In a synthesis of Hawaiian prehistory and archaeology published a little over two decades ago, Kirch used the then-available radiocarbon dates from archaeological sites across the archipelago to suggest that initial Polynesian settlement occurred between A.D. 300 and 600, during what he named the “Colonization Period” (Kirch 1985:67-88, 298, Fig. 238). Recent debates and our re-dating of a significant site lead to a revision of this chronology.

Only two archaeological site components were thought to date to this earliest or colonisation period: Layer III at the Bellows Dune (O18) site in the Waimanalo region of O‘ahu Island (Cordy and Tuggle 1976, Pearson et al. 1971, Tuggle et al. 1978), and Layer III in the Pu’u Ali‘i sand dune site (H1) on Hawai‘i Island (Emory et al. 1959, Emory and Sinoto 1969). The succeeding “Developmental Period” in Kirch’s sequence, from A.D. 600 to 1100, was represented primarily by Layers II and IIa at the Bellows Dune, by Layer II at Pu’u Ali‘i, by the lower cultural deposits in the H8 rockshelter at Wai‘ahu on South Point, and notably by the Hālawa Dune site (MO-A1-3) in the Hālawa Valley on the eastern tip of Moloka‘i Island (Kirch 1985:302). A few other sites were also regarded as having been first occupied during the Developmental Period, including the Kuli‘ou‘ou rockshelter (O1) and a coastal midden at Kahana Valley, both on O‘ahu Island, and the Ke‘e beach site at Ha‘ena, Kaua‘i Island.

Since Kirch’s cultural sequence for the Hawaiian Islands was proposed, the issue of the chronology of Polynesian expansion into Eastern Polynesia—including Hawai‘i—has been hotly debated. Spriggs and Anderson (1993) questioned the chronology of virtually all early Eastern Polynesian sites in their call for greater “chronometric hygiene” in Pacific Island colonisation research. Subsequent re-dating of several key central East Polynesian sites has increasingly reinforced the view that settlement of the region was indeed later than originally thought (Allen 2004; Anderson et al. 1999; Anderson et al. 1994; Anderson and Sinoto 2002; Conte and Anderson 2003; Hunt and Holson 1991; Rolett 1993, 1996; Rolett and Conte 1995). In this regard, the
initial radiocarbon chronologies for both the Pu‘u Aliʻi Dune site and the Bellows Dune site have been called into question (Dye 1992, Tuggle and Spriggs 2000), with implications for the proposed settlement date for the Hawaiian Islands. While some scholars (Graves and Addison 1995, 1996) have argued that there are sufficient radiocarbon dates from Hawai‘i to support an initial settlement date early in the first millennium A.D., others (Athens et al. 2002, Masse and Tuggle 1998) regard the recent evidence as supporting an initial settlement date of not earlier than the 9th century. Tuggle and Spriggs (2000:188) asserted that “a site-based argument for pre-A.D. 800 settlement of Hawai‘i is approaching a case list of zero”.

At the time that the Hālawa Dune site on Moloka‘i was excavated, in 1969-70, radiocarbon dating had yet to benefit from later technical and methodological improvements, such as high-precision accelerator mass-spectrometry (AMS) dating and the use of advanced calibration curves and computer programs to calibrate dates. Moreover, the initial series of 14C dates from Hālawa was fraught with several problems (see below), making the assignment of the lower part of this dune site to “the fifth to sixth century” A.D. (Kirch 1985:77) somewhat tenuous. Given that the Hālawa Dune site is critical to the definition of the Developmental Period in Kirch’s Hawaiian sequence, we decided to attempt a re-dating of the cultural deposit at site A1-3 using contemporary radiocarbon dating methods.

This paper presents the results of six new AMS 14C dates, along with a re-evaluation of the original suite of dates, to present a revised chronology for the Hālawa Dune site. The broader implications of this revised chronology are then considered for the prehistoric sequence of Moloka‘i Island and for the larger problem of the cultural chronology of the Hawaiian Islands.

**THE HĀLAWA DUNE SITE (MO-A1-3)**

Before presenting our new dating results, we review a few key aspects of the Hālawa Dune site: its stratigraphy, the nature of the non-portable and portable artefact assemblage, and the original dating results obtained in 1969-70. A preliminary report on the Hālawa Dune site excavations was published by Kirch (1971) and a definitive site report by Kirch (1975a). Radiocarbon and obsidian hydration rind dates for the site were originally presented by Kirch (1975b) and by Barrera and Kirch (1973). Kirch (1974) discussed the apparent chronology for early Hawaiian settlement, based on then available radiocarbon and obsidian hydration dates for the Bellows, Hālawa, and Waiahukini (H8) sites. Weisler (1989) reviewed the entire radiocarbon corpus available for Moloka‘i Island and regarded the Hālawa Dune site (along with the Kaupikiawa rockshelter on Kalaupapa Peninsula) as a key site attesting to the Developmental Period.
Setting and Stratigraphy

First discovered in 1964, the Hālawa Dune site consists of two low mounds rising slightly above the coastal flood plain at the mouth of Hālawa Valley, on the southern side of the river (Fig. 1). Hālawa is one of four large, amphitheatre-headed valleys on the windward side of Moloka‘i, which together with the Kalaupapa Peninsula comprised the Ko‘olau District. The only one of these four valleys readily accessible by sea throughout the year, owing to its protected bay, Hālawa was noted in the historic period as a major centre of irrigated taro cultivation (Anderson 2001, Kirch 1975a). With its permanent stream, broad alluvial floodplain, gentle colluvial slopes and ready access to marine and forest resources, Hālawa arguably offers the combination of environmental attributes thought to be most attractive for early Polynesian settler groups.

Figure 1. View of Hālawa Bay from the north showing the protected beaches, river mouth, and alluvial floodplains. Site MO-A1-3 is situated on the far side of the embayment, on the coastal flat. (Photo: P. Vitousek)
Kirch (1975a:18) interpreted the low mounds at site A1-3 as the “erosional remnants of a once more extensive deposit, largely destroyed by the 1946 tsunami”, which caused major damage to the mouth of Moloka‘i Island’s Hālawa Valley. Excavation of the larger of these mounds, designated Mound B (15m long x 11.5m wide x 1m high), proceeded in stages from 1968 to 1970 beginning with a test trench, followed by a 4m$^2$ test unit in 1969 and ending with a horizontally extensive 53m$^2$ excavation in 1970 (Kirch 1975a:18-20). Fortunately, since only roughly one-third of Mound B was excavated—unlike Pu‘u Ali‘i (H1), for example, where virtually the entire site was destroyed through excavation—future re-examination of the site is still possible.

Six stratigraphic units were defined in Mound B, as seen in the stratigraphic section given in Figure 2 (see also Kirch 1975a, Tables 5 and 6). The base of the site consists of a culturally sterile beach sand of mixed carbonate and basalt grains (Layer VI), overlain with a culturally sterile brown clay (Layer V), representing a flood deposit from nearby Hālawa Stream. Capping Layer V, and in places cutting into both Layer V and VI with postholes and other features, is the approximately 60cm thick Layer IV, which is the primary cultural deposit (a mixed carbonate-basalt sand stained dark gray with abundant fine charcoal particles), containing abundant prehistoric period artefacts and features along with faunal materials. A “thin, hard-packed lens of beach sand, with thicker pockets in some places” (Kirch 1975a:23) divided Layer IV about half-way through its depth. This allowed the excavators to subdivide Layer IV into upper and lower sectors, by which most of the cultural remains are categorised. A single 1m$^2$ unit (Square H8) was excavated by 10cm levels for finer vertical control of faunal remains. For the most part, however, artifacts were collected and cataloged by upper and lower 30cm sectors within Layer IV. As was common practice in Hawaiian archaeology at the time, all excavated sediment was screened through 0.25-inch mesh.

Layer IV was capped throughout Mound B by Layer III, a deposit of culturally sterile beach sand that accumulated after the site ceased to be used as a primary habitation locus. Overlying this sterile sand is Layer II, a hard-packed sand and clay deposit containing historic-period artefacts dating to between c. A.D. 1850-1946. (See Anderson [2001:136-256] for an in-depth discussion of Hālawa Valley historic artefacts.) Historic photographs indicate the presence of a wooden house in this location before its destruction in the 1946 tsunami. A thin deposit of beach sand and humus (Layer I) forms the uppermost stratigraphic unit in the Mound B sequence. The key Layer IV deposit contains no post-contact artefacts of Euro-American origin, hence deposition of the sterile sand Layer III occurred entirely before European contact.
Figure 2. Stratigraphic section through Mound B of the Hālawa Dune site; see text for discussion of principal stratigraphic units. (Source: Kirch 1975a, Fig. 9).
The Layer IV Features and Artefact Assemblage

The Hālawa Mound B excavations yielded a collection of 496 portable artefacts (not including about 2,000 basalt lithics), from a context of non-portable structural features that includes several house foundations, hearths and earth ovens. These portable and non-portable artefacts have been fully described in Kirch (1975a), but several key points are worth reiterating. The oldest structural remains are a set of postholes, pits and hearths or charcoal concentrations in the lower sector of Layer IV, with many of the postholes penetrating the underlying Layers V and VI. One of the hearths at the base of the Layer IV deposit (Feature 57) yielded the $^{14}$C date (GaK-2743) of 1421 ± 90 B.P., which was taken as evidence for initial site occupation in the 5th or 6th centuries A.D. Another hearth in the lower sector (Feature 56) yielded a charcoal sample dated to 422 ± 170 B.P. (GaK-3062). At the top of the lower sector a small, round-ended house foundation built of rounded beach cobbles was exposed (Structure 1a), and this was overlain at the base of the upper sector, with a rebuilt house of roughly the same form (Structure 1b). Structures 2 to 5, all in the upper sector of Layer IV, were manifested by posthole patterns and in two cases by small stone-lined hearths. One of these hearths (Feature 48 in Structure 2) yielded a $^{14}$C date (GaK-2741) of 845 ± 80 B.P., while another hearth (Feature 49 associated with Structure 3) produced a charcoal sample dated to 216 ± 100 B.P. (GaK-3065). Three larger earth ovens were also exposed in the upper sector, but all were believed to be intrusive from the top of Layer IV, having been cut into Layer IV after the primary occupation was abandoned (Kirch 1975a:32, Table 11). One of these ovens (Feature 58) produced a $^{14}$C date (Gak-2742) of 237 ± 120 B.P., consistent with the interpretation of these ovens being intrusive into Layer IV. Although Layer IV clearly contains numerous intact structures and features, it is important to recognise that the complex sequence of rebuilding and reoccupation on the site undoubtedly resulted in continual redeposition and mixing of cultural materials, as the digging of postholes, pits and ovens brought older materials to the current occupation surface.

The round-ended form of the small houses or structures in Layer IV, both in the stone-outlined Structures 1a and 1b, and in the posthole patterns of the later Structures 2 to 5, differs from the typical rectangular form of later prehistoric Hawaiian houses and is more similar to ethnographically attested houses in other parts of Eastern Polynesia, such as Mangareva or Napuka in the Tuamotu Islands (Kirch 1975a:66-67, Fig. 29). This was one line of evidence adduced for the Hālawa Dune site representing a relatively early phase of Hawaiian material culture.

The portable artefact assemblage from Layer IV includes a wide variety of functional types including tools, fishing gear and items of personal adornment,
which are all indicative of a permanent residential site. Of particular interest are the basalt adzes and fishhooks, as these present morphological categories not typical of later Hawaiian artefact assemblages. Again these were adduced by Kirch (1975a, 1985) as evidence that the Hālawa Dune site represented an early phase in the development of Hawaiian material culture. These include adzes of quadrangular or trapezoidal cross sections, but lacking pronounced tangs, and in one complete example thoroughly ground with rounded shoulders (Kirch 1975a:36, Fig. 20a), a form known otherwise from the enigmatic Nihoa and Necker Islands in the northwestern Hawaiian chain (Emory 1928:40-42, 92-95, Figs 19, 64, 65). The Hālawa fishhook assemblage is noteworthy for its small, two-piece points of bone, closely matching hooks from Layers II and III of the Bellows Dune site on O‘ahu (Pearson et al. 1971: 223, Plate V: r, s) and the early Waiahukini sites on Hawai‘i (Sinoto and Kelly 1975, Figs 10, 11), which differ from the two-piece hooks typical of later Hawaiian sites (characterised by more pronounced, formal knobs and usually larger in size). The few one-piece hooks from Hālawa also include head types of forms 1a and 1b (Sinoto 1962, 1991), thought to be typical of early assemblages, and from the upper sector of Layer IV, one example of head type 4.

The 1969-1970 Dates

Two sets of radiocarbon samples from Mound B were submitted to the Gakushuin Laboratory in Japan; three at the end of the 1969 field season and five more at the close of the expanded 1970 areal excavations (Table 1). All of these were from well defined hearths or earth ovens, and all samples consisted of significant quantities of wood charcoal. Several factors must be taken into account when interpreting these radiocarbon dates. First, according to reports from Dr. K. Kigoshi of Gakushuin, the 1969 samples were pre-treated with hydrochloric (HCl) and nitric (NaOH) acid rinses to eliminate humic acids and modern organic contaminants; the 1970, samples, however, were pre-treated only with HCl, which may not have entirely eliminated modern organic contaminants (Kirch 1975a:49-51). Second, the Gakushuin lab did not routinely measure $\delta^{13}$C values, and these are unknown for the eight samples listed in Table 1. As a result, the reported $^{14}$C values are not “conventional radiocarbon dates” in the sense of Stuiver and Polach (1977). Moreover, in the new sample of AMS dates (discussed below), the three charcoal samples all have $\delta^{13}$C values of $\sim$ -10‰, presumably because these are from C4 pathway plants, quite typical of dryland and mesic Hawaiian forest taxa.¹ The Gakushuin lab calculated its $^{14}$C ages on an assumed “normal” $\delta^{13}$C value of approximately -25‰ typical of C3 pathway plants. Thus if some or all of the 1969-70 charcoal samples consisted of C4 taxa with lower $\delta^{13}$C values (as seems likely given our recent results), the reported ages would be
<table>
<thead>
<tr>
<th>Sample No. GaK-</th>
<th>Provenience</th>
<th>Age B.P.</th>
<th>Calibrated Age (2σ) A.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2741</td>
<td>Upper sector, Feature 48, stone-lined hearth associated with Structure 2</td>
<td>845 ± 80</td>
<td>1020-1280</td>
</tr>
<tr>
<td>2742</td>
<td>Upper sector, Feature 58, earth oven intrusive into Layer IV</td>
<td>237 ± 120</td>
<td>1460-1960</td>
</tr>
<tr>
<td>2743</td>
<td>Lower sector, Feature 57, hearth at base of Layer IV</td>
<td>1421 ± 90</td>
<td>410-780</td>
</tr>
<tr>
<td>3061</td>
<td>Upper sector, Feature 54, hearth</td>
<td>82 ± 70</td>
<td>1660-1780, 1790-1960</td>
</tr>
<tr>
<td>3062</td>
<td>Lower sector, Feature 56, hearth</td>
<td>422 ± 170</td>
<td>1250-2000</td>
</tr>
<tr>
<td>3063</td>
<td>Upper sector, Feature 59, earth oven intrusive into Layer IV</td>
<td>Modern</td>
<td>—</td>
</tr>
<tr>
<td>3064</td>
<td>Upper sector, Feature 55, hearth, not associated with structure</td>
<td>Modern</td>
<td>—</td>
</tr>
<tr>
<td>3065</td>
<td>Upper sector, Feature 49, stone-lined hearth associated with Structure 3</td>
<td>216 ± 100</td>
<td>1480-1960</td>
</tr>
</tbody>
</table>
too young. In short, the combined effect of incomplete pre-treatment (of the five samples from 1970), the necessity of pooling unidentified charcoal and the lack of determination of $\delta^{13}C$ values (and subsequent correction of the $^{14}C$ ages) is likely to have systematically skewed the Gakushuin lab dates towards the younger end of the time scale.

At the time these dates were received, and in light of then-current views regarding Eastern Polynesian and Hawaiian chronology (e.g., Emory 1968, Green 1966), the early GaK-2743 date of A.D. 410-780 seemed reasonable and was accepted as a valid age for the initial settlement of the site. Sample GaK-2741, at A.D. 1020-1280 from the upper sector of Layer IV, was also seen as a valid age for this phase of occupation. The 1970 suite of five samples, however, appeared to be inconsistent with the results from the 1969 season and were at the time rejected as being “contaminated and not representative of the age of the site” (Kirch 1975a:51). These were the samples that had been only partially pre-treated for modern organic materials. In light of our new AMS results, however, it may not be necessary to reject out of hand the 1970 samples, although we must keep in mind the caveats mentioned above and that all of the Gakushuin ages are likely to represent some systematic error.

In addition to radiocarbon dating, a second method of age determination was applied to the Hālawa Dune site in 1969-70: hydration dating of the alteration rinds (or rims) on flakes of basalt glass, a relatively low silica type of volcanic glass similar to obsidian. Five specimens of basaltic glass from Square H8 in Mound B (three from 30-40cm depth within Layer IV, and two from 40-50cm) were analysed by M. Morgenstein, who pioneered the application of hydration-rind dating to Hawaiian artefacts (Morgenstein and Rosendahl 1976). Applying Morgenstein’s rate formula, which was developed by measuring the rind thicknesses of known-age basaltic glass from historic-period lava flows, mean ages of A.D. 1026 ± 54 and of A.D. 895 ± 69 were obtained for the samples from the 30-40cm and 40-50cm levels of Layer IV, respectively (Barrera and Kirch 1973: Table 2, Kirch 1975b: Table 42). While the validity of Morgenstein’s rate formula and hence the actual calendar age calculated could certainly be questioned, the relative age of the basalt glass flakes from the Hālawa Dune site was indicated by their average hydration rind thicknesses, when these were compared to samples from other sites within the Hālawa Valley. Flakes from the lower sector Layer IV in Mound B had rind thicknesses ranging from 10.97 to 13.01µ, whereas flakes from later period house sites in the valley interior had rind thicknesses ranging from 3.10 to 7.98µ (Kirch 1975b: Table 42). Thus, simply taking the basalt glass hydration rind data as a rough index of relative age adds additional evidence that the lower portion of the Mound B Layer IV deposit dates to an early phase in the Hālawa Valley sequence.
NEW AMS RADIOCARBON DATES FOR THE HĀLAWA DUNE SITE

All of the charcoal samples excavated from discrete hearth or oven features in 1969 and 1970 were destroyed during the original phase of radiocarbon dating by the Gakushuin lab, leaving nothing for renewed dating. However, samples of faunal material and generalised (non-feature specific) samples of wood charcoal from the upper and lower sectors of Layer IV were available, and these were used in a renewed attempt at dating the site, employing the accelerator mass spectrometry (AMS) method. It is important to understand that these samples were provenienced only in the most general way to upper and sector sectors, i.e., from the upper 0-30cm and the lower 30-60cm of this 60cm thick cultural deposit. A sample labeled “lower sector” could as readily have come from 31cm as from 59cm depth, and similar an “upper sector” sample could as likely be from 29cm as from 2cm. Moreover, during the extensive 1970 excavations, only about half of the exposed lower sector was excavated down to the top of Layer V, with the other half taken down only to a depth of 40-45cm within Layer IV. Thus roughly two-thirds of the excavated lower sector volume actually comes from the 30-40/45cm zone. Additionally, as noted earlier, extensive digging of postholes, ovens, pits and other kinds of activities during the occupation of the site are very likely to have moved and displaced cultural materials, both vertically and horizontally, within Layer IV. Thus we do not put a great deal of weight on these coarse stratigraphic divisions within Layer IV and it is therefore probable that, with one exception, our new samples are representative of the middle part of Layer IV. The exception is sample Beta-217002 that comes from Square H8, which was excavated in controlled 10cm levels. This sample was from the lowest level, 50-60 cm, within Layer IV.

The six new samples are listed in Table 2, with details of provenience, material and dating results. Beta-21700 was a pig incisor (55mm long, matching a mandible fragment with two intact incisors); it was cut into horizontally into two parts, with the root sent to the University of Auckland for extraction of aDNA. Beta-217001 was a maxillary fragment of a dog, with one partial premolar in situ. The sample from Square H8, Beta-217002, and the only sample with a secure provenience from the base of Layer IV, was the lower pharyngeal grinding plate of a Scarus sp. parrotfish. The remaining three samples, Beta-217003 to -217005 were twig-sized pieces of wood charcoal, all selected because they had intact diameters ranging from 4-7mm and thus were unlikely to represent old wood. We were not able to secure taxonomic identifications of these specimens before dating, but the samples were each split into two halves and the non-dated half retained for future identification.
Table 2. New AMS Radiocarbon Dates for the Hālawa Dune Site.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Provenience</th>
<th>Material</th>
<th>Measured $^{14}$C Age</th>
<th>$\delta^{13}$C ($%$)</th>
<th>Conventional $^{14}$C Age</th>
<th>Calibrated Age A.D. (2$\sigma$) with associated probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>217000</td>
<td>Layer IV, Lower sector</td>
<td>Pig incisor</td>
<td>90 ± 40</td>
<td>-19.8</td>
<td>180 ± 40</td>
<td>1640-1890 (78%), 1910-1960 (17%)</td>
</tr>
<tr>
<td>217001</td>
<td>Layer IV, Lower sector</td>
<td>Maxillary fragment of dog</td>
<td>330 ± 40</td>
<td>-21.8</td>
<td>380 ± 40</td>
<td>1440-1530 (55%), 1540-1640 (40%)</td>
</tr>
<tr>
<td>217002</td>
<td>Square H8, 50-60 cm</td>
<td>Scarus sp. bone</td>
<td>530 ± 40</td>
<td>-12.2</td>
<td>740 ± 40</td>
<td>1210-1300 (92%), 1360-1390 (3%)</td>
</tr>
<tr>
<td>217003</td>
<td>Layer IV, Lower sector</td>
<td>Wood charcoal</td>
<td>300 ± 50</td>
<td>-10.2</td>
<td>540 ± 50</td>
<td>1290-1370 (41%), 1380-1450 (54%)</td>
</tr>
<tr>
<td>217004</td>
<td>Layer IV, Lower sector</td>
<td>Wood charcoal</td>
<td>30 ± 50</td>
<td>-10.9</td>
<td>260 ± 50</td>
<td>1480-1690 (73%), 1730-1810 (18%), 1930-1960 (5%)</td>
</tr>
<tr>
<td>217005</td>
<td>Layer IV, Upper sector</td>
<td>Wood charcoal</td>
<td>180 ± 40</td>
<td>-10.4</td>
<td>420 ± 40</td>
<td>1410-1530 (79%), 1570-1630 (17%)</td>
</tr>
</tbody>
</table>
All six samples were processed and dated by the Beta Analytic laboratory (Darden Hood pers. comm., 20 June 2006). The wood charcoal samples received standard “full pretreatment” with hot HCl acid washes to remove carbonates and alkali washes (sodium hydroxide, NaOH) to remove secondary organic materials. The bone samples were washed in de-ionised water, had their outer surfaces scraped free of the outermost layers and then were gently crushed. Dilute, cold HCl acid was repeatedly applied and replenished until the mineral fraction (bone apatite) was eliminated. The collagen was then dissected and inspected for rootlets. Any rootlets were removed and additional pretreatment with NaOH was undertaken to ensure the absence of secondary organic materials. In Table 2 we present the measured $^{14}$C age, as well as the “conventional” $^{14}$C age determined after correction for isotopic fractionation (based on the $\delta^{13}$C value). The conventional age was then calibrated using the Oxcal calibration programme (version 3.10) with atmospheric data from Reimer et al. (2004). Although we applied the same calibration curve to all samples, we are aware that sample Beta-217002, consisting of fishbone, should technically have some correction applied for the marine reservoir effect. The problem here is that a reliable $\Delta R^2$ value for Hawai‘i has not yet been derived. Moreover, given that approximately 28 million gallons of fresh (terrestrially derived) water flow every day into Hālawa Bay (the presumed source of the dated parrotfish jaw), it is likely that the influence of the usual marine carbon reservoir is highly diluted in this inshore embayment (Kirch 1975c:9). In the absence of any empirical data on how to correct this marine sample, we have chosen to calibrate it on the same atmospheric curve with the other five samples.

REVISED HĀLAWA DUNE SITE CHRONOLOGY

Figure 3 presents the Oxcal calibrated probability distributions for all 12 radiocarbon dates from Layer IV of Mound B. Without doubt, GaK-2743, upon which the original estimate of the site’s age was based, is an outlier and must be rejected. The most likely explanation for the age of this sample is that it was derived from old wood. The remaining 11 samples, however, form a continuously overlapping set of probability ranges, and it is not immediately apparent that any of these samples should be rejected outright. The oldest of these samples is GaK-2741, which came from a stone-lined hearth securely associated with Structure 2, near the bottom of the lower sector. Sample Beta-217002 overlaps with GaK-2741, and together the two samples suggest an age between A.D. 1200-1300. However, Beta-217002 is the fish jaw for which some reservoir correction may be necessary. The next oldest sample, Beta-217003, derives from a twig from the generalised lower sector wood sample and is unlikely to contain an in-built age factor. With its highest probability calibrated age range at A.D. 1380-1450, it gives us a secure minimum age for
the Layer IV deposit. Our view is that the deeper parts of Layer IV date to at least c. A.D. 1400, with a distinct possibility that occupation may have begun a century or so earlier. Any occupation before A.D. 1200 is certainly ruled out. This leaves something of a “gray zone” of chronometric interpretation for the period A.D. 1200-1400, but in the absence of additional samples from secure contexts (i.e., discrete features) at the very base of the Layer IV deposit, this is the most precise interpretation possible.

The remaining eight samples (GaK-3062 through GaK-3061 in Figure 3) provide evidence for the continued use of the site, and the accumulation of the Layer IV deposit, from about A.D. 1400 until sometime in the later pre-contact period. For just how long the dune site continued to be occupied, however, is not clear. The absence of any post-contact artefacts of Euro-American origin in the upper sector and the deposition of the sterile Layer III sand suggest that the site was abandoned some time before the late 18th century. Here, the radiocarbon dates are not especially helpful, because of the multiple calibration intercepts that are characteristic of such late prehistoric samples.

Figure 3. Oxcal plot of all radiocarbon dates from Mound B of the Hälawa Dune site.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Calibration Date (BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GaK-2743</td>
<td>1421±90BP</td>
</tr>
<tr>
<td>GaK-2741</td>
<td>845±80BP</td>
</tr>
<tr>
<td>Beta-217002</td>
<td>740±40BP</td>
</tr>
<tr>
<td>Beta-217003</td>
<td>540±40BP</td>
</tr>
<tr>
<td>GaK-3062</td>
<td>422±170BP</td>
</tr>
<tr>
<td>Beta-217005</td>
<td>420±40BP</td>
</tr>
<tr>
<td>Beta-217001</td>
<td>380±40BP</td>
</tr>
<tr>
<td>Beta-217004</td>
<td>260±50BP</td>
</tr>
<tr>
<td>GaK-2742</td>
<td>237±120BP</td>
</tr>
<tr>
<td>GaK-3065</td>
<td>216±100BP</td>
</tr>
<tr>
<td>Beta-217000</td>
<td>180±40BP</td>
</tr>
<tr>
<td>GaK-3061</td>
<td>82±70BP</td>
</tr>
</tbody>
</table>

Calibrated date

500CalBC CalBC/CalAD 500CalAD 1000CalAD 1500CalAD 2000CalAD
In sum, the Hälawa Dune site can no longer be regarded as dating to the first millennium A.D. as suggested in earlier syntheses of Hawaiian prehistory. Indeed, it is unlikely to have been settled prior to A.D. 1300. There is no doubt that the site was in use by A.D. 1400, and the Layer IV deposit is likely to represent between two to four centuries of continued use before it was abandoned at sometime before European contact.

DISCUSSION

The re-dating of the Hälawa Dune site, combined with a recent review of all available Moloka'i radiocarbon dates (McCoy 2007), highlights the remarkably poor state of our knowledge of life on the island before A.D. 1200. Currently, the earliest, acceptable evidence for human arrival comes from a single paleoenvironmental core located in a defunct fishpond on the island's central southern coast (Denham et al. 1999). A clear transition from pristine Pritchardia palm dryland forest (Zone A: 60-500cm below the surface) to the “initial occurrence of and subsequent rise in frequency of charcoal particles” (Zone B: 65-160cm) is consistent with the timing of a similar transition of O‘ahu Island from approximately A.D. 800-1200 (Denham et al. 1999:42). Nonetheless, the “limited dating... will not support detailed chronological interpretations” (Denham et al. 1999:54), leaving open to interpretation the question of precisely when this process began.

While sites dated to the Early Expansion Period (A.D. 1200-1400) are rare on Moloka‘i, they nonetheless suggest that early populations may have been surprisingly heavily focused on wild natural resources and, as Athens (1985) has suggested, they may have settled the more favourable portions of the windward and leeward eastern coastline by A.D. 1200, and only made temporary use of the western shore (McCoy 2007). This scenario is supported by the distribution of dated samples, by signs of temporary use on the coastal plain near Kaunakakai (Weisler 1989:126, Beta-7564), and by the initial use of western basalt quarries (Dixon et al. 1994). An excavation of an Early Expansion Period midden has uncovered dense fish bone and the presence of turtle and endemic bird, including the Hawaiian goose (Nesochen sandvicensis) (Weisler 1989:127), which further supports the importance of wild foods. There is currently no evidence of intensive agriculture at this stage in Moloka‘i prehistory, although charcoal consistent with swidden practices has been recovered from wet and dry environments (Kirch et al. 2003, McCoy 2007).

Analyses of oral traditions and material evidence suggest that life on Moloka‘i changed dramatically between A.D. 1400 and 1650. First, traditions point to the rise to power of the island’s first royal dynasty around A.D. 1360
(McCoy 2005, 2006; Summers 1971). However, unlike other Hawaiian island-wide polities, this political system appears to have collapsed roughly a century after it began. Considering the best indicators of the state of prehistoric society—ritual sites, including temples (heiau), fishing shrines (ko’ā) and other structures—we have another strong marker of social change in an unprecedented spate of construction c. A.D. 1400-1650 (Kirch and Sharp 2005; McCoy 2006, 2007; Weisler et al. 2006). Second, in terms of demography, if we posit a correlation between the number of $^{14}$C dates per period and population size, the Late Expansion Period was a stage of unchecked, steady population growth. This pattern is not only evident for Moloka‘i, but is also evident in an even larger suite of radiocarbon dates from Kaua‘i Island (Fig. 4). Indeed, dates from this period account for >60 percent of all dates before A.D.1650. Third, it is during this period that agriculture clearly shifted toward large, intensive systems; this is best seen in the establishment of a 9km$^2$ continuous landscape of non-irrigated plots known as the Kalaupapa Field System (McCoy 2005, 2006). In the western half of the island, Dixon et al. (1994) have detected a spike in the manufacture of stone adzes, characterised as “superabundant production”, which the authors suggest is directly linked with an island-wide trend towards intensive agriculture.

Figure 4. Number of radiocarbon dates per cultural period for Moloka‘i (left) and Kaua‘i (right) Islands, Hawai‘i (A.D.800-1650). (Sources: For Moloka‘i, McCoy 2007; for Kaua‘i, Carson 2006).
The Hālawa Dune site provides rare direct evidence of changes in domestic life during this critical period in the island’s prehistory, especially in its subsistence history. As first noted by Kirch (1975a), the concentration of domesticates (pig and dog) and fish fauna (measured as grams per cubic metre or g/m$^3$) recovered from controlled excavation shows an initial phase of high marine resource exploitation gradually replaced by a reliance on domestic food (Fig. 5). However, given that sea turtle and endemic birds are not present and that the only extirpated endemic species is a freshwater mollusc (*Neritina granosa, hīhīwai*), which today is “common in the fast-flowing sections of many undiverted Hawaiian streams” (Fitzsimons *et al.* 2005:277, emphasis added), this transition appears to have taken place well after the initial human impact on the endemic fauna and corresponds to the advent of intensive pondfield agriculture in the Hālawa Valley.

Overall, if the Hālawa Dune site is representative of changes in Moloka‘i during a period of marked population growth and changes in subsistence patterns from A.D.1400-1650, it appears that there was a shift both in production (i.e., intensification) and in the relative importance of domestic versus wild foods in people’s diet. Future research might productively focus on teasing out these concurrent processes from each other to better understand the underlying causes.

The larger implications of this revised chronology for Hawaiian prehistory are at least twofold. First, the accumulated evidence from radiocarbon dating

![Figure 5. Concentration of vertebrate fauna (g/m$^3$ per level) in Mound B of the Hālawa Dune site, quantitative Square H8. (Source: Kirch 1975a).](image-url)
increasingly fails to support an interpretation of Polynesian colonisation of the Hawaiian archipelago between A.D.300-600. The known sites that might possibly date to pre-A.D.800 are now only Waiahukini (H8) at South Point, Hawai‘i Island and Kuli‘ou‘ou (O1), O‘ahu. But the dating of H8 is highly questionable, and the single early date of 680-1392 cal A.D for Kuli‘ou‘ou (Emory and Sinoto 1961, see also Dye and Steadman 1990:209) has a very wide error range. Until these sites can be re-dating using modern $^{14}$C methods, these dates must remain in doubt; indeed, we suspect these sites are much younger than initially assessed. To us, the mounting evidence points to the Polynesian discovery of the Hawaiian Islands after A.D.800, but probably no later than A.D.1000. The process by which individual islands in the Hawaiian archipelago were colonised may have proceeded slightly differently on each island; this may best be measured through paleoenvironmental indicators of the presence of humans such as evidence for forest clearance (e.g., Athens et al. 2002), followed some time afterwards by site based evidence of settlement. For example, the earliest definitive settlement sites on Moloka‘i date to A.D.1200-1400 and include the earliest component of the Hālawa Dune and as well as five other sites—a coastal midden in Kaunakakai (03-630), a habitation site in Kalaupapa (03-2303), two sites on the islands’ west end in Kaluako‘i (B6-161 and 02-21), and one site in the region of Kalae (03-885) (Dixon et al. 1994; McCoy 2005, 2006, 2007; Weisler 1989). However, these sites were occupied well after the oldest direct evidence for the arrival of humans in the archipelago.

Second, the emerging picture of a somewhat later settlement of the Hawaiian archipelago by Polynesians requires that we think how best to divide the process of Hawaiian cultural development into historical culture periods and phases. Clearly, the nearly millennium-long period of gradual cultural change subsumed under Kirch’s original “Colonization Period” (A.D.300-600) and “Developmental Period” (A.D.600-1100) must now be radically collapsed, because of the lack of definitive, uncontested evidence of critical historical turning points, not only of initial human colonisation, but also of the permanent settlement of individual islands and districts and the development of a style of material culture and architecture unique to the archipelago. McCoy (2005, 2007) has recently proposed a “Foundation Period” (A.D.800-1200) that would subsume these initial phases of Polynesian arrival and adaptation to new environmental conditions. The neutrally named “Foundation Period” (A.D.800-1200) permits us to separate analytically the difficult problem of identifying and interpreting specific phenomena, such as the events and processes listed above, which is quite different from the relatively straightforward business of reporting material evidence in culture historical periods.
Nonetheless, we believe that with further research archaeologists will in the future be able to marshal a body of evidence sufficient to parse the era before A.D.1200 in to finer culture historical phases.

*      *      *

The Hālawa Dune site—critical to the original definition of the Hawaiian Developmental Period—has been re-dated here using six new AMS $^{14}$C dates, and the original dating suite has been re-evaluated. We now regard this site as dating no earlier than A.D.1300, with the main occupation phase occurring during the Late Expansion Period (A.D.1400-1650). These results significantly narrow site-based evidence for an early colonisation of the Hawaiian Islands, simultaneously strengthening the view that Polynesians did not arrive in Hawai‘i before A.D. 800. Indeed, as is evident in the revised chronology of Moloka‘i Island, the best current evidence for initial human arrival consists of records of anthropogenic changes to local environments that are dated between around A.D. 800-1200, rather than of actual archaeological sites. It seems likely that the Hawaiian cultural sequence will need to be revised, and we suggest substituting the process-neutral term “Foundation Period” (A.D.800-1200) to replace the previously defined “Colonization” (c. A.D. 800-1000) and “Developmental” (c. A.D. 1000-1200) designations. The addition of a “Foundation Period” (A.D. 800-1200) allows us to separate analytically the interpretation of early sites from the process of reporting on trends in material evidence in culture historical periods.

ACKNOWLEDGEMENTS

This research was supported by a grant to the authors from the National Science Foundation (BCS-0535706). We would also like to acknowledge the insightful comments of an anonymous reviewer.

ENDNOTES

1. In a large suite of 160 radiocarbon dates from Kahikinui, Maui, 27% of the charcoal returned δ$^{13}$C values of this magnitude; PVK, unpublished data.
2. Delta-R signifies the difference (delta) between atmosopheric and the “model” mixed open ocean reservoir.
3. Archaeologists commonly use period names that refer to general historical processes rather than specific ones. The “Neolithic” is a good example of this, since it is a temporal classification that helps organise research across a large region under one category while minimising interpretive baggage. Thus, scientists are left to research, report and debate what happened during the Neolithic rather than squabble over what it should be called.
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