# RE-DATING OF THE KULI‘OU‘OU ROCKSHELTER, O‘AHU, HAWAI‘I: LOCATION OF THE FIRST RADIOCARBON DATE FROM THE PACIFIC ISLANDS

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In the early 1950s, Kenneth Emory excavated a number of rockshelters along southeastern O‘ahu, Hawaiian Islands (Emory and Sinoto 1961). Among these, Kuli‘ou‘ou Rockshelter (O1) has a certain status as the first archaeological site in the Pacific Islands to be directly dated via the then newly introduced radiocarbon method (Fig. 1). The date of 946 ± 180 before 1950 (Lab sample identifier: Chicago C550; Emory and Sinoto 1961: 14-15, Fig. 11) from the base of the rockshelter's cultural deposit (Emory and Sinoto 1961, Fig. 6) greatly influenced archaeologists' views of regional cultural sequences in East Polynesia. The suggestion of a 1,000 year prehistory in the islands and the ability to directly date cultural materials "…..opened up undreamed possibilities for reconstructing the prehistory of the area," as Emory and colleagues (Emory, Bonk and Sinoto 1959: ix) so aptly stated. Largely ignored at the time was a second, much later radiocarbon date from the site of "AD 1739 ± 150" as reported by Emory and Sinoto (1961: 15).

Over the last three decades archaeologists have debated "long" versus "short" chronology models for the settlement of East Polynesia, including Hawai‘i, stimulating many to re-analyse and re-date sites originally excavated and dated in the 1950s, 60s, and 70s. This work has led to a revised understanding of the colonisation period for Hawai‘i, with an emerging consensus that the archipelago was settled after AD 800–1000 (Athens, Rieth and Dye 2014; Dye 2011; Kirch 2011; Mulrooney, Bickler, Allen *et al*. 2011; Rieth, Hunt, Lipo *et al*. 2011; Wilmshurst, Hunt, Lipo *et al*. 2011a, 2011b). This research stimulated our renewed interest in re-dating the use of Kuli‘ou‘ou Rockshelter. Even if correct, the wide error range for the early

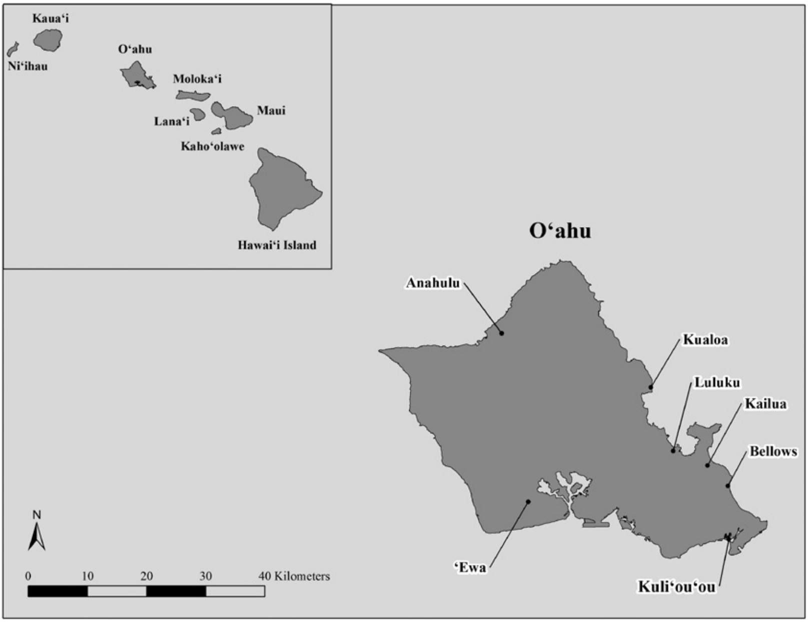


Figure 1. Map of the Hawaiian Archipelago displaying the location of Kuli‘ou‘ou Rockshelter and the earliest reliably dated sites on O‘ahu. Anahulu (Kirch 1992), Kualoa (Carson and Athens 2007), Luluku (Leidemann, Hartzell, Gordon *et al.* 2003), Kailua (Athens n.d.), Bellows (Dye and Pantaleo 2010), ‘Ewa (Athens, Ward, Tuggle *et al.* 1999; McDermott, Shideler, Winieski *et al.* 2000).

Site O1 date (see discussion below) had led archaeologists to argue for the need to re-date the lower Kuli‘ou‘ou deposits using modern $^{14}C$ methods (Kirch 2011, Kirch and McCoy 2007).

This paper presents the results of six new AMS $^{14}C$ dates run on charcoal of identified short-lived and medium-lived species. We utilise these data, along with a re-evaluation of the two dates obtained by Emory and Sinoto, to present a revised chronology for the Kuli‘ou‘ou Rockshelter. In addition, we discuss the implications of new wood charcoal identifications from the two lower deposits at the O1 rockshelter for illuminating general vegetation patterns in the Expansion to Proto-Historic periods. Finally, the broader implications of our revised chronology are considered for the prehistoric sequence of O‘ahu Island and in the larger context of the settlement sequence for the Hawaiian archipelago (see Fig. 1).

## HAWAIʻI AND THE EAST POLYNESIAN CHRONOLOGY DEBATE

The development of a robust, reliable chronology for Hawaiʻi and East Polynesia has had a long history, with advances made as new techniques have become available and with greater attention being paid to the specific materials dated and their contexts. During the last half century, estimates for the Polynesian colonisation of Hawaiʻi have ranged from the claim of Emory *et al*. (1959) for a settlement at South Point dating to AD 124 ± 60 to Wilmshurst *et al*.'s (2011a, 2011b) recent assertion that the archipelago was not discovered by Polynesians until after c. AD 1200. Certainly, there is no longer any reliable empirical support for claims that Hawaiʻi was settled during the first few centuries AD (*contra* Graves and Addison 1995; Hunt and Holsen 1991; Kirch 1985, 1986). Current debates focus on a c. 300-400 year span for colonisation between roughly AD 950-1200 (Athens *et al*. 2014; Dye 2011; Kirch 2011; Mulrooney *et al*. 2011; Rieth *et al.* 2011; Wilmshurst *et al*. 2011a, 2011b).

Kirch (2011; see also Kirch 1986) summarises the history of archaeological estimates for the colonisation of Hawaiʻi, contextualising these investigations within the regional frameworks for East Polynesia as a whole. Two issues have clearly driven these estimates and ensuing: (i) the substantive issue of the geographical structure of East Polynesian colonisation that is as much based on linguistic and comparative ethnographic data as archaeological data and (ii) the technical improvements in radiocarbon dating and their application to the archaeological record.

For multiple reasons including linguistic phylogenies, oral histories, comparative ethnography, and general geography, the origination point of the Polynesian voyagers who discovered Hawaiʻi is Central East Polynesia, namely the Society and Marquesas archipelagos. This fact has often caused mentally elastic interpretations of chronometric data from Hawaiʻi and Central East Polynesia in order to conform to a contemporary orthodoxy (see Kirch 1986 for a well-articulated summary). Logically, the earliest evidence for human colonisation in Hawaiʻi has to post-date similar evidence in Central East Polynesia.

Although the geographical pattern of East Polynesian colonisation is robust, the first several decades' of radiocarbon dates (1950s-1980s), and subsequent re-evaluations of these original data, created a bed of sand for a chronological foundation. This is not meant as a critique of the pioneering archaeological work, but rather is knowledge gained by 50+ years of refinement to radiocarbon dating technology and its application by archaeologists. The initial series of dates for most East Polynesian archipelagos are fraught with imprecision (i.e., large standard errors) and likely inaccuracy (e.g., inbuilt age, lack of correction for isotopic fractionation, etc.).

Spriggs and Anderson's (1993) application of a chronometric hygiene method and more recently the use of a dating sample classification approach by Wilmshurst *et al*. (2011a) and Rieth *et al*. (2011) are two approaches to identifying reliable and problematic dates based on technological and sample-selection issues. Dye's (2011, Dye and Pantaleo 2010) application of Bayesian calibrations, as a model-based method that incorporates paleoenvironmental and archaeological data, offers a novel approach for estimating colonisation in the Pacific. Athens *et al*. (2014) expanded Dye's (2011) dataset and provide a more precise colonisation estimate using this model.

Recently, Allen and Huebert (2014) have developed criteria for assessing inbuilt age of wood charcoal and macrobotanical samples, resulting in the definition of short-lived, medium-lived, and long-lived categories. Improvements to radiocarbon dating and a more sophisticated understanding of the technology and sample selection on the part of archaeologists have been the primary drivers improving the precision and accuracy of colonisation estimates for Hawaiʻi and East Polynesia.

Our new results for Kuliʻouʻou are consistent with previous re-dating efforts of presumed early Hawaiian (Dye and Pantaleo 2010, Kirch and McCoy 2007) and other East Polynesian (Anderson and Sinoto 2002) archaeological deposits in determining that the site is considerably younger than originally thought.

## THE KULIʻOUʻOU VALLEY ROCKSHELTER: SITE O1

### *Setting and Objectives*

The Kuliʻouʻou Rockshelter is situated near the tip of Moʻomuku or Ka-lapa-o-Mana, the ridge separating Kuliʻouʻou Valley on the east and Niu Valley on the west. The rockshelter overlooks the mouth of the Kuliʻouʻou Valley and the adjacent reef situated in Maunalua Bay. Two natural ponds, Paikō and Waiha, were once situated in the vicinity, being fed by Kānewai spring (Emory n.d.). A small fishpond, Kūpapa, was once located in Niu Valley, while the large extant Maunalua Fishpond (Keahupua-o-Maunalua) lies to the east along the coastline.

Kuliʻouʻou Rockshelter was first tested by student archaeologist Jack Porteus in 1938, whose discovery of a wealth of artefacts led Emory to choose the site for a University of Hawaiʻi at Mānoa archaeological methods course in 1950 (Fig. 2). The six objectives of Emory's excavations were: (i) to determine the temporal length and sequence of occupation of the rockshelter, (ii) to identify the occupation and habits of the rockshelter residents, (iii) to identify changes in artefact types through time, (iv) to study the domesticated fauna, (v) to gain information about the origins and dates of the first occupation of the Hawaiian Islands in order to test "linguistic and lineage" hypotheses; and,

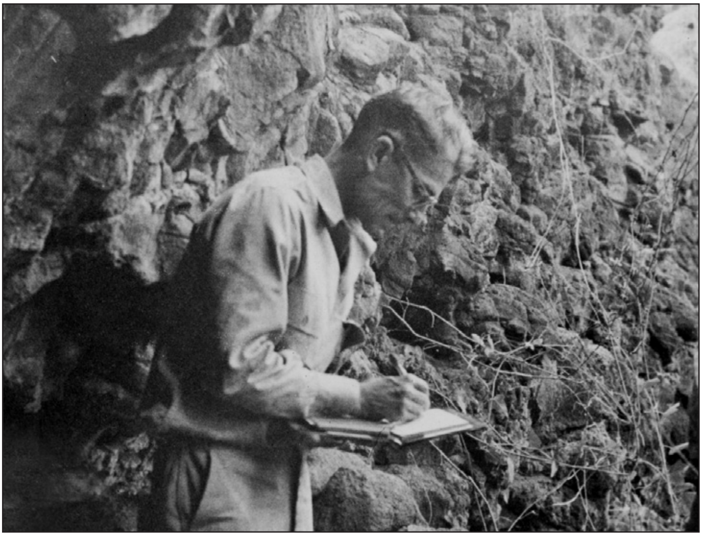

Figure 2. Photograph of Kenneth Emory during the 1950 excavations; reproduced with permission from Bernice P. Bishop Museum Archives (www.bishopmuseum.org).

(vi) to aid in developing archaeological methods and techniques for excavating sites in the Hawaiian Islands (Emory n.d.). These goals were consistent with the culture historical approach to archaeology that was in vogue in Hawai‘i and the mainland United States at the time, an approach that favoured the excavation of rockshelter and sand dune sites that could provide large fishhook and artefact assemblages useful for developing material culture sequences.

*The 1950 Field Methods*

Emory and Sinoto (1961) describe Site O1 as a remnant lava tube which forms a spacious shelter 15.5 m in length, with a maximum width of 8 m and a maximum height of 2.4 m (Fig. 3). Two stacked stone walls are found at the entry to the rockshelter, along the eastern and southern limits. In the rockshelter's interior, Emory laid out two baselines: an alphabetical line running N-S and a numerical line running E-W, delineating excavation units of three feet by three feet. A total of 42.5 units were excavated during the Porteus and Emory projects (Fig. 4). The Porteus excavations focused mainly to the east of the D line along the rear of the rockshelter and in a small area in the southern part of the rockshelter.

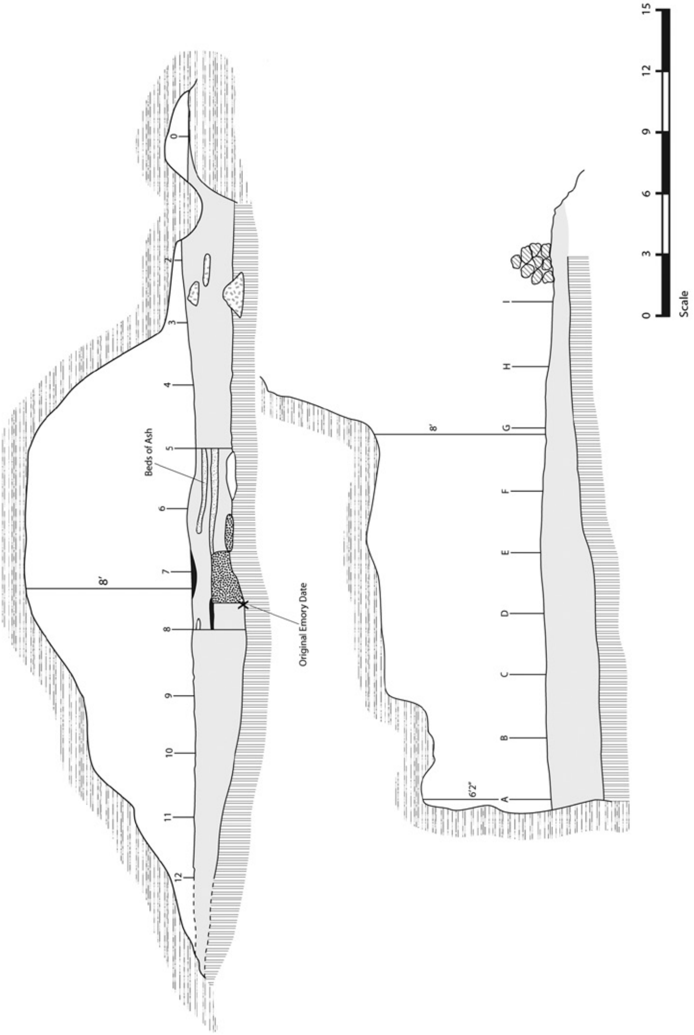


Figure 3. Cross section of O1 Rockshelter with stratigraphic profile (after Emory and Sinoto 1961). X refers to where the original Emory $^{14}C$ sample was collected.

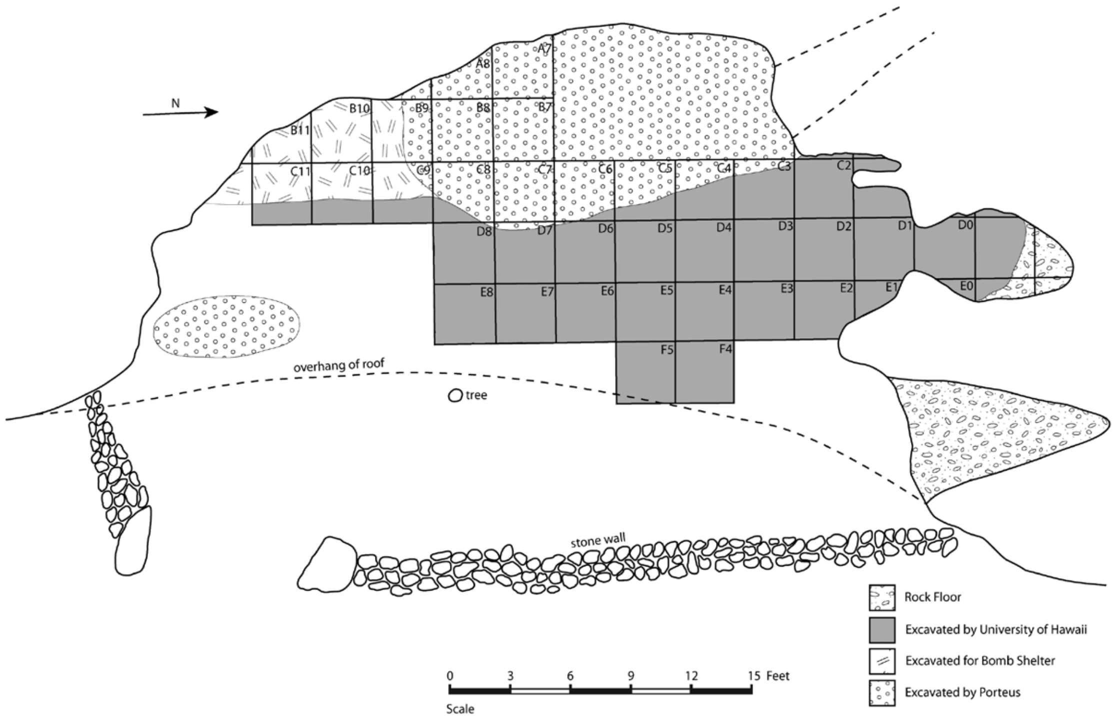


Figure 4. Plan view of Site O1 with units excavated.

Following methods current at the time, Emory excavated in six inch levels as measured from the surface (i.e., 0-6 inches below surface, 6-12 inches below surface, etc.) which are retained herein to facilitate comparison with their original field notes and collections. Excavated deposits were screened through ¼ inch (6.4 mm) mesh (Emory and Sinoto 1961: 12); as a result, the Site O1 collections are biased towards larger artefacts. Smaller remains such as fish bone are undoubtedly underrepresented. Only in two "quantitative units" (D6, D7) defined by Emory and Sinoto as units where "all shell, bone, wood, and foreign stone materials w ere taken from each six inches of depth for a quantitative analysis" (Emory and Sinoto 1961: 11) were full samples of floral, faunal and artefact remains collected. In all other units it must be presumed that formal tools (adzes, adze flakes) and modified faunal remains (cut bone) were likely collected and recorded, but that other unmodified items and waste debris (such as basalt debitage) were not.

Field notes and profile sketches indicate that numerous ash lenses and perhaps pit and fire features were encountered in the Kuli‘ou‘ou excavations, but these were not recorded or excavated separately from the surrounding deposits. As a case in point, we could not identify any archived wood charcoal samples collected by Emory and Sinoto specifically point-provenienced from *in situ* fire features. Because artefacts and wood charcoal samples were not point-provenienced within the 6 inch levels, and at least some features were dug into these levels but were not excavated separately from the surrounding matrix, these procedures pose a challenge for any re-analysis of the site's stratigraphy and artefact assemblages. Fortunately, units D6 and D7, which Emory and Sinoto identified as among the least disturbed of the rockshelter's deposits in the central protected living floor (1961: 9),[1] were excavated as "quantitative units". Given that special care was taken in the excavating and recording of these two units in 1950, and that they were noted as representing some of the most undisturbed deposits in the rockshelter (Emory and Sinoto 1961: 9), we focused our current project on dating wood charcoal samples that were recovered, in part, from unit D6.

*Stratigraphy*

Emory and Sinoto (1961) reported the stratigraphy of Kuli‘ou‘ou Rockshelter in terms of the 6-inch levels in which it was dug, but their notes make it clear that there were four depositional units or stratigraphic layers. The only stratigraphic section provided in their published report is for excavation unit D2 (Emory and Sinoto 1961: 11, Fig. 7) where four layers are identified. Layer I, ranging from 0-6 but sometimes 0-8 inches below surface, consisted of a "yellow-brown, powdery soil". This was mixed with goat manure in the upper portion, clearly indicating a post-European contact depositional environment. Beneath this, the matrix became a more compact dark brown in which both indigenous Hawaiian artefacts and a limited number of Euro-American artefacts were recovered. Layer II was a grey brown soil with cobble and gravel inclusions, generally 6-14 inches below the surface, but in some areas reaching 18 inches below the surface. Field notes indicate that the upper part of Layer II had a significant quantity of ash and midden including an abundance of faunal remains and organic materials. Based on our analysis of the original field records, the lower part of Layer II had a discontinuous ash lens that appears to have extended along sections of the northern two-thirds of the site. Layer III was lighter grey brown in color, with more frequent gravel inclusions, as well as larger stones. This layer extended from 18-24 inches below the surface and produced fewer artefacts than Layer II. The basal deposit, Layer IV, was light brown in color, ranged in depth and thickness across the site, and has been interpreted as a sterile deposit (Moniz 1997). One must be cautious, however, in assuming that materials from any particular 6-inch level can unambiguously be assigned to any one of these stratigraphic layers. Figure 9 in Emory and Sinoto (1961: 12) provides a photograph of an exposed face (excavation unit not indicated) through the site's deposit, with a large intrusive pit feature cutting through multiple levels.

*The Layer III Artefacts and Faunal Remains*

Emory and Sinoto (1961) described the numerous artefacts recovered from Site O1 which included coral files, fishhooks and other fishing gear, stone tools, and the broken handle of a shark-tooth knife. Here we focus on artefact types which have relevance to the site's chronology. Adzes, an artefact whose cross-sections were used by Emory and Sinoto as chronological markers, were relatively abundant at Kuli‘ou‘ou, with 14 complete specimens, 15 fragments, and two blanks/preforms (Emory and Sinoto 1961: 60). The majority of adzes from Site O1 are quadrangular in cross-section, a type regarded by many archaeologists as typical of later phases in the Hawaiian cultural sequence (Cleghorn 1982; Kirch 1985, 1990; but see Cleghorn 1992; Kahn, Mills, Lundblad *et al*. 2009). The recovery of at least two quadrangular adzes in Layer III suggested to Emory and Sinoto that this adze type was present during the first period of rockshelter use. However, four sub-triangular adzes also were collected. This suggested to Emory and Sinoto that Site O1 had a colonisation period occupation, as such adzes were believed to represent earlier forms commonly used in West Polynesia and in early East Polynesian assemblages in the Marquesas and Society Islands (Green 1971, 1974; Kirch 1985: 184-185; Suggs 1961: 63, 110).

Emory and Sinoto quantified faunal remains ("midden") from O1 by weight from the two "quantitative units", D6 and D7 (1961: 17, Table 1). Weight distributions for candlenut, marine shell, land mammal, and crustacean were the highest in 6-inch levels 18-24 in unit D6 and 6-12 in unit D7. Bird bone had the highest frequency in the 18-24 and 24-30 inch levels in both units (0.85 and 1.05 g in 18-24 layer, 0.75 g in 24-30 layer, as opposed to <.20 to .03 g in the 6-inch levels above 18 inches) (Emory and Sinoto 1961: 17, Table 1). Thus bird bone, as measured in weight (g) was highest in the deepest 6-inch levels of both units (Moniz 1997) and found above the underlying sterile deposit (24 inches below surface and deeper), leading Kirch (1982) to posit that Site O1 may have been initially used during an early phase prior to significant human impact on the natural bird populations of the islands. While 17 percent of the overall bird bone assemblage exhibited burning (Moniz 1997), the lack of detailed taphonomic analysis of the site O1 bird bones leaves open the possibility that some of these avifaunal remains could have resulted from pre-cultural (i.e., paleontological) depositional processes.

*The 1950 Dates*

The primitive radiocarbon dating methods available in 1950 necessitated large samples of charcoal, such as the entire contents from a single hearth or burn event. Not only did this practice potentially merge charcoal burned in a number of different events, but no thought was given to identifying the species of wood or other plant materials involved. In unit D7, a bulk charcoal sample (1 and 5/8 ounces) was collected by Emory. This sample derived from between 24-36 inches below the surface (thus presumably from Layer III). The sample yielded an uncalibrated radiocarbon date of 946 ± 180 before 1950 (Lab sample identifier: Chicago C550, Emory and Sinoto 1961: 15). Lacking isotopic fractionation information, which can result in an adjustment in the radiocarbon age, calibration of this date should be considered with caution. A second sample recovered from excavation unit D7, at 18-24 inches below surface (again, presumably from Layer III) was later dated. This sample yielded a date reported by Emory and Sinoto (1961: 15) as "AD 1739 ± 150" (Lab sample identifier: Michigan M564, Emory and Sinoto 1961: 15).[2] These initial dates suggested that this cultural deposit had at least two phases.

What was unknown at the time, and has been overlooked since, is that these dates were not adjusted for isotopic fractionation (i.e., $\delta^{13}C$ value) and are uncalibrated. They were originally presented as absolute calendar year dates that could be subtracted from 1950. These issues, combined with the large error estimates, make these dates highly suspect.

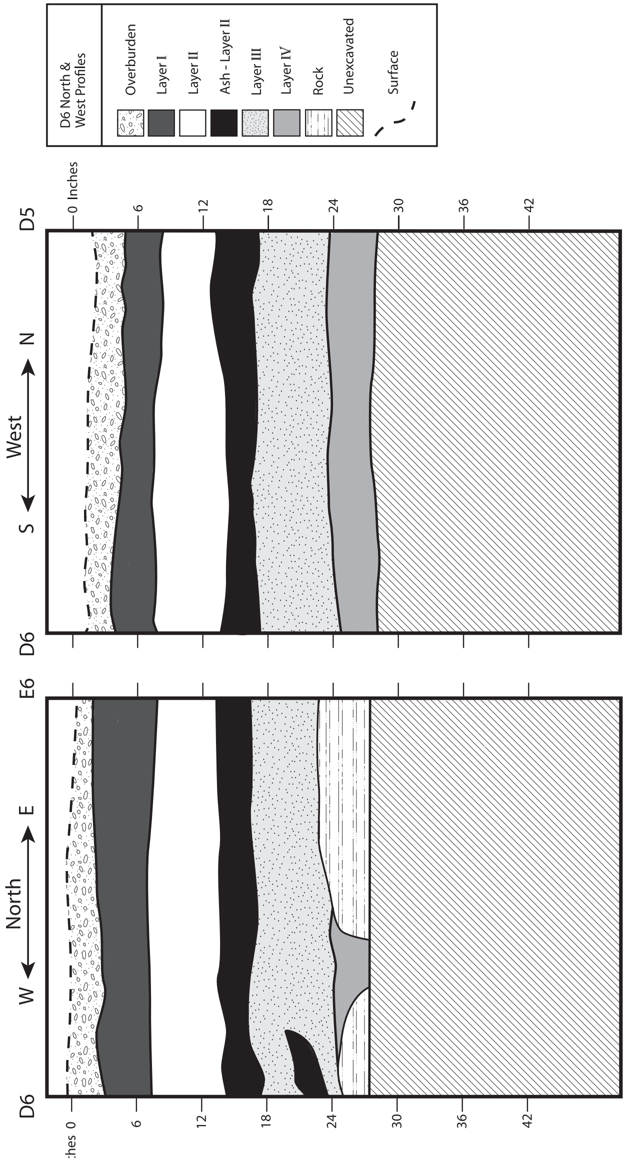


Figure 5. Stratigraphic profile, Unit D6, Site O1.

## NEW AMS RADIOCARBON DATES FOR THE KULI‘OU‘OU VALLEY ROCKSHELTER

The two samples dated by Emory were completely destroyed during radiocarbon dating, requiring us to target other contexts for the re-dating of the site. Generalised (non-feature specific) samples of wood charcoal from the cultural deposits were available for dating and we employed the accelerator mass spectrometry (AMS) method. These samples were contextualised according to the 6-inch levels by which Emory excavated. Emory’s dates derived from unit D7, one of the “quantitative units”. Since there are no archived charcoal samples from the deepest levels of unit D7, we targeted archived samples from adjacent unit D6 which also was excavated as a “quantitative unit”. The stratigraphic profile for unit D6 is presented in Figure 5. In addition, we dated other samples that were designated in the original excavations as “radiocarbon samples” rather than bulk charcoal, assuming that the former had been designated by Emory or Sinoto as being the most appropriate materials to date the site, even if their exact reasons are unknown.

Prior to dating, each sample was identified to species by wood charcoal specialist Gail Murakami (Table 1). The six newly dated samples are listed in Table 2, with details of provenience, sample materials and dating results. Beta-306140 and 306139 date rind from the Polynesian introduced bottle gourd (*Lagenaria siceraria*) and fruit of the indigenous pan-Pacific screwpine (*Pandanus tectorius*); both of these samples lack significant inbuilt age and are classified as short-lived (lifespans of a decade or less, after Allen and Huebert 2014). The *Chenopodium* sample (Beta-306124) would also be classified as short-lived (Athens *et al.* 2014). Beta-306123 dates a stem fragment of *Cordyline fruticosa*, another Polynesian introduction that has the potential for a moderate inbuilt age of several decades, and thus would be considered a medium-lived taxa. Beta-306121 derives from a native shrub unlikely to have significant inbuilt age and would be considered short-lived, while Beta-306122 and Beta-306124 derive from native shrubs that would be considered medium-lived (Allen and Huebert 2014; Rieth and Athens 2013, Table 1). All six samples were processed and dated by Beta Analytic. The wood charcoal samples received standard pretreatments with hot HCl acid washes to remove carbonates and alkali washes (sodium hydroxide, NaOH) to remove secondary organic materials.

Table 2 presents the measured $^{14}$C age, as well as the conventional $^{14}$C age determined after correction for isotopic fractionation (based on $\delta^{13}$C values). The conventional age was calibrated using the Oxcal calibration program (version 4.2) and INTCAL09 (Reimer, Baillie, Bard *et al*. 2009).

Table 1. Wood charcoal identifications.

| Provenience | WIDL # | Taxa | Common/ Hawaiian Name | Origin/Habit | Part | Weight (g) |
|---|---|---|---|---|---|---|
| D6: 1st 6" | LI | cf. *Lagenaria siceraria* | *Ipu* | Polynesian Introduction/Vine | Fruit rind | 0.12 |
| | LI | *Euphorbia* spp. | *‘Akoko* | Native/Shrub | Wood | 5.02 |
| | LI | Unknown 1 | | | Wood | 0.11 |
| | LI | *Diospyros sandwicensis* | *Lama* | Native/Tree | Wood | 0.11 |
| | LI | *Chenopodium oahuense* | *‘Āheahea* | Native/Shrub | Wood | 0.37 |
| | LI | cf. *Metrosideros polymorpha* | *‘Ōhi‘a lehua* | Native/Tree | Wood | 0.28 |
| | LI | *Hibiscus tiliaceus* | *Hau* | Native/Shrub-Tree | Wood | 0.29 |
| | LI | *Aleurites moluccana* | *Kukui* | Polynesian Introduction/Tree | Nutshell | 0.33 |
| | LI | cf. *Prosopis pallida* | *Kiawe* | Historical Introduction/Tree | Wood | 0.85 |
| | LI | Unknown 2 | | | Wood | 0.11 |
| | LI | cf. *Dodonaea viscosa* | *‘A‘ali‘i* | Native/Shrub | Wood | 0.64 |
| D6 West: 12-18" | LII | cf. *Coprosma* sp. | *Pilo* | Native/Shrub-Tree | Wood | 0.48 |
| D6 East: 12-18" | LII | *Hibiscus tiliaceus* | *Hau* | Native/Shrub-Tree | Wood | 0.43 |
| | LII | cf. *Dodonaea viscosa* | *‘A‘ali‘i* | Native/Shrub | Wood | 1.12 |

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Table 1. – *continued*

| Provenience | WIDL # | Taxa | Common/ Hawaiian Name | Origin/Habit | Part | Weight (g) |
|---|---|---|---|---|---|---|
| D6 East: 18-24" | LIII | cf. *Osteomeles anthyllidifolia* | *‘Ūlei* | Native/Shrub | Wood | 0.09 |
| O1 Sample #102 | LII | *Lagenaria siceraria* | *Ipu* | Polynesian Introduction/Vine | Fruit rind | 0.64 |
| D6: 12-18" | LII | *Pandanus tectorius* | *Hala*, screwpine | Native/Tree | Key | 0.46 |
| | LII | *Euphorbia* spp. | *‘Akoko* | Native/Shrub | Wood | 3.05 |
| | LII | *Styphelia tameiameiae* | *Pūkiawe* | Native/Shrub | Wood | 1.17 |
| | LII | *Diospyros sandwicensis* | *Lama* | Native/Tree | Wood | 0.26 |
| | LII | *Psydrax odoratum* | *Alahe‘e* | Native/Tree | Wood | 0.51 |
| | LII | *Erythrina sandwicensis* | *Wiliwili* | Native/Tree | Wood | 0.05 |
| | LII | cf. *Dodonaea viscosa* | *‘A‘ali‘i* | Native/Shrub | Wood | 0.97 |
| | LII | *Acacia koa* | *Koa* | Native/Tree | Wood | 0.98 |
| O1 Sample #103 | LIII | *Diospyros sandwicensis* | *Lama* | Native/Tree | Wood | 2.84 |
| D6 West: 18-24" | LIII | cf. *Dodonaea viscosa* | *‘A‘ali‘i* | Native/Shrub | Wood | 1.22 |
| | LIII | *Euphorbia* spp. | *‘Akoko* | Native/Shrub | Wood | 2.59 |
| | LIII | *Cordyline fruticosa* | *Kī, ti* | Polynesian Introduction/Shrub | Wood | 0.63 |
| | LIII | *Erythrina sandwicensis* | *Wiliwili* | Native/Tree | Wood | 0.06 |

| Provenience | WIDL # | Taxa | Common/ Hawaiian Name | Origin/Habit | Part | Weight (g) |
|---|---|---|---|---|---|---|
| | LIII | *Hibiscus tiliaceus* | *Hau* | Native/Shrub-Tree | Wood | 0.55 |
| | LIII | *Chenopodium oahuense* | *‘Āheahea* | Native/Shrub | Wood | 0.14 |
| | LIII | cf. *Wikstroemia* sp. | *‘Ākia* | Native/Shrub | Wood | 0.07 |
| | LIII | cf. *Nothocestrum* sp. | *‘Aiea* | Native/Tree | Wood | 0.11 |
| | LIII | Unknown 3 | | | | 0.72 |
| | LIII | cf. *Metrosideros polymorpha* | *‘Ōhi‘a lehua* | Native/Tree | Wood | 0.17 |
| | LIII | *Psydrax odoratum* | *Alahe‘e* | Native/Tree | Wood | 0.47 |
| | LIII | cf. *Bobea sandwicensis* | *‘Ahakea* | Native/Tree | Wood | 0.32 |
| | LIII | cf. *Syzygium* sp. | Mountain apple, roseapple, Java plum, *‘ōhi‘a ai* | Native + Historic Introductions/Tree | Wood | 0.06 |
| | LIII | Unknown 4 | | | Wood | 0.05 |
| O1 Sample #34 | NR | *Cordyline fruticosa* | *Kī, ti* | Polynesian Introduction/Shrub | Wood | 0.03 |
| | NR | *Euphorbia* spp. | *‘Akoko* | Native/Shrub | Wood | 0.06 |
| | NR | *Diospyros sandwicensis* | *Lama* | Native/Tree | Wood | 0.03 |
| | NR | cf. *Dodonaea viscosa* | *‘A‘ali‘i* | Native/Shrub | Wood | 0.01 |
| | NR | cf. *Metrosideros polymorpha* | *‘Ōhi‘a lehua* | Native/Tree | Wood | 0.09 |

Table 2. New AMS radiocarbon dates for Site O1, Kuli‘ou‘ou Rockshelter.

| Lab # | Other Sample # | Material & species | Provenience | Conventional age BP | $\delta^{13}C$ | Calibrated AD age range (2σ) |
|---|---|---|---|---|---|---|
| Beta-306140 | WIDL-1109-22 | Charred *Pandanus tectorius* key | D6, 12-18 inches below surface; O1 sample #102 | 270 +/- 30 | -23.1 | 1515-1598 (42.2%)<br>1616-1669 (46.4%)<br>1781-1798 (6.4%)<br>1948-1952 (0.4%) |
| Beta-306139 | WIDL-1109-21 | Charred *Lagenaria siceraria* fruit rind | D6, 12-18 inches below surface; O1 sample #102 | 40 +/- 30 | -24.9 | 1694-1728 (21.2%)<br>1812-1854 (19.1%)<br>1866-1919 (55.1%) |
| Beta-306121 | HRC-1579, 01-1 | *Osteomeles anthyllidifolia* charcoal | D6, 18-24 inches below surface | 60 +/- 30 | -25 | 1692-1728 (23.6%)<br>1811-1920 (71.8%) |
| Beta-306122 | HRC-1580, 01-2 | *Dodonaea viscosa* charcoal | D6, 18-24 inches below surface | 80 +/- 30 | -26.4 | 1690-1730 (25.2%)<br>1810-1926 (70.2%) |
| Beta-306123 | 01-3 | Charred *Cordyline* fruticosa stem | D6, 18-24 inches below surface; O1 sample #103 | 0 +/- 30 | -23.7 | Modern |
| Beta-306124 | 01-4 | *Chenopodium oahuense* charcoal | D6, 18-24 inches below surface; O1 sample #103 | 470 +/- 30 | -24.0 | 1409-1457 (95.4%) |

REVISED KULI‘OU‘OU ROCKSHELTER CHRONOLOGY

Figure 6 presents the Oxcal calibrated 2-sigma (95.4%) probability distributions for the six new radiocarbon dates from samples originally collected from levels with depths between 12 and 24 inches below surface. We assume that these samples derived from stratigraphic Layers II (12-18 inches) and III (18-24 inches). The results are indicative of the complex site stratigraphy and the coarse-grained excavation techniques of the 1950s, as described above. The deposits were mixed through prehistoric activities (e.g., creation of scoop hearths and pits), as well as by more recent goat disturbance and the historic use of the rockshelter as a bomb shelter (Emory n.d.).

The new dates do not yield a stratigraphically consistent chronology, with dates inverted with respect to their 6-inch excavation levels. Of four dates from levels between 18-24 inches, one calibrates as modern, two are statistically similar and calibrate with a highest probability in the 19th century, while the last calibrates to the first half of the 15th century. Similarly, the two calibrated dates from the 12-18 inches level present little overlap and appear to represent two distinct burning events most likely dating to the 16th-17th and 19th centuries.

The oldest sample is Beta-306124, which was retrieved from near the bottom of the cultural deposit in a level 18-24 inches below surface, in a similar context to the original Chicago date. This gives us a secure maximum age of the first half of the 15th century for the earliest occupation of Site O1. The much older date (Chicago C550) produced by Emory from a sample recovered from the lower level in unit D7 is likely due to a combination of factors, including the relatively crude state of radiocarbon dating technology at the time and possible inbuilt age in the sample.

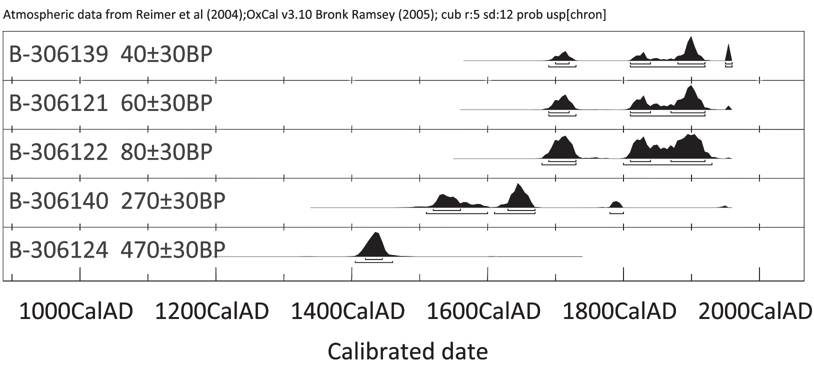


Figure 6. Oxcal plot of new radiocarbon dates from Site O1.

Emory and Sinoto’s (1961) younger date is in line with our present results. However, considering that the same technological and sample issues pertain to this date as the earlier Chicago date, the correspondence may be fortuitous but inaccurate (i.e., the true age range for Emory and Sinoto’s sample will remain uncertain). The individual dates we obtained are reliable estimates for cultural burning events, regardless of stratigraphic location and the possibility of inversions. Based on our results, human use of the Kuli‘ou‘ou Rockshelter occurred from the 15th to early 19th centuries, followed by sporadic short-term use during the 20th century. Although the periodicity of these activities is unclear, the amount of cultural material, number of apparent subsurface features, and level of disturbance suggest that the rockshelter may have been used fairly continuously, or was periodically the location of intense activity over c. 400 years. Emory’s field notes indicate that a single piece of glass was recovered in the upper 12 inches of the site in addition to some modern historic artefacts (Emory n.d.). The absence of early post-contact artefacts of Euro-American origin in the upper sector of Layers I and II suggests that the site was likely abandoned some time before the early 19th century.

## SOUTHEASTERN O‘AHU VEGEGATION DURING THE EXPANSION TO PROTO-HISTORIC PERIODS

Weights of identified wood charcoal taxa from units D6 and D7 are provided in Table 3. Although analysis of diachronic change in the vegetation surrounding the rockshelter as represented by charcoal (fuel taxa) (e.g., Dye and Sholin 2013) is not possible due to the poor integrity of the stratigraphic sequence, some general observations are presented. The majority of taxa identified in the Site O1 charcoal samples are tree and shrub species typical of the Lowland Dry Community of Hawaiian vegetation as defined by Gagné and Cuddihy (in Wagner, Herbst and Sohmer 1990: 45). This designation reflects the lowland elevational band (15-2,000 m) in a dry moisture regime (<1,200 mm rainfall). In this scheme, the charcoal assemblage represents a mixture of two unique communities within the Lowland Dry Community: *‘A‘ali‘i* (*Dodonaea*) Lowland Shrubland (Wagner *et al*. 1990: 71) and *Lama* (*Diospyros*) Lowland Forest (Wagner *et al*. 1990: 73). Although not present in large quantities, the dominant species of these two communities, *Dodonaea* and *Diospyros*, were found in most of the samples analysed, suggesting some abundance in the environment. Exceptions to the lowland forest/shrubland communities are *hau* (*Hibiscus tiliaceus*), which would have grown closer to a water source, *koa* (*Acacia koa*) which could have been culturally transported from a higher elevation forest, and *Ipu* (*Lagenaria siceraria*) and *Kī* (*Cordyline fruticosa*), which are both Polynesian economic introductions. *Kiawe* (*Prosopis pallida*), a historically-introduced tree that dominates the current vegetation community

Table 3. Weights of identified taxa in wood charcoal samples from D6 and D7 by six inch layers; weights are listed in grams. "Not listed" refers to samples lacking precise stratigraphic context but known to derive from D6 and D7.

| Taxon: / Sample Context: | 0-6" | 12-18" | East 12-18" | West 12-18" | East 18-24" | 18-24" | Not listed |
|---|---|---|---|---|---|---|---|
| *Acacia koa* | | 0.98 | | | | | |
| *Aleurites moluccana* nutshell | 0.33 | | | | | | |
| *Bobea sandwicensis* | | | | | | 0.32 | |
| *Psydrax odorata* | | 0.51 | | | | 0.47 | |
| *Euphorbia* spp. | 5.02 | 3.05 | | | | | 0.06 |
| *Chenopodium oahuensis* | 0.37 | | | | | 0.14 | |
| *Coprosma* sp. | | | | 0.48 | | | |
| *Cordyline fruticosa* | | | | | | 0.63 | 0.03 |
| *Diospyros sandwicensis* | 0.11 | 0.26 | | | | 2.84 | 0.03 |
| *Dodonaea viscosa* | 0.64 | 0.97 | 1.12 | | | 1.22 | 0.01 |
| *Erythrina sandwicensis* | | 0.05 | | | | 0.06 | |
| *Hibiscus tiliaceus* | 0.29 | | 0.43 | | | 0.55 | |
| *Lagenaria siceraria* rind | 0.12 | 0.64 | | | | | |
| *Metrosideros polymorpha* | 0.28 | | | | | 0.17 | 0.09 |
| *Nothocestrum* sp. | | | | | | 0.11 | |
| *Osteomeles anthyllidifolia* | | | | | 0.09 | | |
| *Pandanus tectorius* | | 0.46 | | | | | |
| *Prosopis pallida* | 0.85 | | | | | | |
| *Styphelia tameiameiae* | | 1.17 | | | | | |
| *Syzygium* sp. | | | | | | 0.06 | |
| *Wikstroemia* sp. | | | | | | 0.07 | |
| Unknown 1 | 0.11 | | | | | | |
| Unknown 2 | 0.11 | | | | | | |
| Unknown 3 | | | | | | 0.72 | |
| Unknown 4 | | | | | | 0.05 | |

of Kuli'ou'ou, is also present in the upper 6 inches of one of the units. The presence of *kiawe* provides further indication of historic use of the site, either before or after its use as a bomb shelter.

## DISCUSSION AND CONCLUSIONS

Site O1 is not the only rockshelter in the Hawaiian Islands with a putative early date which, upon re-dating, has proven to be younger in age than originally claimed. It is instructive to compare our Site O1 results with the case of Kaupikiawa Rockshelter on the Kalaupapa Peninsula of windward Moloka'i, originally excavated in 1967 by Richard Pearson of the University of Hawai'i. Pearson collected a number of unidentified charcoal samples which were later submitted by Marshall Weisler for radiocarbon dating (Weisler 1989: 137). One sample (Beta-9276) from near the base of the cultural deposit yielded an age of 880 ± 70 BP (calibrated to AD 1026-1262 [95.4%]), one of the earliest dates then known for Moloka'i Island. A second sample from a similar depth yielded an age of <120 years—and potentially should have raised questions regarding the validity of the early date—yet Weisler accepted an initial age for the occupation of Kaupikiawa Rockshelter "by the 11th century" (1989: 126). Subsequently, Kirch, O'Day, Coil *et al*. (2003) conducted limited re-excavations in the site, submitting three new samples of charcoal from identified, short-lived taxa for AMS dating. A stratigraphically well-controlled sample from the base of the cultural deposit yielded a conventional age of 650 ± 40 BP (calibrated to AD 1295-1390; Kirch *et al*. 2003, Table 6). Thus the true age for initial human use of the Kaupikiawa Rockshelter was the 14th, rather than the 11th, century.

The cases of both Kaupikiawa and Kuli'ou'ou rockshelters underscore how important it is to have good stratigraphic control for radiocarbon samples, but also highlight the absolute necessity for submitting samples that have been botanically identified to short-lived taxa (Allen and Huebert 2014, Dye 2000, Rieth and Athens 2013). Both Kuli'ou'ou and Kaupikiawa were excavated at a time when materials were collected by arbitrary levels rather than by natural strata, leaving the stratigraphic context of dated samples uncertain. In both cases, the initial radiocarbon dates were on unidentified charcoal which likely derived from old, hardwood trees or from driftwood collected from the nearby coastlines. Consequently, the initial age estimates for Polynesian use of these two rockshelters were several centuries earlier than subsequent re-dating has demonstrated to be the case.

In sum, the Kuli'ou'ou Rockshelter can no longer be regarded as dating to around AD 1000 as suggested by previous syntheses of Hawaiian prehistory. Six new AMS dates on charcoal samples originally collected by Emory now indicate that the earliest occupation of the site most likely dates to AD 1400-1450. The Layer II and III deposits likely represent up to four or more centuries of continued use before the site was abandoned prior to, or during, the initial decades after European contact. Thus, the site is informative for understanding the transition between the Late Expansion (AD 1400-1650) and Proto-Historic (AD 1650-1778) periods of the Hawaiian cultural sequence (see Kirch and McCoy 2007), but can no longer be considered relevant to the early period of Polynesian colonisation in Hawaiʻi.

## ACKNOWLEDGEMENTS

Our sincere thanks to the Anthropology Department and Archives at the Bishop Museum for providing us access to the Kuliʻouʻou samples and field notes. We particularly thank Tia Reber (Bishop Museum Archives) who was instrumental in locating the photograph presented as Figure 2 and Teresa Ingalls (former Bishop Museum Archaeology Collections Manager) who located the charcoal samples. Diana Izdebeski is thanked for drafting the figures. Melinda Allen and two anonymous reviewers provided insightful comments that greatly improved our final draft.

## NOTES

1. Readers will note that the plan view of site excavations at O1 shows that Porteus' early excavations impinged on the western limit of D7 and perhaps D6. In their monograph, Emory and Sinoto (1961) state that D6 and D7 had among the best preserved deposits in the central portion of the rockshelter, leading them to excavate these two units carefully as "quantitative units". Emory and Sinoto (1961: 9) note that only the first 6 inches of the D7 unit were impacted by Porteus' work, and only in a very small section of the southwest limit of the excavation unit. Thus, it seems unlikely that Porteus' earlier work impacted the integrity of the D6 and D7 deposits in any significant manner.
2. As far as we know this date has only been published in t he A.D. format, however, based on the state of radiocarbon dating technology at the time this likely is not a true calibrated calendar age.

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## ABSTRACT

Kuli‘ou‘ou Rockshelter (Site O1) in the Hawaiian Islands has a certain status as the first archaeological site in the Pacific Islands to be directly dated via the then newly introduced radiocarbon method. The original date of 946 ± 180 before 1950, from the base of the rockshelter’s cultural deposit, greatly influenced archaeologists’ views of regional cultural sequences in East Polynesia. We present the results of six new AMS $^{14}C$ dates run on Kuli‘ou‘ou Rockshelter wood charcoal which has been identified to short-lived and medium-lived species. We use these data, along with a re-evaluation of the two dates obtained by the original excavators, Kenneth Emory and Yosi Sinoto, to present a revised chronology for the rockshelter. In addition, we discuss new wood charcoal identifications from the two lower layers at Site O1 for illuminating general vegetation patterns in the Expansion to Proto-Historic periods. Finally, the broader implications of our revised chronology are considered for the prehistoric sequence of O‘ahu Island and in the larger context of the settlement sequence for the Hawaiian archipelago.

*Keywords:* chronology, settlement sequence, Hawaiian Islands, wood charcoal identification, vegetation patterns

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