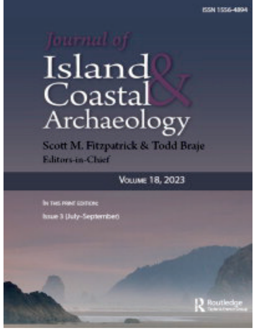

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The Hālawa dune site, Moloka'i, Hawaiian Islands: New excavations, redating, and new interpretations

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ABSTRACT

The Hālawa dune site on Moloka'i Island has played a key role in understanding early Hawaiian history. Initially excavated in 1969–1970 and regarded then as dating to the early phase of Hawaiian settlement, the site yielded a diverse artifact assemblage and the first evidence for round-ended house foundations in Hawai'i. Prior attempts to refine the site's chronology yielded inconsistent results. Renewed excavations and re-analysis of previously excavated collections from the site have allowed for recovery of a stratigraphically controlled sample of faunal materials and charcoal. AMS dating of candlenut endocarp indicates initial use of Mound A cal AD 1366–1610, with occupation continuing into the post-contact period. Matched pairs of candlenut and marine mollusk shell dates allow for the derivation of a Hālawa-specific marine reservoir value ($\Delta R = -267$), in turn permitting the calibration of 12 dates on marine mollusk shells excavated from Mound B in 1970. Faunal materials from the 2020 Mound A excavation add new information on patterns of marine exploitation, and on a trend of increased frequency of domestic pig and dog over time. Charcoal identified from Mound A indicates largely native forest taxa, but with several Polynesian-introduced plants as well, including candlenut, breadfruit, and mountain apple.

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KEYWORDS
Hawaiian archaeology; faunal analysis; marine resources; resource intensification; radiocarbon dating

Introduction

Over the past three decades, the chronology for the settlement of Eastern Polynesia has undergone major revisions, in particular a shortening of the time scale from a "long" chronology extending to the beginning of the first millennium AD to a "short" chronology with the earliest sites in the region now seen to date no earlier than ca. cal AD 900–1100 (Kirch 2017, 198–203, table 7.2; Spriggs and Anderson 1993; Weisler 1989; Weisler et al. 2023). In the Hawaiian Islands, well-stratified coastal sites—typically in sand dune or beach ridge geomorphic settings, or in rockshelters—were critical in defining the early stages of the Hawaiian cultural sequence (Kirch 1985; Kirch and McCoy 2023). One such site, the Hālawa dune site, excavated between 1964 and 1970, played a key role in the definition of the Developmental Period in the Hawaiian cultural

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sequence, as outlined by Kirch (1985, 76–9). In this article we report on renewed excavations at the Hālawa dune site that have resulted in a significant revision of the site's chronology and added fine-grained data on site function and environment.

Background to the Hālawa dune site

First discovered in 1964, the Hālawa dune site (Bishop Museum site number Mo-A1-3) consists of two low mounds rising slightly above the coastal flood plain of Hālawa Valley, on the southern side of the river mouth (Figure 1). Hālawa is one of four large valleys on the windward side of eastern Molokaʻi, which together with the Kalaupapa Peninsula comprised the Koʻolau District. The only one of these four valleys readily accessible by sea throughout the year, Hālawa was a major center of irrigated taro cultivation (Anderson 2001; Kirch and Kelly 1975). With its permanent stream, broad alluvial floodplain, gentle colluvial slopes, and ready access to marine and forest resources, Hālawa offered a combination of environmental attributes thought to be attractive for early Polynesian settlers.

Kirch interpreted the low mounds at site Mo-A1-3 as "erosional remnants of a once more extensive deposit, largely destroyed by the 1946 tsunami" that caused major damage to the lower portion of Hālawa Valley (Kirch 1975a, 18). The smaller Mound A was initially tested by Kirch in 1964, when a single 3 × 3 ft unit was dug into the east face of the partially eroded mound. Excavation of the larger Mound B (15 m long × 11.5 m wide × 1 m high), proceeded in stages from 1968 to 1970 beginning with a test trench, followed by a 4 m^2 test unit in 1969, and finally with a horizontally extensive 53 m^2

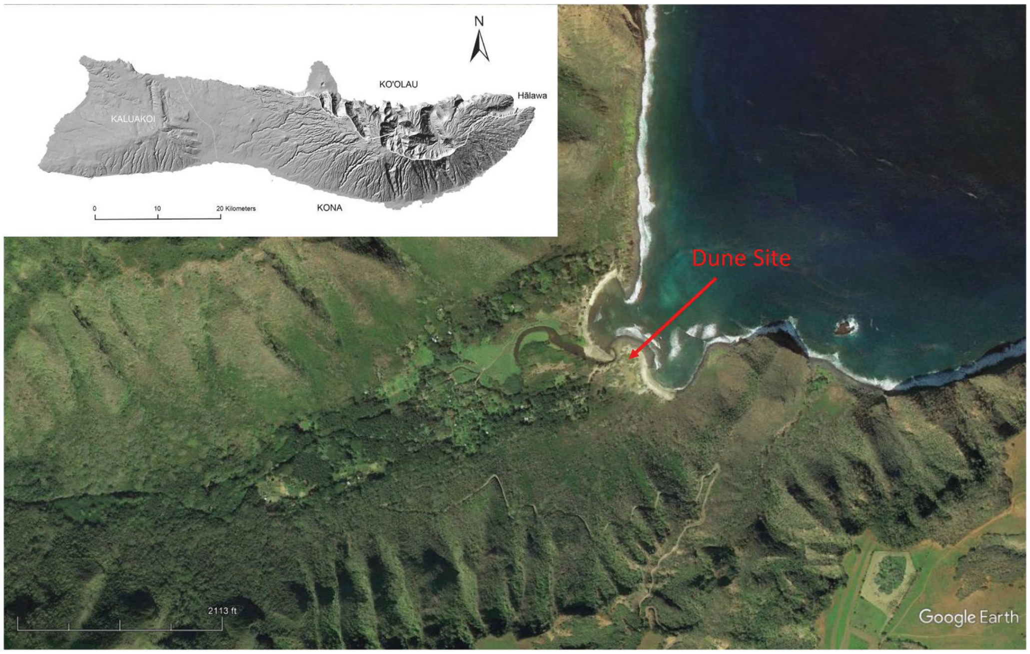

Figure 1. Google Earth view of Hālawa Valley showing the location of the Mo-A1-3 dune site. Inset shows the island of Molokaʻi with Hālawa Valley indicated.

excavation in 1970 (Kirch 1975a, 18–20). A preliminary report on the Hālawa dune site excavations (Kirch 1971) was followed by a definitive site report (Kirch 1975a); radiocarbon and obsidian hydration-rind volcanic glass dates were presented by Kirch (1975b) and by Barrera and Kirch (1973). Six stratigraphic units were defined in Mound B (Kirch 1975a, tables 5 and 6), with the main cultural deposit being the 60 cm thick Layer IV, containing pre-contact period artifacts and features, along with faunal materials. Layer IV was subdivided into upper and lower sectors, with a somewhat discontinuous sand lens separating them.

The Hālawa Mound B excavations yielded a significant collection of portable artifacts from a context of non-portable structural features including house foundations, hearths, and earth ovens (Kirch 1975a). The earliest structural remains are a set of postholes, pits, and hearths or charcoal concentrations in the lower sector of Layer IV. At the top of the lower sector within Layer IV, a small, round-ended house foundation built of rounded beach cobbles was exposed (Structure 1a); this was overlain at the base of the upper sector, with a rebuilt foundation of roughly the same form (Structure 1b). Structures 2–5, all in the upper sector of Layer IV, were manifested by posthole patterns and in two cases by small stone-lined hearths. The round-ended form of the structures in Layer IV differs from the typical rectangular houses of later pre-contact Hawaiʻi, being more similar to ethnographically-attested houses in other parts of Eastern Polynesia, such as Mangareva or the Tuamotu Islands (Kirch 1975a, 66–7, fig. 29). This was one line of evidence adduced for the Hālawa dune site representing an early phase of Hawaiian material culture.

The artifact assemblage from Layer IV in Mound B includes tools, fishing gear, and items of personal adornment, all indicative of a permanent residential site. The basalt adzes and fishhooks represent morphological forms not typical of later Hawaiian artifacts, again adduced by Kirch (1975a, 1985) as evidence that the Hālawa dune site represented an early phase in the development of Hawaiian material culture. Adzes of quadrangular or trapezoidal cross sections lacked pronounced tangs; one complete, untanged adze is thoroughly ground with rounded shoulders (Kirch 1975a, 36, fig. 20a; Kirch 1985, fig. 53a), a form known otherwise from the Nihoa and Mokumanamana (or Necker) Islands in the northwestern Hawaiian chain (Emory 1928, 40–2, 92–5, figs. 19, 64, 65). Mills et al. (2018) reported on an analysis of the lithic assemblage from Layer IV, with geochemical characterization indicating that the majority of the basalt flakes originated from an unknown East Molokaʻi source. The Hālawa fishhook assemblage is dominated by small, two-piece points of bone, closely resembling bone points from Layers II and III of the early Bellows dune site on Oʻahu Island (Pearson, Kirch, and Pietrusewsky 1971, 223, plate V, r, s), and the early Waiahukini sites on Hawaiʻi Island (Sinoto and Kelly 1975, figs. 10, 11). These differ from two-piece hooks typical of later Hawaiian sites, characterized by more pronounced, formal knobs, and usually larger in size. The few one-piece hooks from Hālawa also include head types of forms 1a (flat end, with outer side notched) and 1b (flat end, with both sides notched) (Sinoto 1962, 1991), thought to be characteristic of early assemblages. From the upper sector of Layer IV there is one example of head type 4 (pointed or triangular end, with distinctive protruding knob), which Emory, Bonk, and Sinoto (1965) regarded as evidence of secondary influence from the Society Islands.

The 2020 Mound A excavation

In December 2020 renewed excavations were undertaken at the Mo-A1-3 site as one component of a larger project focused on the development and sustainability of traditional agriculture in Hālawa Valley. Our aims in re-excavating the dune site were: (1) to refine the site's chronology using high-precision AMS dating on identified materials; (2) to obtain a stratigraphically well-controlled sample of faunal remains, including those of pig, dog, and rat that could be used for stable isotope analysis; and (3) to obtain additional cultural materials that might inform as to site function. We decided to focus on the smaller Mound A, because we observed archaeological deposits actively eroding from this mound due to its exposure to stream flooding and ocean wave activity.

Mound A measures roughly 8 m north–south by 7 m east–west, with a maximum height of 0.55 m above the surrounding sandy flat. On the west and north, the edge of Mound A is a mere 5–8 m away from the active channel of Hālawa Stream where this curves around a sand bar to enter the bay (Figure 2). The Hālawa Stream mouth has been gradually shifting to the south over the past several decades, eroding the southern bank during periods of flooding, and washing out most of the sandy flat that separated Mound A from the river and bay 50 years ago (Figure 2A). The west and north edges

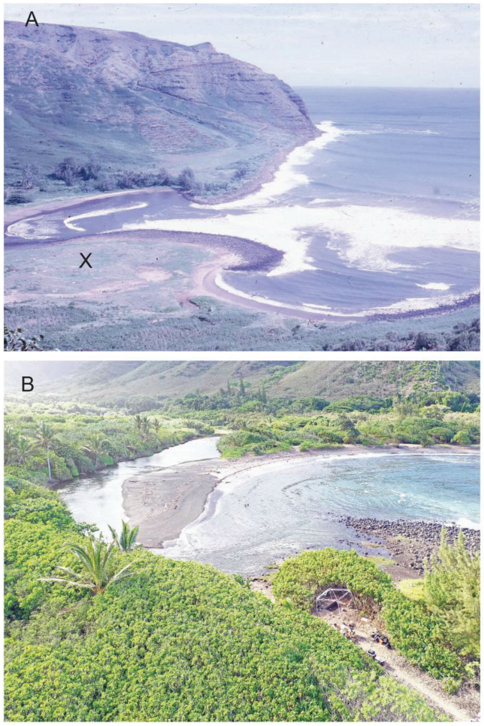

Figure 2. A, view of the mouth of Hālawa Valley in 1964; the approximate position of Mound A is indicated by the X. Note the absence of any tall vegetation. B, drone photo of the river mouth in 2020, with the Mound A excavation visible under the tent frame. Note how the river bank is encroaching on Mound A.

of Mound A are now marked by active erosion scarps cut by the combined action of stream flooding and king tides.

After clearing the top of Mound A of obscuring vegetation (primarily *milo*, *Thespesia populnea*), a metric grid was established; two adjacent 1 m square grid units (designated D4 and D5) at the top of the mound were chosen for excavation (Figure 3). We excavated both units simultaneously following natural stratigraphy, but using arbitrary levels of approximately 5 cm each for fine-grained control within stratigraphic layers, particularly within the relatively thick pre-contact deposit. The units were excavated by trowel, with all sediment dry sieved through 1/8-inch mesh; charcoal and faunal remains from the sieves were retained for laboratory analysis. A column sample in 5 cm intervals was taken from the west face of unit D4 for granulometric analysis.

Stratigraphy of Mound A

The stratigraphy within Mound A was slightly less complex than that previously recorded for Mound B (see Kirch 1975a, 20–5, table 5), but with a similar pre-contact midden capped by a post-contact deposit containing artifacts of Euro-American origin. Four discrete strata were recognized within Mound A, as described below and illustrated in the stratigraphic sections of the east and west faces of the excavation (Figure 4).

Layer I (level 1) consists of a dark gray (7.5 YR 4/1) sandy-clay loam penetrated by rootlets and containing some shell midden. The deposit was loose and appears to have been reworked. The contact with underlying Layer II is sharp.

Layer II (level 2) is a dark reddish-brown (5 YR 2.5/2) compact, stiff deposit of sandy clay containing some fine water-rolled gravel inclusions, along with artifacts of Euro-American origin, indicating a post-contact date of deposition. The contact with Layer III is sharp. The Layer II deposit with its historic artifacts is presumably related to the occupation of a frame house that can be seen in early twentieth-century photographs of the area (the house was destroyed by the 1946 tsunami).

Layer III (levels 3–13), the primary pre-contact cultural deposit, consists of very dark gray (7 YR 3/1), structureless, sandy loam containing shell and bone faunal remains; charcoal flecks and smaller pieces are present throughout the deposit. In the east face of

Figure 3. View of the completed 2020 excavation in Mound A.

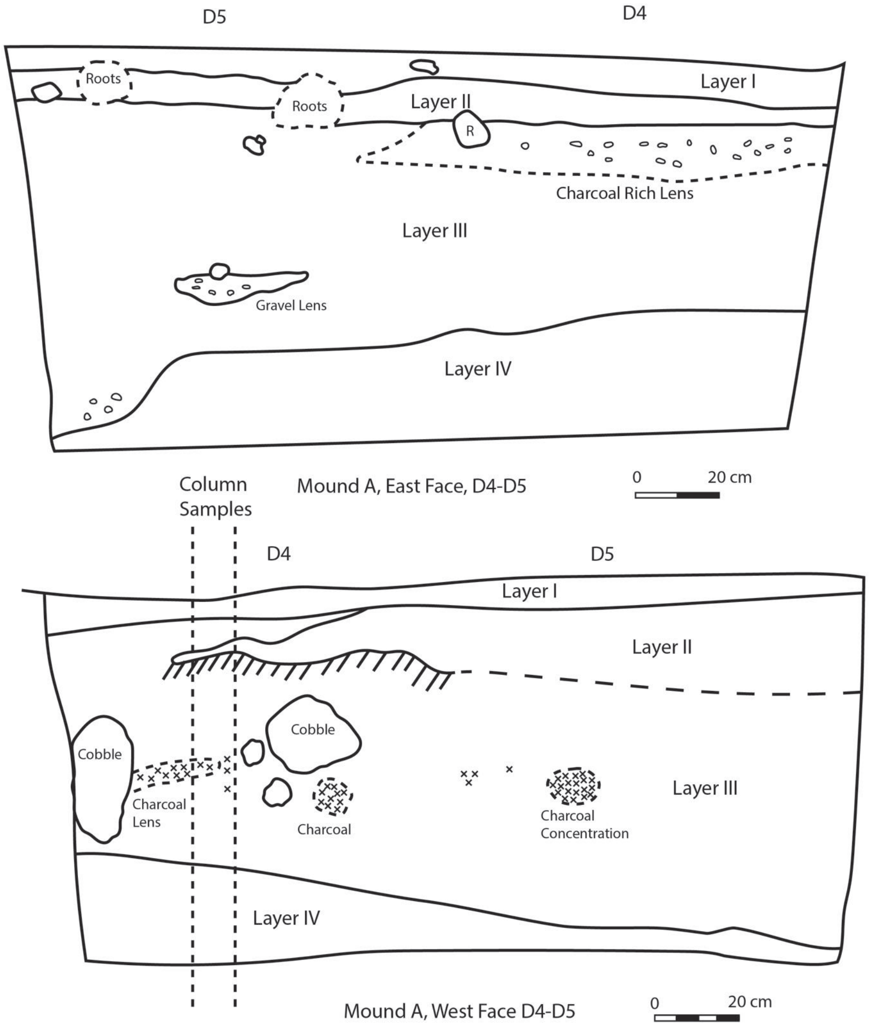

Figure 4. Stratigraphic sections of the east (top) and west (bottom) faces of units D4 and D5 in Mound A.

unit D4 the upper 10–15 cm of Layer III contains a high frequency of charcoal, and may be part of a hearth or earth-oven rake out feature. The contact with underlying Layer IV is somewhat diffuse over a 2 cm zone. At the base of Layer III in unit D4 is a postmold with a diameter of 20 cm extended down 13 cm into underlying Layer IV. This postmold is likely associated with two waterworn beach boulders (diameters ca. 15–25 cm) in the west face of D4 that may have formed part of the foundation of a structure, as with the house structures exposed in the 1970 Mound B excavation. Layer IV (level 14), a brown (7 YR 4/2), structureless, beach sand deposit lacks cultural materials and appears to be the original dune deposit prior to human occupation of the site.

A series of column samples at 5 cm intervals was taken from the west face of unit D4 (see Figure 4); samples were dry-sieved in the laboratory through nested geological sieves using an automated shaker for 15 min per sample. The sieves ranged from -2ϕ (pebble) to 4ϕ (very fine sand) in mesh size. Figure 5 is a plot of the 0ϕ–3ϕ particle

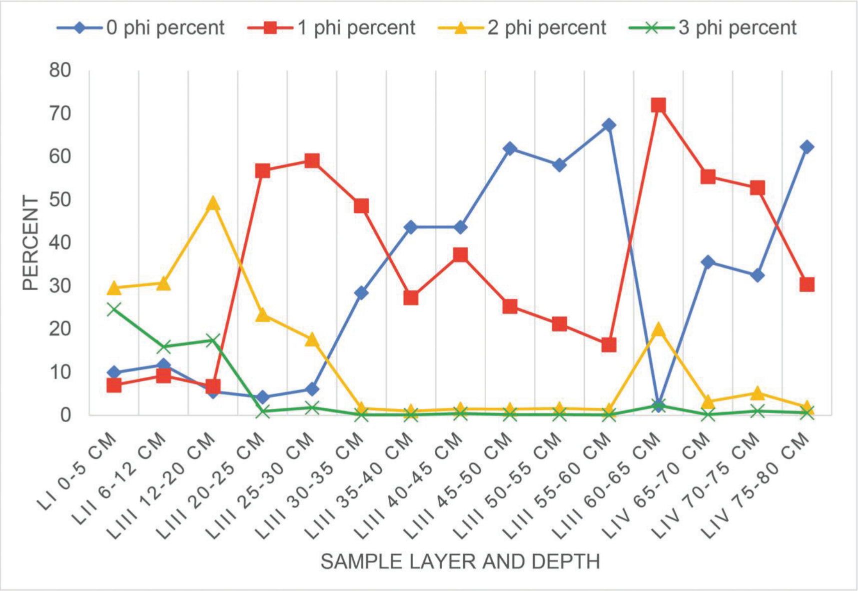

Figure 5. Granulometry plot of Mound A column samples.

frequencies, which exhibited the greatest variation through the column. As can be seen, Layer III is dominated by very coarse to coarse-grained sand, with a transition occurring at about 30 cm below surface, when finer-grained sands increase substantially in frequency. The sand particles throughout the sequence consist of a mix of well-rounded, calcareous and basaltic grains that were transported from the Kaiwili Beach a short distance to the east *via* wind-effected saltation. The transition to finer-sized sand grains in the upper part of the stratigraphic column likely reflects increased stability of the dune surface. The granulometric analysis suggests that the cultural deposit accumulated slowly through a steady progress of trade-wind driven saltation of source grains from the nearby beach.

While the stratigraphy within Mound A differs slightly from that in Mound B, in particular lacking a sterile sand deposit between the historic-period and pre-contact deposits (described as Layer III in Mound B), the pre-contact Layer III of Mound A appears to be a northward extension of the pre-contact Layer IV deposit in Mound B. In Mound B, this deposit is about 8–10 cm thicker than in Mound A. As noted above, this once continuous midden deposit was cut through by the force of the 1946 tsunami, thus creating the separate mounds A and B.

Cultural materials recovered from Mound A

Cultural materials recovered from the Mound A excavations were sorted and identified in the laboratory, and quantified by weight and/or count as appropriate. The weights of the six most prominent classes of cultural material are plotted by excavation level in Figure 6. Marine mollusk shells rise rapidly in quantity from level 13 to level 9, and then remain relatively constant, with a slight decline in levels 1 and 2. Charcoal exhibits a steady increase up to a peak at level 5, then declines rapidly. Fire-cracked rock

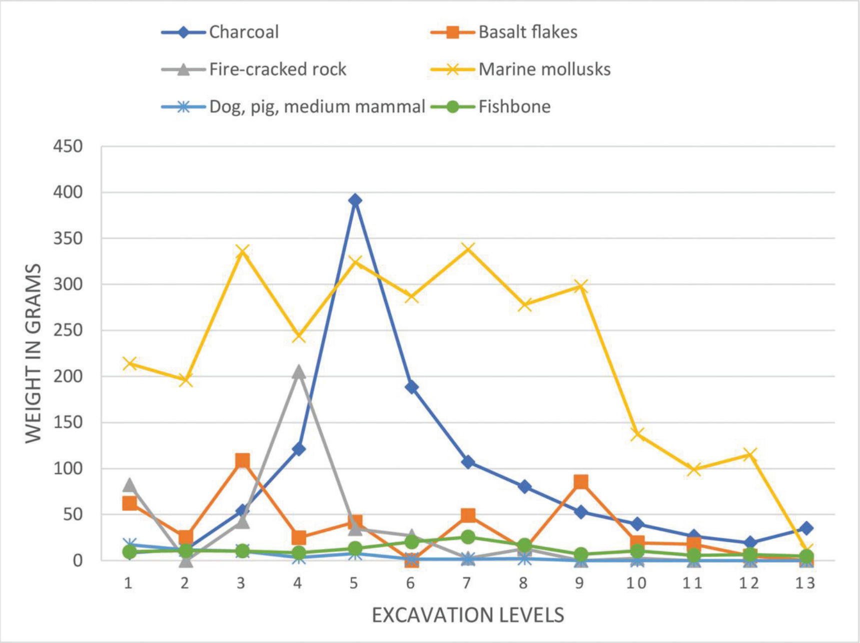

Figure 6. The cultural content of Mound A with major constituents indicated by weight.

(presumably derived from fractured earth-oven stones) is most prevalent in the upper levels from 5 to 1, whereas good-quality basalt flakes (presumably derived from adze or other stone tool manufacture or retouch) occur throughout the deposit, with peaks in levels 3 and 9.

Faunal remains

Invertebrate fauna

Invertebrate remains are the most abundant fauna recovered from the cultural deposit, consisting primarily of the shells of marine mollusks, with lesser quantities of sea urchins, crustacea, and a few pulmonate (terrestrial) gastropod shells. Marine mollusks (total weight 4026.5 g) were sorted into taxonomic categories and quantified by both Minimum Number of Individuals (MNI) and weight, as reported in Table S1 (Supplementary Materials online). The nomenclature of Kay's (1979) definitive monograph on Hawaiian marine mollusks was updated with reference to the World Register of Marine Species (WoRMS: https://www.marinespecies.org/index.php). To determine MNI, the presence of a complete apex in gastropods, or the presence of a complete hinge in bivalves, were used as defining criteria. With weight as the measure, the two most abundant taxa are the limpet *Cellana* spp. followed by the small gastropod *Nerita picea* (Figure 7). When MNI is used, *N. picea* is the most abundant, followed by *Angiola labiosa*, *Isognomon californicus*, and *Neripteron vespertinum*, with *Cellana* spp. dropping to fifth rank (Figure 7). Temporal trends in the frequencies of the six most abundant mollusk taxa, by both weight and MNI, are illustrated in Figure 8.

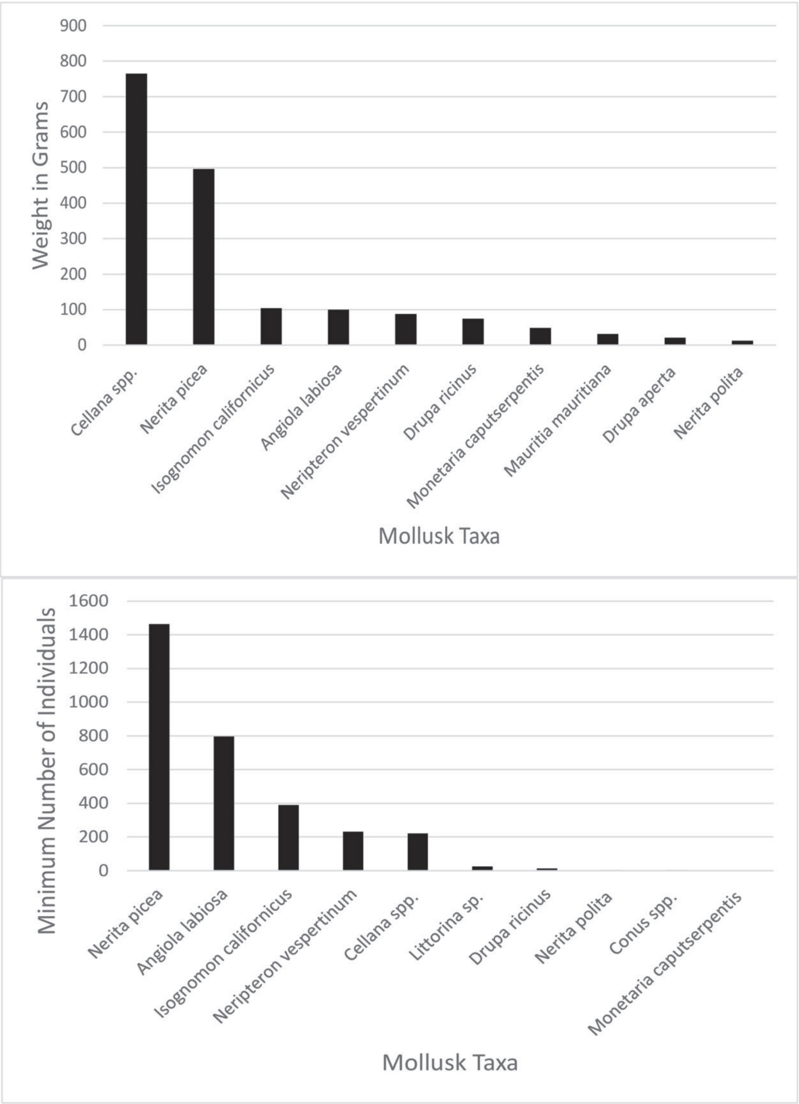

Figure 7. Rank order plots of principal mollusk taxa in Mound A by weight (top) and MNI (bottom).

The limpets in Mound A appear to be mostly, if not exclusively, of the species *Cellana exarata*, although some *C. sandwicensis* individuals may also be present (these can be difficult to differentiate, especially with fragmentary material). Known to the Hawaiians as ʻ*opihi*, these limpets are highly prized as food items (Rogers and Weisler 2021). Kay notes that *C. exarata* "is found on basalt shorelines from the spray zone where it occurs with the nerite, *Nerita picea*," also abundant in the Mound A assemblage (Kay 1979, 44). A different nerite, *Neripteron vespertinum*, known as *hihiwai* in Hawaiian, "occur near the mouths of rivers and streams, in freshwater and in low salinity parts of estuaries" (1979, 67). *N. vespertinum* is no longer present in the Hālawa Stream or estuary, but its presence throughout the cultural deposit indicates that it was formerly present. Other mollusks almost certainly taken as food include *Monetaria*

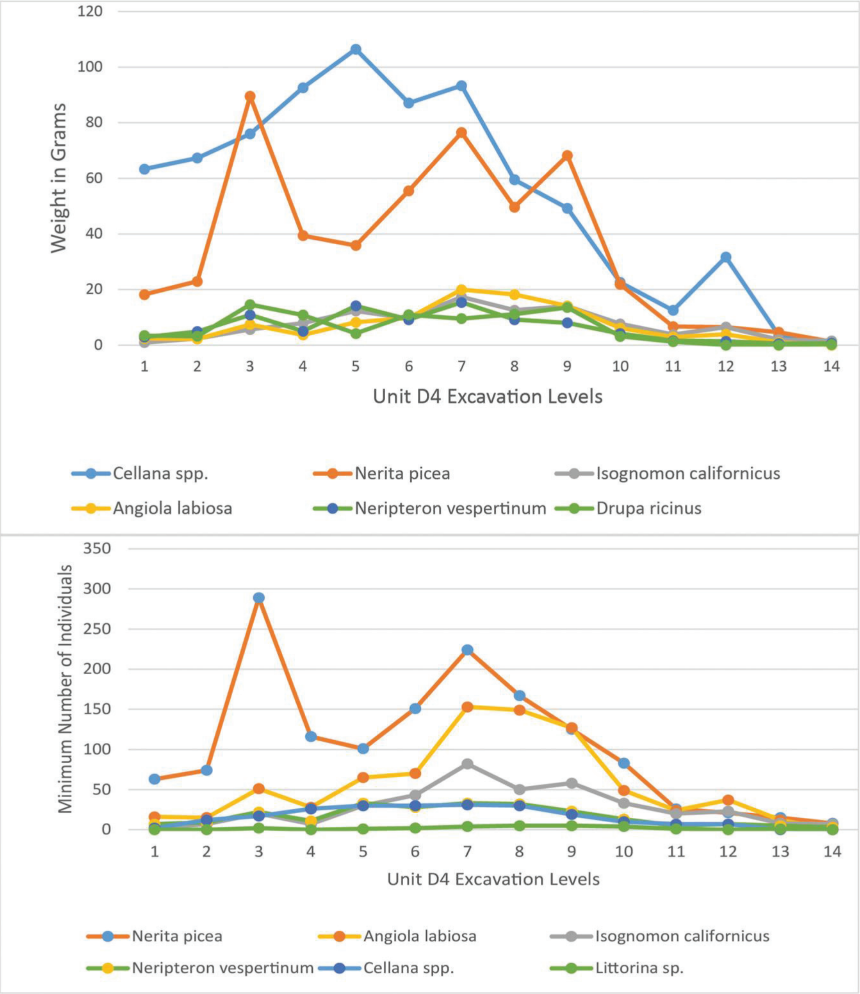

Figure 8. Temporal trends in principal mollusk taxa in Mound A by weight (top) and MNI (bottom).

caputserpentis, *Drupa ricinus*, *Littorina* sp., and *Drupa aperta*. The large cowrie *Mauritia mauritiana* was prized for use in the octopus-lure rig.

The strong presence of the gastropod *Angiola labiosa* in the site is puzzling, as these tiny mollusks had negligent food value, and there is no evidence of the shells being pierced for suspension as necklace components. The small mussel *Isognomon californicus* likewise would seem to have had little value as food, and the shells are too small and fragile for use in fishhook manufacture, yet they are quite abundant in the deposit. Rogers and Weisler (2022, 141) have suggested that a foraging strategy of "targeting high density clusters of small gastropods" may have been an effective risk management strategy. However, it is conceivable that *Angiola labiosa* shells were inadvertently collected while adhering to edible seaweeds that were gathered by the Hawaiians.

Given that *Cellana* spp. limpets are culturally prized food items, it is possible that continuous harvesting pressure by a large resident population in the valley would have resulted in resource depression. Such resource depression is typically manifested by reductions in mean size, with larger (older) individuals becoming depleted or eliminated (e.g., Allen 2002; Butler 2001; Giovas et al. 2016). McCoy (2008) demonstrated that *Cellana* limpets gathered from the shorelines of Kalaupapa Peninsula on the northern coast of Molokaʻi in the pre-contact period exhibited smaller mean sizes than those taken in the post-contact period, when a decline in the human population reduced harvesting pressure. Similarly, Morrison and Esh (2015, 176–81) document decrease in *Cellana* size in pre-contact periods at the Nuʻalolo rockshelter on Kauaʻi Island, followed by a rebound in the post-contact period. To test whether such trends may have been the case in Hālawa Valley, we measured the maximum diameters of all intact *Cellana* shells recovered from the Mound A excavation (Table 1). Although sample sizes from the deepest levels are small, levels 13 and 11 do exhibit larger mean sizes than those in levels 10–3, as evident in Figure 9 (differences in mean *Cellana* spp. shell size between level 13 and level 9, and level 13 and level 7, are statistically significant, $P < 0.05$, based on a Kruskal–Wallis test followed by a post-hoc Wilcoxon Rank Sum test). The *Cellana* sp. shells recovered from level 2, which dates to the post-contact era, show an increase in mean diameter. This is a similar trend to the trends identified by McCoy (2008) for Kalaupapa, and by Morrison and Esh (2015) for Nuʻalolo, and may be explained by decreased harvesting pressure associated with a decline in the Native Hawaiian population due to introduced diseases and other impacts of European arrival. Throughout most of the time that the Hālawa dune site was occupied, mean *Cellana* spp. diameters ranged from 26 to 29 mm, values that are consistent with those reported by McCoy (2008, table 2) for his pre-contact period samples. While increased sample sizes would be desirable to confirm these trends, the available data do point to consistent harvesting of, and possibly resource strain on, the *Cellana* limpet populations of Hālawa Bay during the pre-contact era. However, the post-contact increase in mean *Cellana* spp. shell size suggests that resource depression effects in the *Cellana* populations were not entirely irreversible, and may also have been mitigated through shifting shellfish gathering practices.

In addition to the marine mollusks discussed above, a number of specimens of the terrestrial gastropod *Alopeas gracile* were recovered from Layer III. This small synanthropic landsnail is known to have been transported by Polynesians from island to island, presumably inadvertently while adhering to plant hosts (Christensen and Kirch

Table 1. Maximum diameters (mm) of *Cellana* spp. in Mound A, Site Mo-A1-3.

Level	*N*	Mean	Standard deviation	Median
1	16	30.1	11.6	29.1
2	13	34.2	10.5	31.9
3	22	29.1	5.44	28.9
4	26	28.4	6.70	27.2
5	49	28.1	5.60	27.6
6	39	27.9	4.65	28.1
7	29	26.3	3.62	26.8
8	32	26.4	7.63	24.6
9	34	26.0	4.01	25.6
10	13	27.2	3.73	28.4
11	7	35.2	9.00	37.6
12	8	28.0	9.70	36.3
13	5	46.9	17.0	35.9

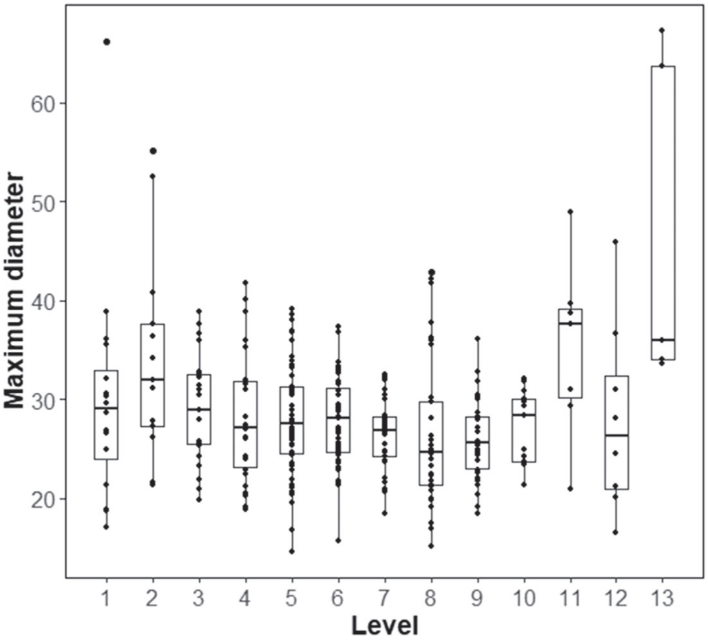

Figure 9. Box and whisker plot of maximum diameters (mm) of *Cellana* spp. limpets by excavation levels in Mound A.

1981). In levels 1 and 2 only, a second species of landsnail introduced following European contact, *Subulina octona*, is present.

Three species of urchin or echinoderm are represented in the Mound A invertebrate fauna. Most abundant are the small, paddle-like spines of *Colobocentrus atratus*, which occurs "on rocky shores washed by the surf" (Edmonson 1946, 92). Weisler, Mihaljević, and Rogers (2020) note the importance of *C. atratus* in coastal midden sites on windward West Moloka'i. This urchin is common on the boulder shoreline of Hālawa and continues to be taken for food by valley inhabitants today. Much less frequent are the needle-like spines of *Echinothrix diadema*, also edible but with poisonous spines. The large spines of the slate-pencil sea urchin, *Heterocentrotus mamillatus*, which occurs in somewhat deeper water (Edmonson 1946, 92), are represented by a number of specimens; these were utilized by the Hawaiians as abrading tools. A number of small fragments of sea urchin test were also recovered, but were not readily identifiable to taxon.

Small numbers of crustacean fragments were recovered from Layer III. We lack suitable reference materials to identify these, but all are likely to be from one or more species of crabs within the superfamily Barchyrhyncha, of which there are numerous reef and rocky-shore dwelling species in Hawai'i. Many of these crab species were taken by the Hawaiians for food.

Vertebrate fauna

Vertebrate faunal remains were quantified by the number of identified specimens (NISP) and weight in grams (details provided in Table S2, Supplementary Materials online). The overall assemblage totaled to 741 NISP, with 76% consisting of fishbone

Table 2. Vertebrate fauna from Mound A, site Mo-A1-3 (NISP).

	Excavation levels													
Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Canis familiaris	1		6		3									10
Sus scrofa	1	1	4	2	2			1						11
Medium mammal	21	7	13	4	6	5	1	1						58
Rattus exulans					7	3	1	1	1	5	2	1		21
Artiodactyl		4												4
Acanthuridae, cf. *Naso* sp.							1							1
Carangidae							1							1
Labridae			1					1		1				3
Lutjanidae						2			1				1	4
Monacanthidae cf. *Pervagor*								1						1
Scaridae cf. *Scarus*	9	9	7	3	9	4	5	3	3	2	1	1	1	57
Scaridae cf. *Calotomus*												1		1
Elasmobranchi					1									1
Shark (tooth)	1				1									2
Osteoichthyes	5	18	38	47	60	70	92	63	38	46	38	34	15	564
Aves				2										2
Total	38	39	69	58	89	84	101	71	43	54	41	37	17	741

(Table 2). Dog and pig were both present but could be identified only by their teeth; post-cranial remains of these species were too fragmented to differentiate and were classed as "medium mammal." However, there are no other species other than dog and pig that could be represented in the medium mammal category. Medium mammal remains were not present in levels 9–13. As seen in Figure 10, there is a consistent trend of increasing quantities of medium mammal from level 8 to level 1, whether this is measured by NISP or by weight. This reinforces a trend first identified by Kirch (1975a, 68, fig. 30; 1985, fig. 54), which he interpreted as a gradual intensification of domestic animal production in the valley based on faunal materials from the 1970 Mound B excavation. Many of the dog and pig teeth are from very young individuals, which suggests frequent culling of juveniles for food.

The Polynesian-introduced Pacific rat (*Rattus exulans*) is represented in levels 12–5, but not in the higher levels. Four bones of an artiodactyl (probably *Capra hircus*, or goat) were present in level 2, which post-dates initial European contact; these are probably from a single individual. Only two bird bones were identified, both in level 4, and consist of small fragments lacking diagnostic features.

Fishbone dominated the vertebrate faunal assemblage, with most of the material consisting of highly fragmented, unidentifiable vertebrae, spines, or scales. However, several taxa were identified on the basis of cranial bones or other distinctive bones (such as the scutes of Acanthuridae), following the methods of Leach (1986), and making use of a comparative reference collection held by the Oceanic Archaeology Lab at the University of Hawai‘i. Most frequent were the dentaries, and upper and lower pharyngeal grinders of parrotfish, most of the genus *Scarus* spp., although one example of a *Calotomus* sp. was noted. These parrotfish bones were present in all excavation levels. There was one distinctive spine of a *Pervagor* sp. (filefish), and one scute from a larger acanthurid, probably *Naso* sp. Other rare elements represent carangid (possibly *Caranx* sp.), lutjanid, and labrid fishes. There were two small

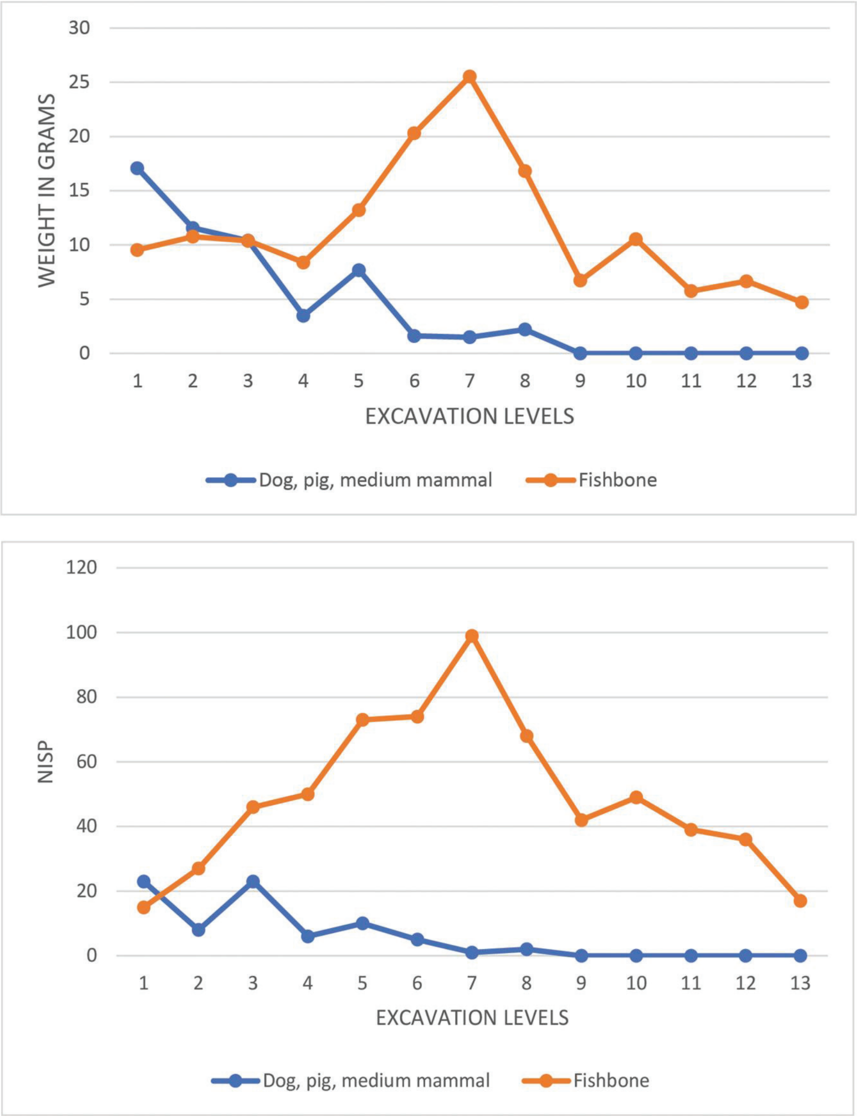

Figure 10. Temporal trends in dog + pig + medium mammal bone versus fishbone in Mound A by weight (top) and NISP (bottom).

shark's teeth, and one elasmobranch vertebrae (either shark or ray). All of these taxa could be expected to be caught within Hālawa Bay, many by netting, such as seine netting in the protected inner embayment, or by throw netting from the rocky shoreline. Both of those traditional fishing methods continue to be practiced by valley residents today. Although sample sizes of identified specimens were too small for meaningful statistical analysis, we noted the very small diameters of most of the fish vertebrae (mean diameter 6.95 ± 2.78 mm, range 2.6–14.4 mm, $n = 23$), as well as of many of the parrotfish mouth parts. The small sizes of fish being taken would also be consistent with netting using a fine mesh.

Charcoal

Identification of three bulk samples of charcoal from levels 3, 7, and 12 of unit D4 was performed by Murakami (2023). The freshly fractured transverse, tangential, and radial facets of charcoal fragments were examined with the aid of a dissecting microscope at magnifications of up to 90×. Taxonomic identifications were made by comparing observed anatomical characteristics with those of woods housed in the International Archaeological Research Institute, Inc. (IARII) reference collection. Bulk samples were initially split in half due to their large sizes. The half samples were then passed through 1/8-inch mesh. All charcoal fragments retained in the screen (approximately 4 mm and greater) were set aside for analysis; most charcoal fragments under 4 mm are generally not diagnostic. The charcoal set aside for analysis was identified and sampled until redundancy was reached and no new taxa were added.

Table 3 lists the identified charcoal from the three samples by taxon and weight. The majority of all samples consists of native (primarily endemic) woody plants, with species typical of lowland to mesic forest. However, several important Polynesian introductions, or "canoe plants," are also present. Candlenut (*Aleurites moluccana*) charcoal occurs in all three levels. Breadfruit (*Artocarpus altilis*) is present only in level 7, while mountain apple (*Syzygium malaccensis*) occurs only in level 3. *Hibiscus tiliaceus*, present in levels 7 and 3, and which forms several thick groves in the valley today, is widespread in the tropical Pacific and is generally regarded as indigenous to Hawai'i. The *milo* tree (*Thespesia populnea*), an important carving wood, is either indigenous or possibly a Polynesian introduction; this is represented in levels 7 and 3. In level 7 there was one instance of a pine (Pinaceae), and although the species could not be identified, this is clearly an exotic, probably due to the burning of driftwood collected from the adjacent beach.

Table 3. Identified charcoal from Unit D4, Site Mo-A1-3 (weight in grams).

Taxon	Status	Level 3	Level 7	Level 12
Aleurites moluccana	Polynesian introduction	0.94	0.41	0.58
cf. *Antidesma pulvinatum*	Native	0.02		
cf. *Artocarpus altilis*	Polynesian introduction		0.04	
Chenopodium oahuense	Native	0.25		0.06
Diospyros sandwicensis	Native	0.06	1.02	0.12
cf. *Dodonea viscosa*	Native	0.47		
Euphorbia celastroides	Native	0.24	0.70	0.14
Euphorbia spp.	Native	0.46	2.02	0.09
cf. *Hibiscus tiliaceus*	Native, or Polynesian introduction?	0.06	0.06	
Metrosideros polymorpha	Native	0.68	3.41	0.03
cf. Metrosideros polymorpha	Native		0.80	
Nesoluma polynesicum	Native	0.02	0.02	
Osteomeles anthyllidifolia	Native	0.69		
Pinaceae	Exotic, driftwood?		0.02	
Pittosporum argentifolium	Native	0.03		
Psydrax odorata	Native	0.50		
Sida fallax	Native	0.35		0.02
Sophora chrysophylla	Native		0.11	
Styphelia tameiameiae	Native	0.47	0.78	0.15
Syzygium sp.	Polynesian introduction	0.05		
Thespesia populnea	Polynesian introduction?	0.88	0.31	
Indeterminate corm or tuber			0.02	
Indeterminate monocot		0.08		
Indeterminate hardwood		0.08		

Artifacts

A total of 105 portable artifacts were recovered from the excavation, of which 65 are flakes of fine-grained basalt, and 17 are small flakes of volcanic glass. The basalt flakes, which were found distributed throughout the deposit, presumably derive from the manufacture or retouch of adzes or other stone tools; most exhibit well-formed bulbs of percussion from hard-hammer flaking. One non-diagnostic adze fragment was recovered from level 6, and a polished basalt flake from level 5. Prior XRF analysis of basalt flakes from Mound B indicate that the bulk of these flakes derive from an East Molokai Volcanics source, now identified as Honokoʻi Bay (which translates literally to "Adze Bay") just south of Hālawa Bay (Mills et al. 2018).

Fishhook manufacture is indicated by two small abraders of *Porites* coral, by four fragments of sea-urchin spine abraders (made from the large spines of *Heterocentrotus mamillatus*), and by three pieces of worked bone. From level 8 in unit D4 we recovered a complete, one-piece rotating fishhook made of bone (Figure 11). The hook is finely made, with an incurved shank, and a line-lashing device of Sinoto's type 3 C (shank head projects forward, with protruding knob made by notching the outer shank edge; Sinoto 1991, fig. 13). In Sinoto's coding system, this hook would be classified as IB3B(1)$\underline{\text{U}}$ HT3c. The hook was found next to a large upright cobble, which may have been part of a house structure.

The only other pre-European artifacts collected were two small beads made from *Conus* shell, with ground surfaces. Several artifacts of Euro-American manufacture were found in levels 1 and 2, consistent with the former presence of a frame house on the site (visible in early twentieth-century photographs). These include seven small porcelain sherds, two with blue-on-white decoration, a white glass button, and a large-caliber rifle shell casing.

Figure 11. Complete one-piece bone fishhook from Mound A.

Radiocarbon dating and site chronology

Prior dating of the Hālawa dune site

Three charcoal samples from Mound B were submitted to the Gakushuin Laboratory in Japan for radiocarbon dating at end of the 1969 field season, and five more at the close of the expanded 1970 excavations (Kirch 1975b). As was common practice at the time, the samples were bulk charcoal from hearths or other features; the charcoal was not taxonomically identified. In light of then-current views regarding Eastern Polynesian and Hawaiian chronology (e.g., Emory 1968), the early GaK-2743 date of cal AD 410–780 seemed a reasonable estimate for the initial settlement of the site. Sample GaK-2741, at cal AD 1020–1280 from the upper sector of Layer IV, was also seen as a valid age for this phase of occupation. The 1970 samples, however, were inconsistent with the results from the 1969 season, and were rejected as being “contaminated and not representative of the age of the site” (Kirch 1975a, 51).

In an effort to resolve these ambiguities regarding the age of the Hālawa dune site, Kirch and McCoy (2007) subsequently obtained AMS ^{14}C dates on charcoal, bone, and a pig tooth that had been curated in the Bishop Museum from the 1970 excavation. These new dates made it clear that the original GaK-2743 date could no longer be regarded as a valid estimate for initial site occupation, as it was likely derived from old wood, possibly driftwood. One of the newly-obtained dates, Beta-217003, dated to cal AD 1380–1450, was regarded as a secure minimum age for the Layer IV deposit in Mound B. Kirch and McCoy concluded that the deeper parts of Layer IV date to at least ca. AD 1400, with a possibility that occupation may have begun a century or so earlier (2007, 397); occupation prior to AD 1200 was ruled out. This was consistent with the trend toward shortening the chronologies for Eastern Polynesian islands resulting from the application of “chronometric hygiene” (Kirch 2017, 198–200, table 7.2). Based on the other dates, Layer IV in Mound B was regarded as likely to represent between two and four centuries of continued use prior to abandonment sometime before European contact.

Mound A dates

In order to date the Mound A deposit, we selected five sets of matched pairs, each consisting of a sample of carbonized candlenut endocarp and a *Nerita picea* mollusk shell, from levels 12, 10, 8, 6, and 4, and submitted these for AMS radiocarbon dating to the Keck Carbon Facility at the University of California, Irvine (UCIAMS). The reason for dating matched pairs of nut shell (which is produced annually) and *N. picea*, one of the major constituents of the Mound A invertebrate fauna, was to be able to derive a Hālawa-specific value for the ΔR correction factor used when calibrating dates on marine organisms (see Mound B dates, below). To be sure, we recognize that these matched pairs do not come from discrete depositional events (such as a hearth, pit, or postmold); however, the matched pairs do reflect depositional correspondence in a stratigraphic sequence without any indication of disturbance or inversion. As such they provide the best opportunity to derive a local estimate of reservoir effect.

As is well understood, materials such as marine mollusks that grew in seawater take up old carbon and must be calibrated using the marine calibration curve (Marine20;

Heaton et al. 2020). However, the amount of old carbon incorporated into marine shells may vary considerably from the global average; this can be corrected if a local ΔR value has been determined. Prior efforts have determined ΔR values for several localities in the Hawaiian Islands, including Molokaʻi, but these values range from -21 ± 42 to 289 ± 103 (Dye 1994; Weisler, Hua, and Zhao 2009).

The five sets of matched pairs from Mound A allow for the calculation of a Hālawa-specific ΔR value, following the methods outlined by Owen (2002). For each calibrated age for a candlenut sample, we determined the corresponding model marine age using OxCal4.3 and the Marine20 calibration curve (with $\Delta R = 0$). The Hālawa-specific ΔR is then the difference between the measured marine ^{14}C age of the corresponding *Nerita picea* sample and the model marine age. The mean ΔR derived from the five matched pairs of candlenut endocarp and *Nerita picea* shell from Mound A is -267 ± 40 (1σ).

The results of the UCIAMS dating of Mound A samples are reported in Table 4. A single-phase Bayesian chronological model for the candlenut endocarp dates from Layer III was first run using OxCal 4.3 (Bronk Ramsey 2009). (OxCal codes provided in Supplementary Materials online.) Incorporating the *Nerita* shell dates to this model (using the locally derived ΔR value) did not appreciably change the results, and added some precision to the modeled ages. The correspondence between the modeled candlenut and *Nerita* shell ages is very strong. As indicated in Table 4, the modeled start boundary for Layer III is cal AD 1366–1610; the modeled age for the deepest sample, from level 12, is cal AD 1489–1635. This corresponds to the Expansion Period in the Hawaiian cultural sequence, as defined by Kirch and McCoy (2023). The modeled end boundary for Layer III is cal AD 1643–1727, which corresponds to the Archaic States Period of the Hawaiian sequence. Levels 1 and 2 (Layers I and II) contain artifacts of the post-contact period. Figure 12 is an OxCal plot of the Bayesian single-phase chronological model for Mound A, Layer III, incorporating both the candlenut and *Nerita* shell dates.

Table 4. Radiocarbon age determinations from Layer III, Unit D4, Mound A, Site Mo-A1-3.

Sample no. UCIAMS-	Level	Material	^{14}C age BP	Unmodeled cal age AD*	Modeled cal age AD**
Boundary Start Mound A Layer III					1366–1610
241396	12	*Aleurites moluccana* endocarp, carbonized	350 ± 15	1476–1633	1489–1635
241397	10	*Aleurites moluccana* endocarp, carbonized	360 ± 15	1461–1630	1480–1633
241398	8	*Aleurites moluccana* endocarp, carbonized	375 ± 15	1456–1623	1466–1629
241399	6	*Aleurites moluccana* endocarp, carbonized	340 ± 15	1481–1636	1499–1638
241403	4	*Aleurites moluccana* endocarp, carbonized	230 ± 15	1643–1799	1643–1668
241164	12	*Nerita picea* shell	695 ± 20	1424–1670	1485–1670
241165	10	*Nerita picea* shell	710 ± 15	1415–1660	1482–1667
241166	8	*Nerita picea* shell	620 ± 15	1461–1745	1517–1684
241167	6	*Nerita picea* shell	660 ± 15	1445–1691	1501–1675
241168	4	*Nerita picea* shell	545 ± 15	1515–1836	1540–1700
Boundary End Mound A Layer III					1643–1727

*Dates calibrated with Oxcal 4.3; 95.4 % probability. *Nerita picea* dates calibrated with Marine20 curve (Heaton et al. 2020) and $\Delta R = -267$.

**Modeled ages determined through Bayesian calibration with Oxcal 4.3.

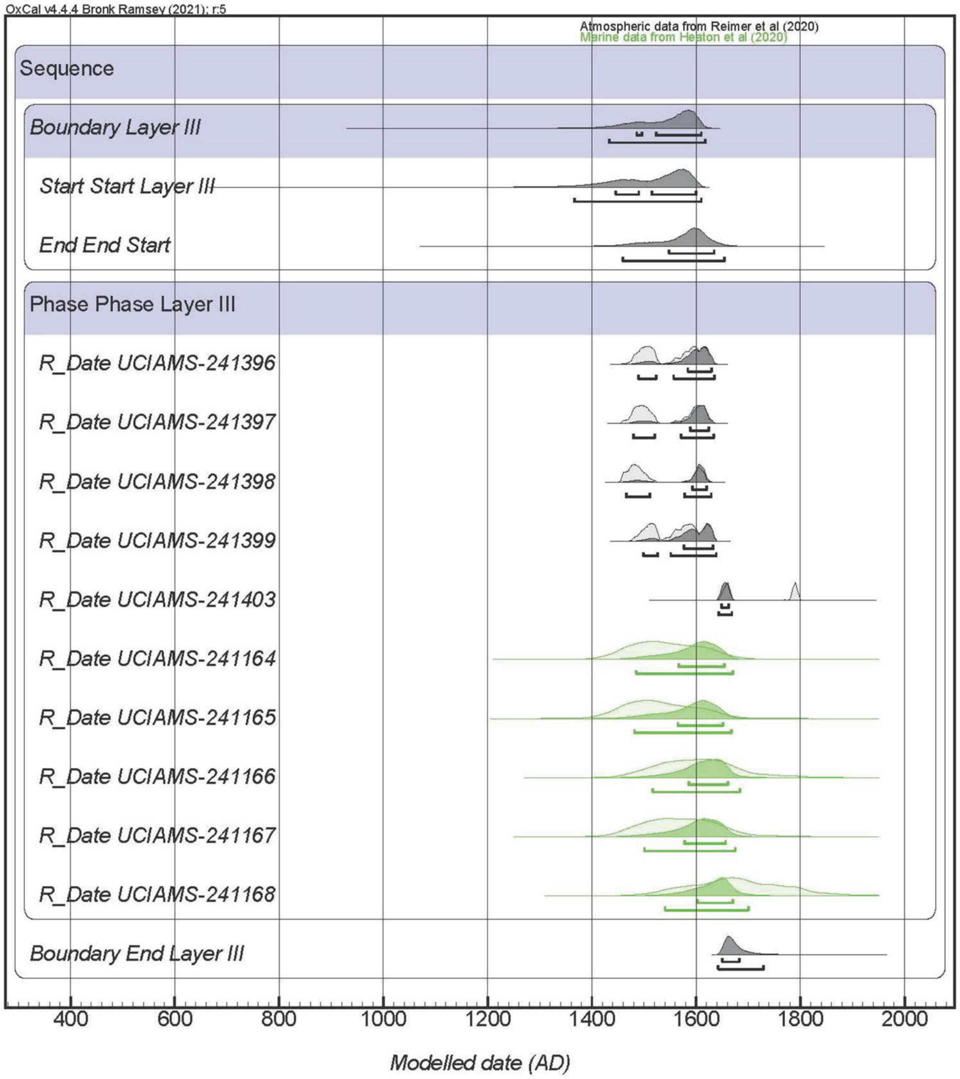

Figure 12. OxCal plot of the candlenut endocarp and *Nerita* shell dates from Layer III of Mound A, using a single-phase Bayesian model.

Mound B dates

Our primary motivation in deriving a Hālawa-specific ΔR value by dating the matched candlenut–marine shell pairs from Mound A was to be able to apply this to a series of marine shell dates from the larger Mound B, excavated in 1969–1970. This is because while most of the materials curated from the 1969–1970 excavation were identified only as being either from the "lower" or "upper" sectors of Layer IV, a set of marine shell samples recovered from unit H8 of the 1970 excavation had been excavated in 10 cm levels, potentially allowing for a finer-grained dating of the cultural deposit. In 2018, Kirch submitted 12 samples of *Cellana* spp. and *Nerita picea* shell, from each of the six 10 cm levels of unit H8 to the Keck Carbon Facility for AMS dating. The ^{14}C ages from the two marine mollusk species matched well, and exhibited good stratigraphic

Table 5. Radiocarbon age determinations from Layer IV, Unit H8, Mound B, Site Mo-A1-3.

Sample no. UCIAMS-	Depth within Layer IV	Material	^{14}C age BP	Calibrated age cal AD*	Modeled age cal AD**
Boundary Start Lower Sector, Layer IV					1366–1618
207935	50–60 cm	*Cellana* sp.	755 ± 20	1350–1640	1421–1641
207936	50–60 cm	*Nerita picea*	700 ± 15	1415–1673	1431–1646
207934	40–50 cm	*Cellana* sp.	750 ± 15	1356–1646	1421–1641
207940	40–50 cm	*Nerita picea*	755 ± 15	1351–1640	1420–1640
207933	30–40 cm	*Cellana* sp.	710 ± 15	1408–1668	1429–1645
207939	30–40 cm	*Nerita picea*	695 ± 15	1418–1675	1431–1647
Boundary Transition to Upper Sector					1456–1695
207932	20–30 cm	*Cellana* sp.	670 ± 15	1432–1693	1490–1754
207938	20–30 cm	*Nerita picea*	585 ± 20	1483–1805	1516–1796
207931	10–20 cm	*Cellana* sp.	525 ± 15	1526–1875	1528–1819
207937	10–20 cm	*Nerita picea*	445 ± 15	1655–	1541–1858
207930	0–10 cm	*Cellana* sp.	535 ± 15	1518–1862	1526–1816
207941	0–10 cm	*Nerita picea*	540 ± 15	1514–1855	1525–1813
Boundary End Upper Sector					1563–1940

*Dates calibrated with Oxcal 4.3; 95.4 % probability; Marine20 curve (Heaton et al. 2020) and ΔR = −267 ± 40.

** Modeled ages determined through Bayesian calibration with Oxcal 4.3.

progression, indicating no significant stratigraphic perturbation or inversions. To properly calibrate the age of dated shells from these 10-cm samples, however, required a Hālawa-specific ΔR value.

The ^{14}C ages of the *Cellana* and *Nerita* samples from unit H8 of Mound B are given in Table 5, along with calibrated age ranges based on the Marine20 calibration curve with a Hālawa-specific ΔR value of −267 ± 40. We developed a two-phase Bayesian calibration model in OxCal 4.3 for these Mound B dates, based on the lower and upper sectors of Layer IV that were noted during the 1970 excavation (0–30 cm depth = upper sector, 30–60 cm depth = lower sector). The Bayesian model yields a start boundary for the lower sector of cal AD 1366–1618; the modeled age for the *Cellana* sample from the 50–60 cm level in Layer IV is cal AD 1421–1641. These results are consistent with our model results from Mound A. The modeled end boundary for the upper sector is cal AD 1563–1940. However, as no post-contact artifacts were present in Layer IV, we can infer that the deposit predates the nineteenth century. Figure 13 is a plot of the two-phase Bayesian calibration of the marine shell dates from Mound B.

Discussion and conclusions

While limited in extent, the renewed excavations in Mound A of the Hālawa dune site have allowed us to address some unresolved questions regarding this important site, not the least of which concerns its position in the Hawaiian cultural sequence. As with a number of other sites in Hawaiʻi and elsewhere in Eastern Polynesia that were at one time thought to date to the period of early human settlement, or soon thereafter (Weisler et al. 2023), initial use of site Mo-A1-3 has now been shown to date to the late fifteenth or early sixteenth centuries, during the Expansion Period of the Hawaiian cultural sequence (Kirch and McCoy 2023). The cultural deposit appears to have accumulated steadily after that, with the final use of the site in the post-contact period.

Although the Hālawa dune site is no longer relevant to discussions of the founding settlement period in Hawaiʻi, it nonetheless continues to offer an important assemblage of cultural materials representing the Expansion and following Archaic States

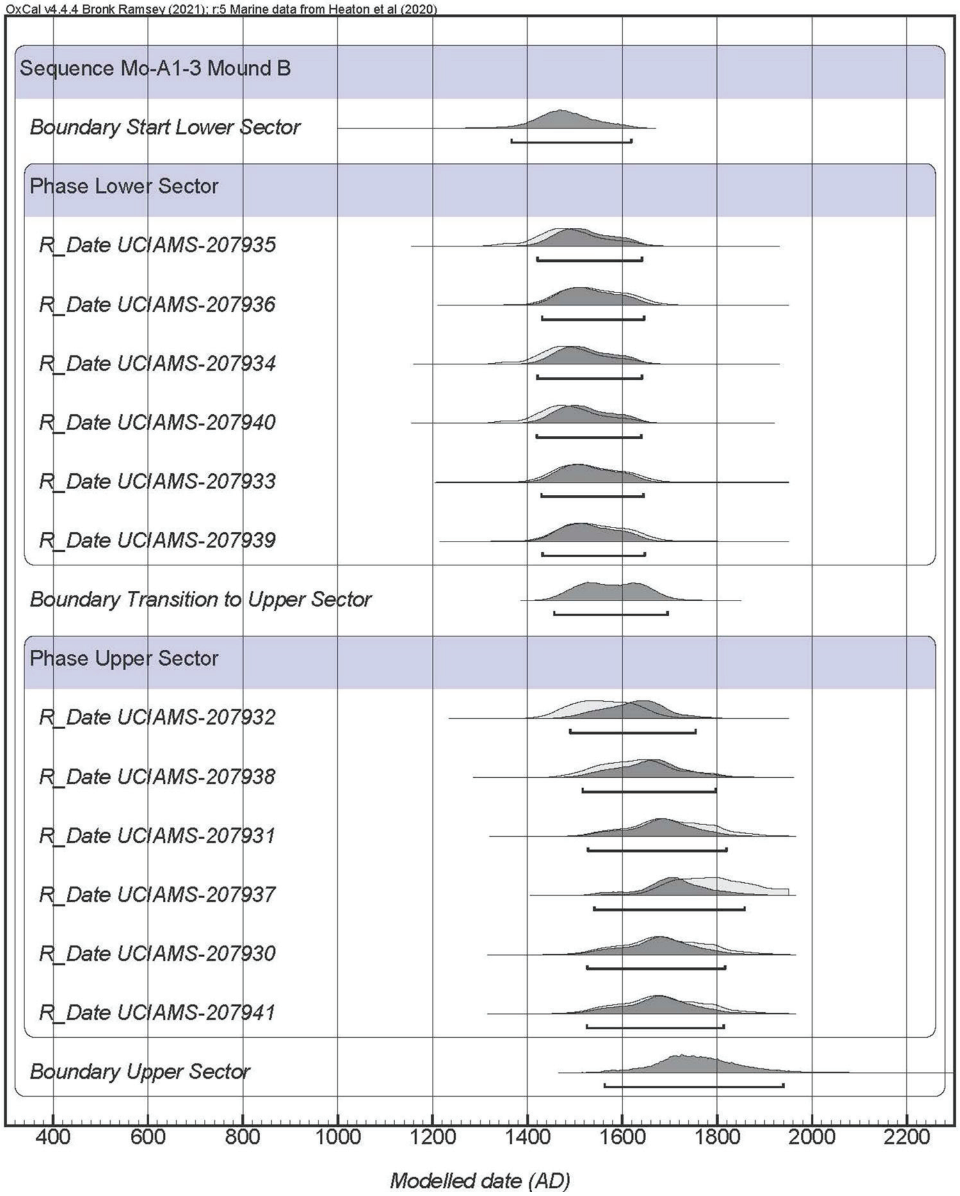

Figure 13. OxCal plot of *Cellana* and *Nerita* shell radiocarbon dates from Mound B, with the lower and upper sectors of Layer IV modeled as separate phases.

Periods on eastern Molokaʻi Island. Excavations in inland agricultural, residential, and ritual sites in Hālawa Valley, results of which will be reported elsewhere, show this to be a time of intensification of the valley's agricultural production system (Kirch, Lincoln, and Swift 2023). Construction of permanent, stone-faced pondfield terraces for taro cultivation began as early as the fourteenth century AD, and by the late seventeenth century AD extensive irrigation complexes extended down onto the alluvial floodplain. By the seventeenth century tributary streams had also been tapped for small irrigation systems, and the valley's colluvial slopes were extensively modified for dryland cultivation with extensive non-irrigated terracing. This extensive agricultural infrastructure was accompanied by the construction of agricultural temples (*heiau ho*ʻ*oulu*ʻ*ai*), which began to be constructed in the early seventeenth century.

The faunal assemblage from Mound A of the Mo-A1-3 site adds an important perspective not available from the inland sites, where acidic soil conditions are not conducive to bone or shell preservation. Significantly, the Mound A cultural deposit exhibits a trend of increasing frequency in dog and pig bones, a trend first documented in the 1969–1970 excavations in Mound B. Dog and pigs were the two primary domestic animals in pre-contact Hawaiʻi, and both were known to have been fed on agricultural produce (Titcomb 1969; Yen 1974). The increasing frequency of these animals in the Mound A sequence provides additional support for an interpretation of a steady intensification of agricultural production in the valley.

While the husbandry of dog and pig were clearly important to the Hālawa production system, exploitation of littoral and marine resources also contributed significant protein to the diet of the valley's population. Although the data are not unequivocal, there are suggestions that steady pressure by a sizeable human population did have an effect on these resources. This is best indicated by the size changes in the culturally prized ʻ*opihi* (*Cellana* spp.), but also in the very small sizes of fish being taken.

Identification of three samples of charcoal from Mound A has added important information on the nature of vegetation in the vicinity of the dune site. Most of the charcoal taxa are representative of native Hawaiian mesic forest species; however, at least three Polynesian-introduced "canoe plants" are present, including candlenut, breadfruit, and the mountain apple. The presence of a pine taxon, clearly exotic to Hawaiʻi, is of note as this presumably derives from driftwood. The radiocarbon dating of old driftwood is thought to have been one of the causes of older dates on a number of Hawaiian coastal sites, including the Hālawa dune site.

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