

## ANTHROPOLOGY

# Simple technologies and diverse food strategies of the Late Pleistocene and Early Holocene at Huaca Prieta, Coastal Peru

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Simple pebble tools, ephemeral cultural features, and the remains of maritime and terrestrial foods are present in undisturbed Late Pleistocene and Early Holocene deposits underneath a large human-made mound at Huaca Prieta and nearby sites on the Pacific coast of northern Peru. Radiocarbon ages indicate an intermittent human presence dated between ~15,000 and 8000 calendar years ago before the mound was built. The absence of fishhooks, harpoons, and bifacial stone tools suggests that technologies of gathering, trapping, clubbing, and exchange were used primarily to procure food resources along the shoreline and in estuarine wetlands and distant mountains. The stone artifacts are minimally worked unifacial stone tools characteristic of several areas of South America. Remains of avocado, bean, and possibly cultivated squash and chile pepper are also present, suggesting human transport and consumption. Our new findings emphasize an early coastal lifeway of diverse food procurement strategies that suggest detailed observation of resource availability in multiple environments and a knowledgeable economic organization, although technologies were simple and campsites were seemingly ephemeral and discontinuous. These findings raise questions about the pace of early human movement along some areas of the Pacific coast and the level of knowledge and technology required to exploit maritime and inland resources.

## INTRODUCTION

Archaeological studies have demonstrated that early humans engaged in hunting, gathering, and fishing along the Pacific coast of the Americas by at least 13,000 years ago (1–9). Fish and shellfish comprised most of the edible meat represented by faunal samples from archaeological sites. Other foods are derived occasionally from terrestrial fauna and plant species. These studies have also been significant in suggesting that the Pacific coast was a major route of initial entry into the Americas (1, 2, 10–14) because it offered consistent resource familiarity and direct and rapid migration farther south. Here, we present new data from two human-made mounds, Huaca Prieta and Paredones (15–17), in the lower Chicama Valley on the north coast of Peru that extend the antiquity of maritime foraging to ~15,000 calendar years ago (cal yr B.P.) (Figs. 1 and 2). We report more extensive excavation and analyses of food remains, stone tools, and cultural features scattered and buried underneath ~7 to 30 m of continuous and intensive human-made mound deposits of the Middle Holocene period at these sites (figs. S1 and S2) (16, 17) and document early asymmetrical but symbiotic strategies of resource procurement from maritime and inland environments.

The Late Pleistocene and Early Holocene cultural deposits underlying the mounds represent a series of short-term, intermittent occupations between ~15,000 and 10,000 years ago, most with apparent gaps of several hundred years between them associated with culturally sterile layers of varying thicknesses (Fig. 3 and figs. S3 and S4). Comparing the evidence from the earliest pre-mound occupational layers, we reconstruct the kinds of littoral and nearby wetland, river delta and valley, and mountain resources gathered; the probable seasons during which some resource procurement occurred; and the complementary food strategies from these environments. It has generally been thought that maritime fishing first developed in the Early Holocene because it would have required sophisticated fishhook, netting, and boat technologies and because fishing was unpredictable in comparison to gathering shellfish and hunting and gathering terrestrial foods (1, 2). Here, we suggest more diverse and symbiotic food strategies organized across a mosaic of juxtaposed maritime and terrestrial environments and more variable and simpler technologies among some early Pacific coast peoples, including the capture of fish and sea lions probably by trapping and clubbing. We also argue for a probable slower-paced human migration along some coastal areas because of the availability of sufficient and complementary maritime and terrestrial resources that could sustain people for long periods of time and because of the experiential learning required to exploit a wide variety of foods in multiple environments.

Calendar age ranges previously suggested that the oldest deposits at Huaca Prieta containing marine fauna, cultural features (figs. S1 to S5), and unifacial stone tools (figs. S6 to S8) dated ~14,500 cal yr B.P. in two small areas of the site, Unit 15/21 and Test Pit 22 (16, 17). Recent findings and dates now place the older occupations in four new localities as early as ~15,000 cal yr B.P. (Table 1) but more importantly expand the variability of cultural remains and reveal new technological and adaptive evidence. Newly excavated and dated contexts now include Units 9 and 12 at Huaca Prieta, Unit 16 near Huaca Prieta, and Unit 22 at the Paredones mound (figs. S1 and S2). Seventeen stratigraphically ordered

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assays from these contexts range from 10,158 to 15,217 cal yr B.P. (Table 1). More than 170  $^{14}\text{C}$  and optically stimulated luminescence (OSL) dates from intact strata in the overlying mounds support these assays (16–18). All  $^{14}\text{C}$  dates were derived from single pieces of well-preserved carbonized and uncarbonized (fig. S9) remains of short- to moderately long-lived plants (~5 to 40 years) [avocado (*Persea* sp.); bean (*Phaseolus* sp.); chile pepper (*Capsicum* sp.); rush (*Juncus* sp.); and a variety of local grasses, shrubs, and small trees (*Capparis* sp., *Cyperus* sp., *Scirpus* sp., *Gynerium* sp., *Equisetum* sp., and *Buddleja* sp.)] and of animal bones contained in intact burned features (Table 1) embedded in occupational lenses.

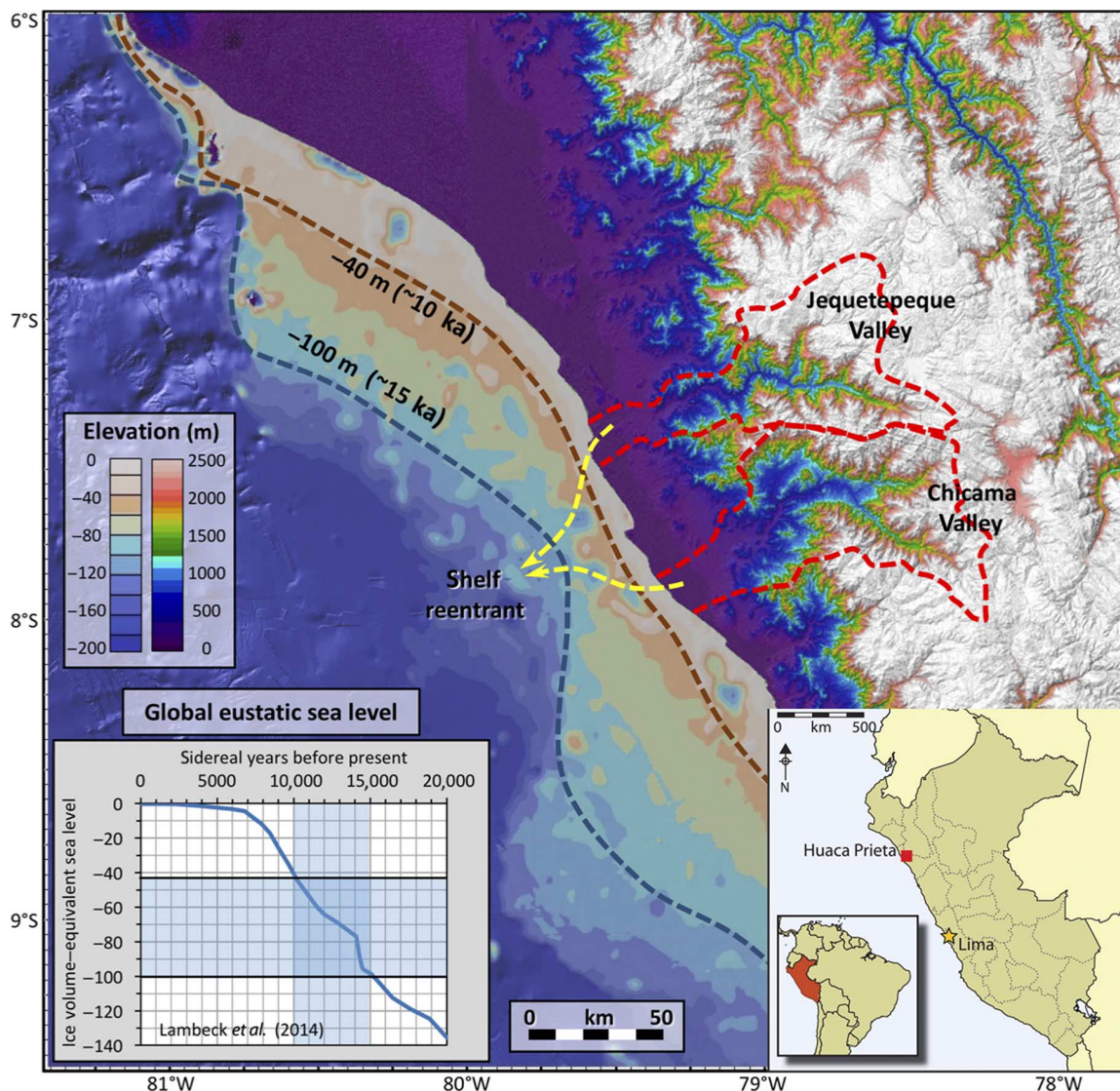
### Geological and site setting

The period of ~15,000 to 10,000 years ago corresponds with the maximum rate of postglacial ice melt and global sea-level rise (19). Ice volume–equivalent water levels over this time rise about 60 m, from an elevation of ~100 to ~40 m below present. With little ice volume at this low latitude and a relatively steep, narrow shelf, isostatic effects on water levels are expected to be minimal, making the global eustatic

curve a potentially suitable first-order record for regional sea-level history (20–26).

Furthermore, this portion of the Pacific collision margin near the Chicama Valley is characterized by flat-slab subduction with little uplift compared to areas north and south. In particular, the Chicama Valley's reach of margin reveals no geomorphological evidence for significant Late Pleistocene and Holocene uplift, either at the coast or along the lower river valley. Thus, for the Chicama Valley coast, tectonic effects are not believed to be a major control on local relative sea level, at least compared to ice sheet melt contributions.

Then, at the first order, we take bathymetry of the modern shelf to provide a reasonable proxy for postglacial paleoshoreline positions with regard to the archaeological sites under discussion here. Other factors support this general assertion. For example, sediment deposition along this arid region is modest and not likely to have led to any major shoreline advances or retreats (>1 km), particularly during the phase of rapid sea-level rise from ~15,000 to 10,000 years ago. Similarly, strong longshore sediment transport and a relatively steep offshore slope ( $\sim 4 \times 10^{-3}$ ) would limit the inland extent of any estuary or lagoon systems that



**Fig. 1.** Location map of the study area and paleoshorelines at 15,000 and 10,000 cal yr B.P.

may have formed during transgression. Thus, shelf bathymetry should reasonably provide at least a first-order proxy for paleoshoreline positions offshore of the Chicama coast. Regardless of changing shoreline positions over time, it is probable that some early archaeological sites are located on now-submerged shelf.

Regionally along the north coast of Peru, continental margin morphology from 6°S to 9°S reveals two zones of shallow, wide shelf that are separated by a broad reentrant along the Chicama Valley reach. The wider regional shelf extends 75 to 100 km offshore to the 120-m isobath, whereas this depth is reached within 40 km of the Chicama coast (19–26). Global eustatic sea level at 15,000 cal yr B.P. was ~100 m below present, and the Chicama paleoshoreline was likely situated ~30 km offshore of the present one. By 10,000 cal yr B.P., eustatic sea level had risen to ~40 m below present, which would place the paleoshoreline 8 to 12 km offshore of the modern coast. By ~8000 to 7000 cal yr B.P., sea level is nearly at the modern level and has not varied substantially since.

Along the coast 2.5 km north of the Chicama River mouth outcrops a prominent 1-km<sup>2</sup> remnant terrace of Sangamon age (section S1), locally known as the Sangamon Terrace. The terrace is ~2 km long and tapers from ~1 km wide at its north end to ~125 m at the south end. At the north of Huaca Prieta, the surface of the terrace is 13.9 m above the modern sea level. At its southern end, the terrace surface varies from 8.3 to 10.9 m above sea level. The surface of the original terrace has been lowered 2 to 5 m in most places to provide material for construction of numerous large adobe brick mounds of more recent age, implying the disturbance or loss of some Late Pleistocene to Early Holocene cultural deposits.

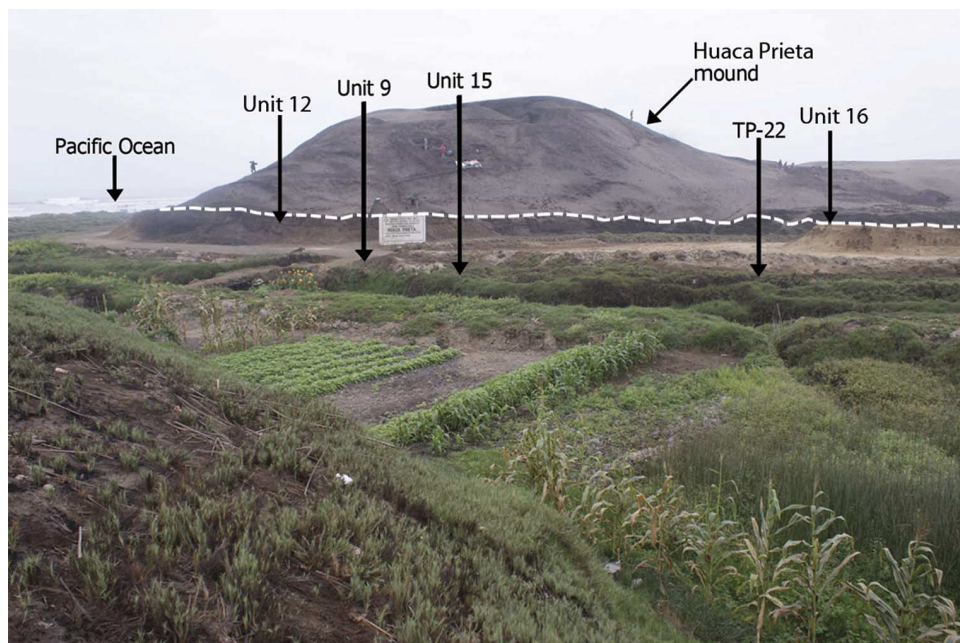
In addition to accessing a wide diversity of resources in the environments of the study area, the terrace remnant stood out as a major physical feature on the flat coastal plains located alongside the Chicama River and at roughly equal distance from the sea and the mountains. To date, extensive wetlands were probably located between the shoreline

and the terrace (18). Few coastal environments along the Pacific coast of South America offered this specific type of littoral and wetland setting, accessed by such a prominent and attractive topographic feature. During the period under study, the coastal plain where the terrace is located was characterized by a grassy environment with gallery trees along braided streams. Farther inland in the coastal valley, the vegetation probably was thicker and more varied (18).

Huaca Prieta is situated on the south tip of the terrace just above the present-day shoreline. The site consists of a large ovoid-shaped, artificial mound that measures ~30 m high, ~65 m wide, and ~165 m long. Human use of the site lasted discontinuously from the Late Pleistocene to ~1800 CE, including pre mound and mound cultural deposits. Unit 16 and the Paredones mound lie 50 and 600 m north of Huaca Prieta, respectively. Late Pleistocene and Early Holocene deposits underneath the two mound sites were difficult to record extensively because of the height of the overlying mounds (~6 to 30 m), which had to be excavated first to reach the underlying early levels.

The type and frequency of artifacts, features, and faunal and floral remains from the deeper Late Pleistocene cultural deposits at these sites are both enticing and frustrating because of the long period of time covered by the excavated record and the limited, deeply buried archaeological areas sampled. The individual pre mound cultural layers dating from ~15,000 to 8,000 cal yr B.P. generally ranged between 0.5 and 7.0 cm in thickness (Figs. 3 and 4 and figs. S3 to S5). These deposits intermittently consist of fine to coarse sand and light scatters of charcoal flecks, ash, shell, bone, fragmented rush stems, lithic tools, and other cultural debris (sections S2 and S3). In the site excavations, in situ pedogenic features (for example, weathering and human-introduced organic matter) were also used as markers for pre mound cultural deposits (18).

In addition to the Late Pleistocene cultural deposits, there is intermittent human occupation during the Early Holocene at Huaca Prieta, Paredones, and Unit 16 that occurred before initial mound construction, as revealed by a series of thin cultural lenses indicative of ephemeral but



**Fig. 2. Huaca Prieta mound situated on the Sangamon Terrace (buried terrace surface with Late Pleistocene and Early Holocene cultural deposits is indicated by dotted line below the mound).** Arrows show location of individual units excavated from the top of the mound down through and to the buried cultural deposits in the terrace. Scale shown by humans standing on the mounds. (Photo Credit: Tom D. Dillehay, Vanderbilt University)

slightly to moderately larger campsites dating between ~11,500 and 8000 cal yr B.P. The exposed south and southeast facies of the terrace below the base of the mound at Huaca Prieta are composed of relatively thin, intermittent stratigraphically ordered pre-mound and early mound slope wash formed from approximately ~8000 to 3000 years ago. However, no Late Pleistocene and Early Holocene cultural deposits were observed in these exposed and other exposed basal fa-

cies of the mound. In these basal areas, the original terrace surface, albeit often heavily modified by early mound construction, is sometimes intact and overlying deeper Late Pleistocene and Early Holocene cultural layers, as described here.

It is likely that some of the conglomerated rock and sediment identified by Bird's work in the 1940s as culturally sterile on the north end of the mound at Huaca Prieta, where his primary excavations were located (15),



**Fig. 3. Stratigraphic profile of Unit 12 showing early basal cultural deposits and radiocarbon dates.** (Photo Credit: Tom D. Dillehay, Vanderbilt University)

were disturbed anthropogenic deposits related to early pre mound fill in this area. The deeper conglomerated sediments of the terrace surface he excavated and described may also have been partially obliterated or emplaced during the initial construction of the mounds at Huaca Prieta.

## RESULTS

The preservation of faunal remains at sites in the Huaca Prieta area is generally outstanding because of the aridity and dryness of the desert conditions. All the bone remains were examined for any signs of digestion and fragmentation due to food preparation, crushing, trampling, or compaction during post-depositional processes before making infer-

ences about human interference. Some bone was burned and cut. Most faunal remains were heavily fractured, making it difficult to estimate the sizes of individual organisms (18).

In the Late Pleistocene to Early Holocene, people exploited several principal habitats surrounding the Sangamon Terrace (fig. S10 and sections S3 and S4). To the east, upvalley, there was a relatively open but dense dry forest biome based on algarrobo (*Prosopis* sp.) and associated species, which would have offered browse for three identified specimens of white-tailed deer (*Odocoileus virginianus*). The other inland specimens from a somewhat more open environment are remains of two Peruvian scrub blackbirds (*Dives warszewiczi*), which probably were opportunistically foraged and eaten.

**Table 1. Radiocarbon dates for Late Pleistocene and Early Holocene layers at sites.** All dates were calibrated using shcal04 (44), unless otherwise noted. Bracketed values indicate that the calibrated range impinges upon the end of calibration data set.

Sample no.	Provenience	$\delta^{13}\text{C}$	Conventional radiocarbon	1 $\sigma$ (68%) calibrated age range (B.P.)	2 $\sigma$ (95.4%) calibrated age range (B.P.)	Material
<b>Unit 9</b>						
Beta437295	Premound occupation, Layer 12	-28.2	12,610 $\pm$ 40	14,771–15,070	14,520–15,155*	Wood charcoal
<b>Unit 12</b>						
Beta235952	Premound occupation, Layer 11	-25.2	9,580 $\pm$ 40	10,698–11,089	10,600–11,159*	Charred rush stem ( <i>Juncus</i> sp.)
Beta437290	Premound occupation, Layer 20	-29.7	12,410 $\pm$ 40	14,154–14,785	14,109–14,961	Wood charcoal
Beta437288	Premound occupation, Layer 23	-29.2	12,420 $\pm$ 40	14,166–14,809	14,119–14,972	Wood charcoal
D-AMS 016635	Premound occupation, Layer 23	-13.3	12,602 $\pm$ 35	14,590–15,137*	14,317–15,182*	Wood charcoal
<b>Unit 15/21</b>						
Beta290621	Premound occupation, Stratum 9	-25.6	11,500 $\pm$ 50	13,294–13,401	13,260–13,420	Charred wood
Beta299536	Premound occupation, Stratum 13	-28.0	11,800 $\pm$ 50	13,757–13,517**	13,794–13,459*	Wood charcoal
Beta310272	Premound occupation top of Layer 13a	-22.8	12,280 $\pm$ 60	14,005–14,477 <sup>†</sup>	13,924–14,867 <sup>†</sup>	Deer bone
Beta310273	Premound occupation bottom of Layer 13a	-29.0	12,240 $\pm$ 50	13,991–14,184 <sup>‡</sup>	13,891–14,530 <sup>‡</sup>	Wood charcoal
<b>Unit 16</b>						
AA86632	Layer 14-6 <sup>§</sup>	-14.2	9,230 $\pm$ 40	10,379–10,183	10,486–10,158	Avocado seed ( <i>Persea</i> sp.)
D-AMS 013332	Layer 16	-23.8	12,594 $\pm$ 62	14,386–15,143*	14,221–15,217*	Bean seed ( <i>Phaseolus</i> sp.)
<b>Unit 22 (Paredones)</b>						
Beta343109	Premound, Sangamon Terrace, Level 7	-19.2	9,330 $\pm$ 40	10,308–10,559	10,285–10,578	Chile pepper seed ( <i>Capsicum</i> spp.)
<b>Test Pit 22</b>						
Beta210862	Premound occupation, Layer 20 (4a)	-27.4	9,530 $\pm$ 50	10,594–10,785	10,579–[11,000]	Wood charcoal
AA75326	Premound occupation, Layer 22 (8a)	-26.8	10,770 $\pm$ 340	12,164–13,096	11,508–13,344	Wood charcoal
Beta310274	Premound occupation, Layer 25 (8b)	-21.7	12,950 $\pm$ 50	13,554–13,828 <sup>†</sup>	13,301–14,034	Sea lion bone
Beta290620	Premound occupation, Layer 28 (11a)	-28.3	11,780 $\pm$ 50	13,510–13,732 <sup>‡</sup>	13,440–13,720	Wood charcoal

\*Calibration done on curve (shcal13) other than shcal04. †Calibrated using marine 09.14c calibration curve with delta uncertainty of 725  $\pm$  173 (35). ‡Calibrated using Intcal09 calibration curve. §Layer 14-6 refers to a layer with several distinct lenses numbered 1 to 7.

Most of the recovered faunal remains come from habitats to the west of the terrace and include the littoral, back-barrier, and vernal pool wetlands (grading from freshwater to brackish), drained by modest outlets connected to the sea, the estuary and delta of the river, and the beach and intertidal zone of the sea (sections S1 and S3) (18). The faunal remains indicate that all of these habitats were visited and faunal and floral remains were brought back to the campsites on the Sangamon Terrace. Fauna from the brackish wetlands and lagoons include mullet (*Mugil cephalus*), an ocean fish that tolerates the brackish water of the lagoon

wetlands and the river estuary. Whereas most wetlands probably had outlets to the sea, which acted as inlets when sea levels are high, the fish were within the confined wetlands and could have been clubbed or netted easily in the shallow waters of the environments (figs. S10 to S12 and sections S3 and S4).

Several lines of evidence consistently suggest that most of the recovered faunal remains were gathered primarily at nearshore and in nearby back-barrier and vernal pool wetlands, located several kilometers to the west of the terrace sites during the Late Pleistocene (fig. S10 and sections



**Fig. 4. Burned and other cultural features and unifacial basalt flakes in Layer 20, Unit 12.** (Photo Credit: Tom D. Dillehay, Vanderbilt University)

S1, S3, and S4). The remains include 281 specimens of marine fauna and three terrestrial specimens (Table 2 and sections S3 and S4). The major taxa exploited are sharks (27.55%), sea lions (and minimally deer) (15.85%), marine birds (13.96%), and marine bony fish (12.83%). All faunal remains are heavily fractured: 2.3% of the fish, sea, and terrestrial mammal bones are burned, and 3.2% are cut or deliberately fractured, suggesting human processing and consumption. Only small amounts of limpets, marine snails/gastropods, crabs, terrestrial faunal, and plant species were excavated in the earliest deposits. The absence of fish-hooks and harpoons and the presence of small sharks [school shark (*Galeorhinus* sp.) and requiem shark (*Carcharhinus* sp.)] and medium-sized fish [such as mullet (*M. cephalus*), croaker (*Paralichthys peruanus*), sea bass (*Sciaenops ocellatus*), and hake (*Merluccius gayi peruanus*)] in all cultural deposits of the Late Pleistocene to the modern era suggest that they washed up on beaches or were caught or trapped in nearshore sandy or calm waters or in brackish wetlands (fig. S12 and section S4). The presence of one perforated pebble tool dated to the Late Pleistocene suggests the possible use of stone weights for anchoring traps made of rush stalks (figs. S8 and S9). Today, fish and small sharks become trapped on beaches and in shallow lagoons either connected to the sea or formed by wave action during storm surges that leave shallow back-barrier water. Hunters today also build blinds and net and club birds in them, which was a likely strategy in the past as well (fig. S11 and sections S3 and S4).

With regard to the seasonality of species procurement, sea lions and larger sea birds appear along the coast during the summer months from December to March. Sharks are present year-round but exist in larger numbers only in the summer. The bony fish are year-round, but winter storm surges wash many more ashore and into seasonal back-barrier and vernal wetlands (section S4). All other floral and faunal species generally appear year-round.

The recovery of six economic plant genera, including chile pepper (*Capsicum* spp.), squash (*Cucurbita* sp.), bean (*Phaseolus* sp.), avocado (*Persea* sp.), rush (*Juncus* sp.), and a possible medicinal plant (*Tessaria integrifolia*), suggests gathering in or exchange with people from the interior valley and western slopes of the Andes, where most of these species likely grew (Table 2 and figs. S13 and S14). With the exception of the bean seed, which dated directly to more than 14,000 cal yr B.P., the other species assayed between 10,600 and 10,200 cal yr B.P. Some of these plants may have been in early stages of domestication (section S4) (27).

In summary, altogether, the pattern for exploitation of faunal and floral resources at the Sangamon Terrace campsites during the Late Pleistocene to Early Holocene indicates the use of all the major biozones surrounding this unusual geomorphological feature on the flat coastal plains at the time. Although the overall configuration and productivity of marine and terrestrial habitats have changed since the end of the Last Glacial Maximum, archaeological assemblages spanning the Late Pleistocene and the entire Holocene at Huaca Prieta and other sites suggest that a similar suite of marine and terrestrial resources has been available for human harvest from the Late Pleistocene to the modern-day era (16–18). During the Late Pleistocene, rapidly rising sea levels probably flooded many former coastal lowlands, leading to the formation of numerous wetlands along much of the mainland coast of Peru. After the Pleistocene, these wetlands probably existed intermittently and in different places, including back-barrier and vernal pool wetlands (18).

### Artifact assemblage

Table S1 shows the distribution, number, and type of cultural features primarily composing the cultural deposits for the Late Pleistocene and

Early Holocene layers. All of these features and deposits are ephemeral and characterized by co-occurring small, thin, ashy burned areas; light charcoal scatters; stains of a red pigment (for example, see fig. S5); fragments of rush; scattered lithics; and faunal and floral remains. Most of these features are limited in thickness (~0.5 to 1.5 cm) and size (~20 to 45 cm in diameter). Figure 3 and figs. S3 to S5 reveal stratigraphically intact thin, discrete habitational lenses almost always separated by culturally sterile deposits. None of these materials and features were observed in numerous other excavated units across the entire length of the terrace that reached the original intact or disturbed surface of the Sangamon Terrace (fig. S1). The absence of these deposits is most likely due to the heavy modification of the surface by extensive mound construction beginning around 5000 cal yr B.P.

Technologically, the stone tool assemblage is of characteristically early unifacial forms, very broadly similar to those documented across the wide region of South America over a similar span of time (14, 15, 28–31). Stone tools are made primarily of locally available cobbles of rhyolite, basalt, andesite, and quartzite (Fig. 5, figs. S6 and S7, and section S2). Two flakes of an exotic green silicate scarn from mountains to the east were also recovered. Some large basalt, rhyolite, and andesite tools are similar to the large primary flakes of the Late Pleistocene Amotape and Carrizal assemblages in the Talara and lower Zana valleys in northern Peru (32).

There is no evidence of formal bifacial tools. Most implements were struck on one side only. The earliest assemblage from ~15,000 to 13,500 cal yr B.P. is characterized by large primary flakes with relatively sharp edges and moderate-sized slicing tools (Fig. 5). A later assemblage from ~13,500 to 11,500 cal yr B.P. is associated with similar tools and also with smaller unifacial tools and a wider variety of scraping, cutting, wedging, and pounding tools (fig. S6). The youngest assemblage studied here, dated from ~11,500 to 10,000 cal yr B.P., covers the Early Holocene and is similar to the ~13,500 to 11,500 cal yr B.P. lithics but has smaller unifacial flakes, occasional serrated edges, and rough limace-like scrapers (fig. S7). Some local fishermen today still strike a pebble tool to produce a sharp flake for scraping fish scales.

Seventy-one flaked stone pieces were recovered from the Late Pleistocene and Early Holocene deposits, 49 of which are reported here (tables S2 and S3). Stone tools were reduced by using direct percussion that resulted in a variety of flakes, tools on flakes, split cobble tools, a possible flake core, a chopper, and two denticulates. All aspects of working these pieces from initial fracturing of the cobbles to trimming the resulting flakes and spalls were by direct percussion, evidently with hard hammer precursors. Most flakes and debris resulted from unifacial dressing of a flake's edge. Ninety percent of the examined assemblage shows macroscopically visible indications of use. This basic, expedient pattern of behavior represents a long tradition of unifacial tools that changed little and continued to be made into the Inka and late Colonial periods (15, 16).

Overall, the flaked stone tools in the assemblage are consistent through time. The Late Pleistocene assemblage stands in distinct contrast to the roughly contemporaneous assemblage from Monte Verde II in several ways (29–31). At Monte Verde II (~14,500 cal yr B.P.), the raw material source was of similar lithologies, but those occurred in smaller pebbles. The limited mass of those small pebbles mitigates against direct handheld percussion like that indicated for the larger cobbles used at Huaca Prieta, Paredones, and Unit 16. This contrast in flaking behavior is reflected in the small number (31) of direct percussion flakes in the Monte Verde II assemblage. The explanation of another contrast between the Monte Verde II tools and those from Huaca Prieta and

**Table 2. Distribution and type of recovered faunal and floral remains in excavated sites.** Species type and distribution for phases I and II, the Late Pleistocene and Early Holocene, in excavated units at Huaca Prieta, Paredones, and Domestic Unit 16. TP, Test Pit; LP, Late Pleistocene; EH, Early Holocene.

Taxon	Unit 9*		Unit 12*				Unit 15/21				Unit 16*		Unit 22*	TP 22			Total	% of total by taxa			
	Layer		Layer				Layer				Layer		EH	Layer							
	LP11	LP12	EH11	EH13	LP15?	LP17	LP20	LP23	EH6-4	LP8?	LP9?	LP13a	EH13	LP15	Premound Level 7	LP22-5a			LP25-8a-b	LP28-11a	
<b>Limpets</b>																					
<i>Fissurella peruviana</i> (keyhole limpet)			3		2		1		3	2	4	4						19			
<i>Fissurella maxima</i> (keyhole limpet)	2															1	2	1	6		
Total limpets																			25	9.43	
<b>Marine snails/gastropods</b>																					
<i>Tegula atra</i> (marine snail)	2															1	3	3	9		
<i>Thais chocolata</i>	2			1	2		1									3		2	11		
Total marine snails/gastropods																			20	7.55	
<b>Bivalves</b>																					
<i>Protothaca thaca</i> (clam)	2	1														7	11	1	22		
Total bivalves																			22	8.30	
<b>Marine crabs</b>																					
<i>Platyxanthus orbigny</i> (violet crab)	1							1	6	2									10		
Total marine crabs																			10	3.77	
<b>Sharks and rays</b>																					
<i>Galeorhinus</i> sp. (school shark)		1																	1	2	
<i>Myliobatis</i> sp. (eagle ray)													1							1	
<i>Carcharhinus</i> sp. (requiem shark)			3		1	1		1	2	3	2		23	34						70	
Total sharks and rays																				73	27.55
<b>Bony fish</b>																					
<i>M. cephalus</i> (mullet)													1							1	
<i>P. peruanus</i> (coco, Peruvian banded croaker)													8							8	
<i>Sciaena deliciosa</i> (drum)													17							17	
<i>S. starksi</i> ( <i>S. weineri</i> ) (sea bass and robalo)													4							4	
<i>M. g. peruanus</i> (hake)													1							1	

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Taxon	Unit 9*		Unit 12*					Unit 15/21				Unit 16*		Unit 22*	TP 22			Total	% of total by taxa	
	Layer		Layer					Layer				Layer		EH Premound Level 7	Layer					
	LP11	LP12	EH11	EH13	LP15?	LP17	LP20	LP23	EH6-4	LP8?	LP9?	LP13a	EH13		LP15	LP22-5a	LP25-8a-b			LP28-11a
Not identified												3						3		
Total bony fish																		34	12.83	
Marine birds																				
<i>Larus</i> sp. (seagull)	1		2	1		1				2		5					1	13		
<i>Phalacrocorax bougainvillii</i> (guanay and cormorant)	2	1						1				6						10		
<i>Pelecanus thagus</i> (Peruvian pelican)												7						7		
Not identified												7						7		
Total marine birds																		37	13.96	
Wetland/land birds																				
<i>D. warszewiczi</i> (scrub blackbird)	1																1	2		
Total wetland/land birds																		2	.75	
Mammals																				
<i>Otaria</i> sp. (sea lion)			2		1	1			6	2		18				6		36		
<i>Otaria flavescens</i> (sea lion)	2	1																3		
<i>O. virginianus</i> (white-tailed deer)										3								3		
Total mammals																		42	15.85	
Faunal subtotal	15	4	10	2	6	3	1	2	7	17	16	4	101	34	0	12	22	9	265	~100
Flora																				
<i>Capsicum</i> spp. (chile pepper)															4				4	25.00
<i>Cucurbita</i> sp. (gourd)															3				3	18.75
<i>Persea americana</i> (avocado)												1							1	6.25
<i>Phaseolus</i> sp. (bean)												1	4						5	31.25
<i>T. integrifolia</i> (palo bobo)												3							3	18.75
Flora subtotal	0	0	0	0	0	0	0	0	0	0	0	4	5	7	0	0	0	16	~100	
Total	15	4	10	2	6	3	1	2	7	17	16	4	105	39	7	12	22	9	281	

\*New data addition since 2012.

Paredones is less clear. Many of the Monte Verde II pieces are naturally or culturally split pebbles with minor amounts of edge modification, usually discontinuous and consisting of small nicks and flake scars onto the exterior of the piece. The Huaca Prieta and Paredones tools are mostly made

on percussion flakes, and the modification is more commonly on the interior rather than on the exterior aspect of the parent spall or flake.

In summary, early Huaca Prieta, Paredones, and Unit 16 artifacts demonstrate a distinctive cobble tool technology in the traditional

typological shapes. As Bird (15) pointed out, the primary peculiarity of this assemblage is, from the early phase of its development, the use of locally available rounded cobbles for toolmaking. Bird also noted that this tradition was very conservative and was technologically changed very little through time. Although we have recovered only small, expedient unifacial assemblages associated with ephemeral occupation sites, there exists the remote possibility that more formal bifacial assemblages with a wider diversity of stone tools appear at larger campsites located farther inland or on the now-submerged ancient coastline. However, if this was the case, given the intermediate location of the terrace between these two areas, we would expect to

have recovered evidence of a bifacial technology during the Late Pleistocene. This does not imply that bifacial flaking did not exist in the area. Later bifacial projectile points of the Fishtail and Paijan types (~13,000 to 10,000 cal yr B.P.) are present in the Andean foothills and interior valleys to the east of the study area (32, 33).

It should be noted that we have examined more than 1 million lithic tools and debris from our excavations and surface collections along the Chicama coast and from Bird's artifact collections from there, and we have not yet documented a single bifacial implement. It is our opinion that the early cultural periods under discussion for this section of the north coast of Peru were exclusively characterized by unifacial lithic



**Fig. 5. Unifacial basalt flakes most representative of 15,000 to 13,500 cal yr B.P. deposits showing marked platforms and bulbs of percussion (arrows).** (Photo Credit: Tom D. Dillehay, Vanderbilt University)

assemblages. The absence of evidence for stone, bone, and shell harpoons and the absence of shell fishhooks are also significant. Bird's excavation at Huaca Prieta produced one possible shell fishhook (15). Our examination of more than 350,000 shell fragments and shell artifacts did not produce any signs of harpoon and fishhook production. There is also no evidence of a boat or raft technology for the period under discussion.

The matting fragments of rush, especially from Layer 11 in Unit 12 (fig. S9), are also notable in the artifact assemblage from Huaca Prieta, which suggests a weaving technology. One fragment, a segment of open, simple twining, sewn with two-ply, Z-twist cordage wefts, was directly dated to 10,600 to 11,159 cal yr B.P. and represents the oldest example of this craft from lowland South America. The thickness of the individual rush fibers, their relatively tight weave, and the rigidity of the sample suggest possible use as a rush trap or basket rather than a net for fishing or matting for sleeping or flooring.

## CONCLUSION

The intermittently present thin cultural lenses in all early sites examined here indicate discontinuous and ephemeral residence on the remnant Sangamon Terrace during the Late Pleistocene and Early Holocene. A boat technology, bifacial stone tools, harpoons, and fishhooks apparently were not required to procure the diverse faunal and floral species in the accessible nearshore and terrestrial habitats of the Chicama valley, as suggested by their absence in all assemblages for all cultural periods at all sites (15–18). Analysis of the food remains, the absence of these technologies, and the presence of unifacial stone tools and possibly weighted rush traps suggest the primary use of simple technologies. Maritime foods could have been gathered or captured by trapping or clubbing, and exotic plant foods and stones for raw materials were obtained through exchange networks with interior groups or were collected directly. For this early period, it is not known whether independent, specialized littoral and interior groups exchanged resources or whether different littoral and interior groups directly exploited multiple environments with little, if any, contact between them. When combined with information from other Late Pleistocene and Early Holocene sites along the Pacific coast of South America (3–9, 34), these data suggest that early people symbiotically exploited a wide variety of resources from complementary environments that probably would have minimized economic risk because of any climatic shifts.

The evidence presented here does not necessarily substantiate initial human entry into the Americas along the Pacific coast. Varied subsistence data and exotic food and stone tools from several sites along the Pacific coast (1–9, 34) indicate that some early people had detailed knowledge of different maritime and occasionally terrestrial environments, which must have required a considerable amount of time to explore, observe, and experiment in a trial and error fashion. This suggests that early human migration along some coastal areas such as resource-rich portions of the north coast of Peru may have been more exploratory and slower than previously thought.

## MATERIALS AND METHODS

Between 2007 and 2013, a total of 32 excavation units and trenches, 32 test pits, and 80 geological cores were placed on, around, and between the Huaca Prieta and Paredones mounds and other sites (16, 18). Of the total number of archaeological units and pits excavated, 17 reached pre-mound layers, the original surface of the Sangamon Terrace, at depths

varying from ~7 to 30 m below mound summits (figs. S1 and S2). Six of the 17 excavations exhibited Late Pleistocene and Early Holocene cultural deposits: Units 9, 12, 15/21, 16, and 22 and Test Pit 22. These six units ranged in size from 1 m by 4 m to 2 m by 2 m. The limited size of these pits was due to their excessive depth below the mound summits: Excavation units were stepped and narrowed downward as we reached greater depths to prevent the collapse of cultural deposits in the wall profiles and to protect excavators. We also inspected the cut walls or profiles of 23 drainages, irrigation canals, and roads, constituting a total distance of 11.2 km in the sugarcane fields east of Huaca Prieta and Paredones. The profiles of and tossed debris around 234 looter's holes on the Sangamon Terrace and in outlying domestic sites north and south of the terrace were also examined. Nonetheless, cultural deposits of the Late Pleistocene and Early Holocene were found in only the six units below the mounds that are reported here (fig. S2). Except for the original terrace surfaces underneath the mounds of Huaca Prieta and Paredones, all other original surfaces across the entire length of the terrace have been heavily disturbed or completely removed in the production of hundreds of thousands of adobe bricks for the construction of later mounds dated from ~3500 to 350 cal yr B.P.

All cultural deposits reported here were excavated stratigraphically (18). All excavated sediments were screened over 3-mm mesh and/or subjected to water flotation, which produced microspecimens of organic and inorganic materials. Although 3-mm screens can cause biases in small-fish assemblages, the exceptional preservation of the faunal and floral remains suggest that our samples are relatively representative. Moreover, many fish bones were recovered by water flotation.

Most of the taxonomic identifications of the faunal and floral remains in this study (Table 2) was performed by using comparative collections at the Laboratorio del Centro de Investigaciones Arqueobiológicas y Paleocológicas Andinas (ARQUEOBIOS) in Trujillo, Peru. Specialty studies on materials reported here were carried out at the Smithsonian Institution (Panama City and Washington, DC), University of California (Berkeley, CA), Museo Nacional de Ciencias Naturales (Madrid, Spain), Universidad Cayetano Heredia (Lima, Peru), Vanderbilt University (Nashville, TN), and Mercyhurst University (Erie, PA). The faunal and floral remains were identified to the most specific taxon possible, including identifications to order, family, genus, and species following the nomenclature, seasonality, and habitat information.

The qualitative and quantitative discrepancies between food remains in some individual units and layers appear to relate as much to limited excavation and sampling bias in reaching and exposing the deeper strata overlaid by the mounds as to differential human use of specific areas in the past. Nonetheless, as suggested by the preliminary data in Table 2, the frequency and importance of various taxa varied considerably through time and habitat. The variation in the remains of food resource densities may also reflect differential processing and intrasite heterogeneity because the number and type of taxa identified in each unit are relatively similar, except for the bony fish of the Late Pleistocene and Early Holocene period in Unit 16. Although the data are meager for any specific time period and specific site location, our dietary reconstruction suggests that sea lions and sharks were the two largest contributors of meat to the economy over several millennia, a pattern that holds for the entire Holocene as well (18). Estimated Late Pleistocene and Early Holocene ages of undated strata referenced in the tables are based on their stratigraphic position relative to overlying and underlying radiocarbon assayed layers and on their cultural and/or natural depositional rates (18).

The radiocarbon date on the sea lion bone (Table 1) was calibrated using a marine reservoir factor of  $725 \pm 173$  for the north coast of Peru

(35). Over the past several years, in reporting the radiocarbon dates from these sites in various publications, we have wavered in using various calibration programs to seek greater chronological accuracy. We hope that this has not led to slight numerical differences in published calibrated ages for the same dated samples.

OSL dates were taken from off-terrace lagoon deposits immediately east of the Huaca Prieta mound. At 4.5 m below the present-day ground surface, the first river outwash sand was found underneath lagoon carbonates and muds. The oldest OSL date (HP-01) was  $14,327 \pm 2227$  on the alluvial sands, which corresponds with the Chicama River and some of the oldest human occupation on the Sangamon Terrace (18).

Last, most artifactual and faunal data presented here for Unit 15/21 and Test Pit 22 were published in a preliminary 2012 report on Huaca Prieta (17) and more recently in a large volume given to our research in the study area over the past several years (18). There may be slight quantitative and qualitative differences in the data presented in these publications and in the report here with respect to faunal counts and types for some strata in Unit 15/21 and Test Pit 22 (the latter previously reported at Unit 22). Any differences derive from additional excavations and from the study of more flotation samples since the 2012 report, which have slightly altered some counts and types. As can be determined in Table 2, most of the faunal remains represent Late Pleistocene deposits. Furthermore, it should be noted that the 2012 publication reported the faunal data from Test Pit 22 as Unit 22. This is corrected here, whereby Test Pit 22 is distinguished from Unit 22, both of which contain Early Holocene and/or Late Pleistocene materials. Furthermore, the more recent 2017 publication (18) focuses almost exclusively on Middle Holocene databases from these sites and only partially documents the Late Pleistocene and Early Holocene information. When initially submitted for publication in 2015, not all of the early data reported here had been studied. The report here is considered the most complete and reliable for the Late Pleistocene and Early Holocene levels at sites.

## SUPPLEMENTARY MATERIALS

Supplementary material for this article is available at <http://advances.sciencemag.org/cgi/content/full/3/5/e1602778/DC1>

section S1. Sangamon Terrace and wetlands

section S2. Cultural features and artifacts

section S3. Exploited biozones

section S4. Faunal and floral assemblages

fig. S1. Location map of all excavated Late Pleistocene and Early Holocene units at all reported sites.

fig. S2. Schematic location of Late Pleistocene and Early Holocene deposits underneath mounds.

fig. S3. Stratigraphic profile of Unit 15/21.

fig. S4. Stratigraphic profile of Test Pit 22.

fig. S5. Buried cultural layer in Unit 15/21.

fig. S6. Stone tools dated between 15,000 and 12,000 cal yr B.P.

fig. S7. Stone tools dated between 12,000 and 10,000 cal yr B.P.

fig. S8. Perforated and worked pebble possibly used as weight stone for a trap made of rush stems.

fig. S9. Fragment of rush matting tightly woven.

fig. S10. Schematic of the isolated remnant Sangamon Terrace coastal biotic zones showing the ocean and back-barrier wetlands in the distance and the Chicama River running nearby.

fig. S11. Views of live and dead sea lions on beach before and after being clubbed by local fishermen (to the right and not included in the photo).

fig. S12. Present-day hunters and fishermen on the coast.

fig. S13. Archaeological bean seed and avocado stem.

fig. S14. Archaeological chile pepper seed.

table S1. Distribution and type of cultural features recovered from sites.

table S2. Distribution and attributes of lithics recovered from sites.

table S3. Distribution and other attributes of flake tools, spalls, and other tools from sites.

table S4. *Capsicum* spp. seed attributes.

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**Simple technologies and diverse food strategies of the Late Pleistocene and Early Holocene at Huaca Prieta, Coastal Peru**

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