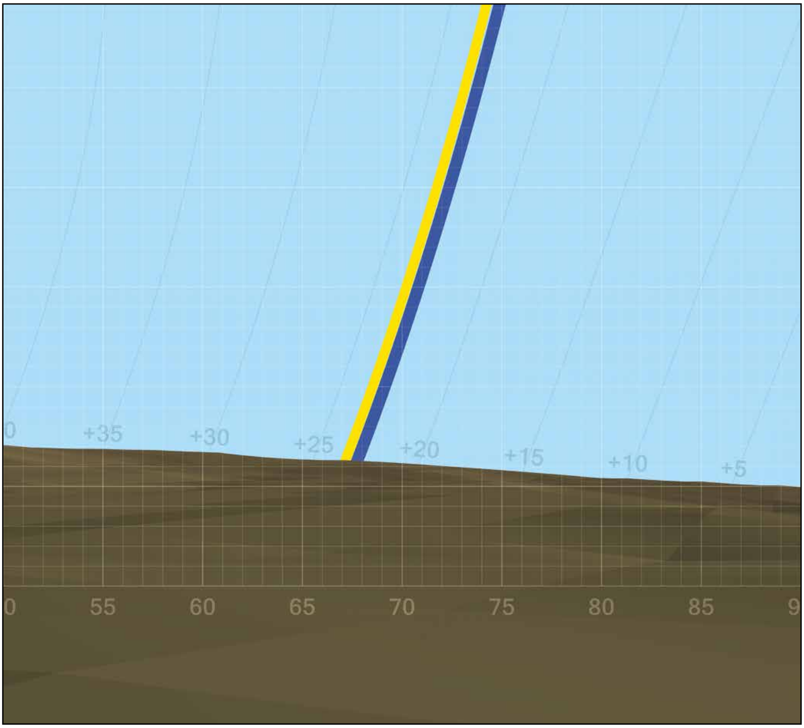

Figure 10. Magnified section of the digitally generated horizon profile, between azimuths 55° and 80°. Lines of constant azimuth, altitude and declination are visible. Vertical lines represent azimuths at 1° intervals, annotated by numbers at the bottom of the grid. Horizontal lines represent altitudes at 1° intervals, with the line at the foot of the grid representing 0°. Curved lines above the horizon represent declinations, again at 1° intervals, annotated at the horizon.

(that is, the precession of the equinoxes). By AD 1550 the Pleiades spanned the declination range +22.5° to +23.1°; by 1600 +22.6° to +23.2° and by 1650 +22.8° to +23.4°.

While the mean orientation of the enclosure to the ENE (declination +23.6°) seems to correspond more closely to the June solstice sunrise than the Pleiades, the cluster would have risen in line with the SSE wall (declination +23.1°) from about AD 1550 onwards, ceasing to do so in about AD 1720.

Other Alignments

In the opposite direction, to the WSW, the alignment misses the direction of December solstice sunset by between 1° and 2.5° in azimuth, or about 2 to 5 solar diameters (see Fig. 8 for horizon altitude and declination data). The orientations of the perpendicular walls to the NNW and SSE are well outside the solar range. Thus, the obvious astronomical potential in relation to the sun or the Pleiades is confined to the ENE direction.

As viewed from the geometrical centre of the enclosure, the top of a large outcrop boulder visible to the left of the small shrine consisting of five upright boulders described earlier (azimuth 294.5°, horizon altitude +2.0°, declination +23.4°) sits squarely at the setting position of the June solstice sun (the boulder is indicated in Figure 4, with a height of 1.7 m above ground). Also, the left-hand side of the boulder (azimuth 293.9°, horizon altitude +1.9°, declination +22.8°) was in line with the setting position of the Pleiades throughout the period AD 1500 to 1650. It has to be noted, however, that no structure has been found marking the geometrical centre of the enclosure and there is currently no independent reason to select the left-hand boulder—rather than, say, the shrine centre or the right-hand boulder—as the potential target.

In summary, the mean axis of the enclosure is accurately aligned upon the June solstice sunrise to the ENE. However, the NNW and SSE walls are not quite parallel, and the SSE wall is itself better aligned upon the rising position of the Pleiades between about AD 1550 and 1720, a range that includes the most likely date of construction of the wall. There is no obvious relationship with the solstitial sun in the opposite (WSW) direction for that time period, but as viewed from the geometrical centre of the enclosure, the large boulder to the left of the shrine is aligned with June solstice sunset and the setting position of the Pleiades.

DISCUSSION

Hawaiian ethnohistoric sources indicate the existence of special gathering places where members of an *ahupua'a* community would assemble during the Makahiki period, especially for the offering of tribute to the Lono priests and for various sports, games and other ceremonies associated with this important ritual period. The evidence obtained from the large upland enclosure at Honouliuli is consistent with this site having been such a Makahiki assembly place. The structure is monumental in scale (requiring substantial labour to construct) and thus likely to have served an entire community, rather than just a few households. Its morphology, however, does not resemble that of typical Hawaiian *heiau* 'temples' (Kirch 1985, McAllister 1933); rather, the large open enclosure seems designed as a gathering space. The presence of branch coral is also suggestive of ritual activity. Radiocarbon dates indicate that the enclosure was most likely constructed between the late 16th to early 17th centuries, with a well-attested period of use involving the pavement of the mid-17th century; these dates correspond to the Late Expansion to Proto-Historic Periods of the Hawaiian cultural sequence (Kirch 1985).

The archaeoastronomical evidence strongly supports this conclusion. During this time interval, the enclosure is aligned upon the rising position of the Pleiades, with the SSE wall being precisely aligned upon the point on the horizon at which the star cluster first appeared above the horizon, and the axial orientation of the enclosure is only half a degree further to the left. The acronychal rise (rising at sunset) of the Pleiades each November marked the beginning of the Makahiki season.

Given that, at around AD 1600, the declination of the Pleiades is close to that of the June solstice sunrise (Ruggles 2014b), it could also be argued that the enclosure axis was solstitially aligned. However, while there is firm evidence of systematic solstitial orientations being used for calendrical regulation in Mangareva (Kirch 2004b), in Hawaiʻi ethnographic references to solstitial observations are very rare. Emerson (1909: 197) refers to sunrise observations being used to mark the passage of the seasons, using lava pillars at Cape Kumukahi on the Big Island (Emerson 1909: 197). A second reference is by Kamakau (1976: 14) regarding a hill called Puʻu o Kapolei, situated within Honouliuli, the same *ahupuaʻa* as the Pālehua enclosure (but at a lower altitude, closer to the ocean). According to Kamakau, "When the sun moved south from Puʻuokapolei—and during the season of the sun in the south—for the coming of coolness and for the sprouting of new buds on growing things—the season was called Hoʻoilo" (p. 14). Although no further details are provided, this does hint at the practice of solar observation to determine the Kau (approximately summer) and Hoʻoilo (broadly winter) seasons of the calendar, at least on Oʻahu. While we cannot therefore discount the possibility that the solstitial alignments also were of significance in Hawaiʻi, the ethnographic evidence for the most part strongly favours the conclusion that it was the alignment on the rising of the Pleiades that was of paramount importance at the Honouliuli enclosure.

Our radiocarbon chronology for the enclosure—while not extremely precise—is nonetheless consistent with our astronomical findings, with enclosure construction most likely occurring during the late 16th to early 17th centuries. The early AD 1600s saw the likely peaking and stabilisation of population on O‘ahu, the expansion of settlements into leeward and marginal zones, and a considerable investment in monumental architecture (Kirch and McCoy 2007). Kirch (2010) has suggested that the construction of temples relating to the worship of the god Lono and the Makahiki period, supporting the related annual extraction of taxes and tribute, were likely to have been part of a strategy of consolidation of power by an archaic state. It is noteworthy that in the Kahikinui and Kaupō districts on the island of Maui, there are over 60 small temples, of which a significant proportion are oriented within a few degrees of the rising position of the Pleiades, and have been identified as Lono temples (Kirch 2004a, Ruggles 2007). The majority of these temples have been precisely dated by U-series dating of coral offerings to the period between AD 1550–1600 (Kirch and Sharp 2005, Kirch *et al*. 2015). McCoy (2008) has documented a solstice and Pleiades-oriented *heiau* at Kalaupapa, Moloka‘i Island, as well as institution of the Makahiki ritual complex there immediately after subjugation of Kalaupapa by an O‘ahu chief. Archaeological evidence from the Leeward Kohala Field System on Hawai‘i Island is also consistent with the notion that *heiau* were constructed for Lono-centred worship (McCoy *et. al*. 2011). The enclosure at Honouliuli thus suggests that what has been evident in the dryland areas of the eastern islands of Maui and Hawai‘i (Big Island) was also occurring in the uplands of west O‘ahu at around the same time.

* * *

The orientation of the enclosure in the uplands of Honouliuli, O‘ahu, taken together with the radiocarbon evidence, strongly suggests that the enclosure was purposely and precisely laid out in alignment with the rising of the Pleiades, and that it was used for ceremonies in association with the Makahiki ritual season during the last one to two centuries before European contact. This research adds to our understanding of the changing ideological structures that accompanied, and helped to facilitate, the development of archaic states in the Hawaiian Islands a mere two centuries before the arrival of the Europeans.

ACKNOWLEDGEMENTS

We thank Gill Ewa Lands, LLC for access to the land and for financial support; Pacific Legacy, Inc. for the loan of excavation equipment; our research team; and Thomas Anuheali'i and others for their cultural protocols throughout the excavations. Ruggles is grateful to Tony Gill for guidance to the site and assistance with the archaeoastronomical survey. He also thanks Jo Lynn Gunness at the Department of Anthropology at the University of Hawai'i, Mānoa, for the loan of the Total Station. We thank Andrew Smith of the University of Adelaide for generating the digital horizon profile.

REFERENCES

Athens, J.S., T.M. Rieth and T.S. Dye, 2014. A paleoenvironmental and archaeological model-based age estimate for the colonization of Hawai'i. *American Antiquity* 79: 144-55.

Bayman, J. and T. Dye, 2013. *Hawaii's Past in a World of Pacific Islands*. Washington DC: The Society for American Archaeology.

Bronk Ramsey, C., 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51: 337-60.

Bronk Ramsey, C., M. Scott and H. van der Plicht, 2013. Calibration for archaeological and environmental terrestrial samples in the time range 26-50 ka cal BP. *Radiocarbon* 55(4): 2021-27.

Buck C.E., J.A. Christen and G.N. James, 1999. BCal: An on-line Bayesian radiocarbon calibration tool. *Internet Archaeology*, 7. (http://intarch.ac.uk/journal/issue7/buck/).

Dye, T.S., 2009. Traditional Hawaiian surface architecture: Absolute and relative dating. In T.S. Dye (ed.), *Research Designs for Hawaiian Archaeology*. Honolulu: Society for Hawaiian Archaeology, pp. 93-160.

Emerson, N.B., 1909. *Unwritten Literature of Hawaii: The Sacred Songs of the Hula*. Washington DC: Government Printing Office.

Emory, K.P., 1928. *Archaeology of Nihoa and Necker Islands*. Bernice P. Bishop Museum Bulletin 53. Honolulu.

——1943. Polynesian stone remains. In C.S. Coon and J.M. Andrews IV (eds), *Studies in the Anthropology of Oceania and Asia: Presented in Memory of Roland Burrage Dixon*. Papers of the Peabody Museum of American Archaeology and Ethnology, Vol. XX. Cambridge: Harvard University, pp. 9-21.

Handy, E.S.C. and E.G. Handy, 1972. *Native Planters in Old Hawai'i: Their Life, Lore, and Environment*. Bernice P. Bishop Museum Bulletin 233. Honolulu.

Hommon, R.J., 2013. *The Ancient Hawaiian State*. Oxford: Oxford University Press.

Kamakau, S.M., 1964. *Ka Po'e Kahiko: The People of Old*. Translated by M.K. Pukui. Bernice P. Bishop Museum Special Publication 51. Honolulu.

——1976. *The Works of the People of Old: Na Hana a ka Po'e Kahiko*. Translated by M.K. Pukui. Bernice P. Bishop Museum Special Publication 61. Honolulu.

Kepelino, K., 1932. *Kepelino's Traditions of Hawaii*. Edited by Martha Beckwith. Bernice P. Bishop Museum Bulletin 95. Honolulu.

Kirch, P.V., 1985. *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory.* Honolulu: University of Hawai'i Press.

——2004a. Temple sites in Kahikinui, Maui, Hawaiian Islands: Their orientations decoded. *Antiquity* 78: 102-14.

——2004b. Solstice observation in Mangareva, French Polynesia: New perspectives from archaeology. *Archaeoastronomy* 18: 1-19.

——2010. *How Chiefs Became Kings: Divine Kingship and the Rise of Archaic States in Ancient Hawai'i*. Berkeley: University of California Press.

——2012. *A Shark Going Inland Is My Chief: The Island Civilization of Ancient Hawai'i.* Berkeley: University of California Press.

Kirch, P.V. and R.C. Green, 2001. *Hawaiki, Ancestral Polynesia: An Essay in Historical Anthropology*. Cambridge: Cambridge University Press.

Kirch, P.V. and M. McCoy, 2007. Reconfiguring the Hawaiian cultural sequence: Results of re-dating the Halawa dune site (MO-AI-3), Moloka'i Island. *Journal of the Polynesian Society* 116: 385-406.

Kirch, P.V., R. Mertz-Kraus and W.D. Sharp, 2015. Precise chronology of Polynesian temple construction and use for southeastern Maui, Hawaiian Islands determined by ^{230}Th dating of corals. *Journal of Archaeological Science* 53: 166-77.

Kirch, P.V. and W.D. Sharp, 2005. Coral ^{230}Th dating of the imposition of a ritual control hierarchy in precontact Hawaii. *Science* 307: 102-04.

Makemson, M.W., 1941. *The Morning Star Rises: An Account of Polynesian Astronomy*. New Haven: Yale University Press.

Malo, D., 1951. *Hawaiian Antiquities*. Bernice P. Bishop Museum Special Publication 2. Honolulu.

McAllister, J.G., 1933. *Archaeology of Oahu*. Bernice P. Bishop Museum Bulletin 104. Honolulu.

McCoy, M., 2008. Life outside the temple: Reconstructing traditional Hawaiian ritual and religion through new studies of ritualized practices. In R. Fogelin (ed.), *Religion, Archaeology and the Material World.* Occasional Paper No. 36, Center for Archaeological Investigations, Southern Illinois University, Carbondale, Illinois, pp. 261-78.

McCoy, M., T. Ladefoged, M. Graves and J.W. Stephen, 2011. Outside strategies for constructing religious authority in ancient Hawai'i. *Antiquity* 85: 927-41.

McCoy, P.C., M.I. Weisler, J. Zhao and Y. Feng, 2009. ^{230}Th dates for dedicatory corals from a remote alpine desert adze quarry on Mauna Kea, Hawai'i. *Antiquity* 83: 445-57.

Pimenta, F.L. Tirapicos and A. Smith. 2009. A Bayesian approach to the orientations of central Alentejo megalithic enclosures. *Archaeoastronomy: The Journal of Astronomy in Culture* 22: 1-20.

Reimer, P.J., E. Bard, A. Bayliss, J.W. Beck, P.G. Blackwell, C. Bronk Ramsey, P.M. Grootes, T.P. Guilderson, H. Haflidason, I. Hajdas, C. Hatté, T.J. Heaton, D.L. Hoffmann, A.G. Hogg, K.A. Hughen, K.F. Kaiser, B. Kromer, S.W. Manning, M. Niu, R.W. Reimer, D.A. Richards, E.M. Scott, J.R. Southon, R.A. Staff, C.S.M. Turney, and J. van der Plicht. 2013. IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0-50,000 Years cal BP. *Radiocarbon* 55(4): 1869-887.

Ruggles, C.L.N., 1999a. Astronomy, oral literature, and landscape in ancient Hawai‘i. *Archaeoastronomy: The Journal of Astronomy in Culture* 14: 33-86.

——1999b. *Astronomy in Prehistoric Britain and Ireland*. New Haven and London: Yale University Press.

——2007. Cosmology, calendar, and temple orientations in ancient Hawai‘i. In C.L.N. Ruggles and G. Urton (eds), *Skywatching in the Ancient World: New Perspectives in Cultural Astronomy*. Boulder: University Press of Colorado, pp. 287-329.

——2014a. Archaeoastronomy in Polynesia. In C.L.N. Ruggles (ed.), *Handbook of Archaeoastronomy and Ethnoastronomy.* New York: Springer, pp. 2231-245.

——2014b. Ancient Hawaiian astronomy. In C.L.N. Ruggles (ed.), *Handbook of Archaeoastronomy and Ethnoastronomy*. New York: Springer, pp. 2247-260.

Sahlins, M., 1995. *How "Natives" Think: About Captain Cook, for Example*. Chicago: University of Chicago Press.

Sterling, E.P. and C.C. Summers, 1978. *Sites of Oahu*. Honolulu: Bishop Museum Press.

Tulchin, J. and H. Hammatt, 2007. Literature Review and Field Inspection of an Approximately 790-Acre Parcel at Pālehua, Honouliuli Ahupua‘a, ‘Ewa District, Island of Oahu TMK: [1] 9-2-003:002 por. and 005 por. Unpublished report prepared for James Campbell Company.

——2008. Archaeological Literature Review and Field Inspection of Approximately 809 Acres of Kahe Ranch Land, Honouliuli Ahupua‘a, ‘Ewa District, Island of O‘ahu TMK: [1] 9-2-003: 004, 009, 029, 084 por., and 085. Unpublished report prepared for James Campbell Company.

Valeri, V., 1985. *Kingship and Sacrifice: Ritual and Society in Ancient Hawaii*. Chicago: University of Chicago Press.

Von Holt, I.E.K., 1985. *Stories of Long Ago: Niihau, Kauai, Oahu*. Honolulu: Daughters of Hawai‘i.

ABSTRACT

The Hawaiian people before Western contact gathered at special places during the Makahiki period, a time that was sacred to the god Lono, and during which sports, games and other ceremonies took place. Archaeological excavation and archaeoastronomical investigation together suggest that an approximately 40 m^2 rock enclosure in the uplands of Honouliuli on the island of O‘ahu was such a special gathering place. Radiocarbon dating indicates that the enclosure was most likely constructed between the late AD 1500s and early AD 1600s, with a notable period of use during the mid-AD 1600s. The archaeoastronomical evidence supports this conclusion, in that the enclosure is precisely aligned upon the horizon rising point in AD 1600 of the Pleiades star cluster (Makali‘i in Hawaiian), whose first appearance each November marked the beginning of the four-month Makahiki "annnual harvest" period dedicated to the god Lono. That time period saw the peaking and stabilisation of population on O‘ahu, and the expansion of settlements into marginal environmental zones such as Honouliuli. A significant number of temples built around the same time on the island of Maui are oriented in a similar manner.

Keywords: Archaeoastronomy, Hawaiian religion, monumental architecture, Hawaiian archaeology, Polynesian religion

CITATION AND AUTHOR CONTACT DETAILS

Gill,[1] Timothy M., Patrick V. Kirch,[2] Clive Ruggles[3] and Alexander Baer,[4] 2015. Ideology, ceremony and calendar in pre-contact Hawai‘i: Astronomical alignment of a stone enclosure on O‘ahu suggests ceremonial use during the Makahiki season. *Journal of the Polynesian Society* 124(3): 243-268; DOI: http://dx.doi.org/10.15286/jps.124.3.243-268

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