ARTICLES

THE CROSS CREEK SITE (CA-SLO-1797) AND ITS IMPLICATIONS FOR NEW WORLD COLONIZATION

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Recent excavations at the Cross Creek site (CA-SLO-1797) on the central coast of California revealed a stratigraphically discrete midden component dating between ca. 8350 and 7700 cal B.C., making it the oldest mainland shell midden on the west coast of North America. A large recovery volume revealed an assemblage dominated by grinding implements (handstones and milling slabs) and crude core and flake tools typical of California's Milling Stone horizon, but the Cross Creek findings extend the antiquity of Milling Stone back to the terminal Pleistocene. The tools and associated faunal remains suggest a gathering economy profoundly different from the terminal Pleistocene big-game hunting of interior North America. This variation is difficult to reconcile as a simple adaptive outgrowth from late Pleistocene hunting and may reflect a separate coastal migration route into the New World.

Recientes excavaciones arqueológicas en el sitio de Cross Creek (CA-SLO-1797) en la costa central de California revelan un discreto depósito de túmulos datado entre los años calendario 8350–7570 A.C., lo que lo convierte en el depósito continental más antiguo de conchas en la costa occidental de Norteamérica. El gran volumen de material recobrado revela un conjunto formado principalmente por implementos de molienda (piedras y muelas) y núcleos toscos y de lasca típicas del Período Arcaico de California, pero los descubrimientos hechos en Cross Creek extienden la antigüedad del Período Arcaico hasta fines del Pleistoceno. Las herramientas y los restos de fauna asociados con ellas, sugieren una economía de recolección profundamente diferente de la de caza mayor de fines del Pleistoceno, del interior de Norte América. Esta variación es difícil de interpretarse como un simple crecimiento de adaptación dentro de la caza del Pleistoceno tardío, y puede reflejar una ruta diferente de migración por la costa hacia el Nuevo Mundo.

With increasing evidence for broad-scale subsistence economies in South America as old or older than the Paleoindian hunting cultures of North America (Dillehay 1997, 2000; Keefer et al. 1998; Meltzer et al. 1997; Roosevelt 2000; Roosevelt et al. 1996; Sandweiss et al. 1998; Yesner 2001), there is growing evidence for adaptive variability among early New World cultures and a need to rethink the process of human colonization (Anderson and Gillam 2000; Dixon 2001; Fiedel 2000; Mandryk et al. 2001). Findings from the Cross Creek site (CA-SLO-1797), a pericoastal shell midden in central California, are reported here. This site produced a stratigraphically discrete component dating 9900–9340 radiocarbon years B.P. (8350–7700 cal B.C.; 2-sigma range 9050–7540 cal B.C.), making it the oldest mainland shell midden on the west coast of North America,[1] and the first coastal residential site to yield a substantial artifact collection in association with ca. 8000 cal B.C. dates. Radiocarbon-dated shells from Daisy Cave on San Miguel Island (Erlandson et al. 1996; Rick et al. 2001) and human remains from Santa Rosa Island (Arlington Woman) (Johnson et al. 2001) place maritime gathering peoples on California's Channel Islands (Figure 1) by at least 9750 and possibly 11000 cal B.C.

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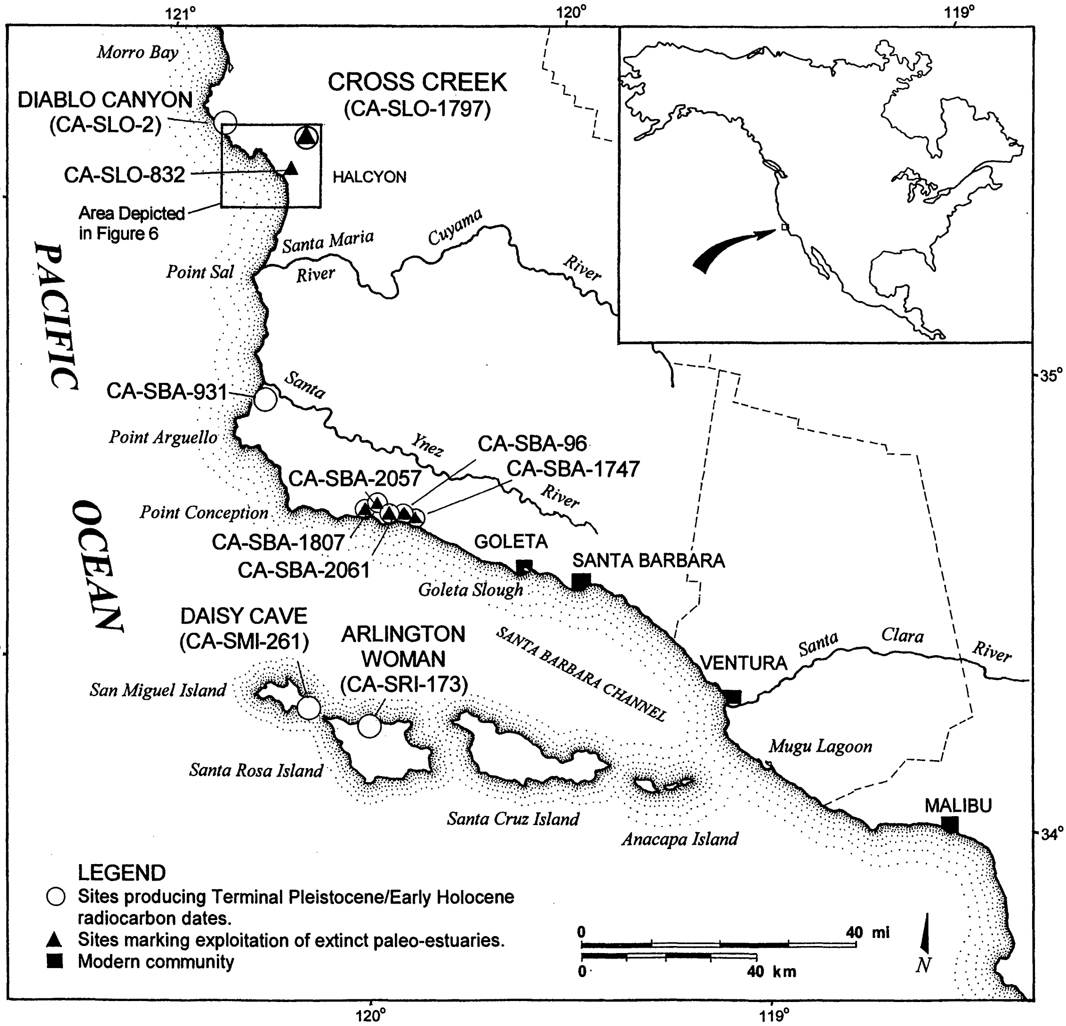

Figure 1. Location of Cross Creek (CA-SLO-1797), Diablo Canyon (CA-SLO-2), Daisy Cave (CA-SMI-261), Halcyon Bay, and selected sites marking extinct paleoestuaries on the south-central California coast.

respectively, but neither of these locations produced substantial assemblages of associated tools.

Owing to a greater recovery volume and its residential character, the Cross Creek site produced a large assemblage dominated by milling slabs, handstones, and crude core and flake tools. The collection is typical of California's Milling Stone culture, long interpreted as a coastal gathering adaptation derived from late Pleistocene hunting specializations (Chartkoff and Chartkoff 1984; Wallace 1955). The Cross Creek findings push the antiquity of the Milling Stone culture back to the Pleistocene/Holocene interface. While this is insufficient antiquity to challenge the temporal priority of fluted-point cultures (traditionally dated ca. 9500 B.C. [Haynes 1992] but most recently pushed back to ca. 11500 B.C. on the basis of recalibrated ^{14}C dates [Fiedel 1999]), Cross Creek and Daisy Cave represent adaptations profoundly different from Clovis, Folsom, and other terminal Pleistocene/early Holocene hunting complexes in North America. The distinctiveness of the tools found at Cross Creek and the lifeways inferred from this and other coastal sites are not easily interpreted as logical adaptive outgrowths of late Pleistocene hunting.

Human Colonization of Western North America: Chronology and Culture

An alternative explanation for the existence of a gathering culture on the south-central California coast at the close of the Pleistocene is that early findings from Cross Creek, Daisy Cave, and Arlington Woman reflect an adaptive outgrowth from a separate coastal migration corridor employed by people with a maritime gathering adaptation tied to the Pebble Tool Tradition of the Northwest Coast (Carlson 1990, 1995, 1996). The possibility of a coastal migration corridor into the New World has been considered hypothetically for at least three decades (Bryan 1973; Fladmark 1979), but the apparently recent antiquity of coastal adaptations in western North America stood in opposition to this theory for many years. Radiocarbon findings have slowly accumulated to show that human use of the northeastern Pacific littoral zone was considerably older than previously thought (Erlandson 1994; Jones 1991); however, the relationship of late Pleistocene/early Holocene coastal foragers to Paleoindian big-game hunters has remained unclear. Meighan (1989) suggested that the earliest coastal dwellers were distinct from both the big-game hunters and Milling Stone plant-using cultures and instead were descended from simple coastal gatherers of northeast Asia; the cultural affiliations of late Pleistocene shellfish collectors have not been established with any degree of certainty.

Based partially on findings from Diablo Canyon (CA-SLO-2), a shell midden on the south-central California coast that produced uncalibrated radiocarbon dates of 9320 ± 140 (UCLA-1686A on human bone) and 8960 ± 190 (GAK-02044 on marine shell) (Greenwood 1972), a separate Paleo-Coastal tradition was proposed to describe the early coastal inhabitants of California (Davis et al. 1969; Moratto 1984). Hypothetically, the Paleo-Coastal tradition was linked with early hunting/lacustrine adaptations of western North America, and was thought to pre-date the California Milling Stone culture. Paleo-Coastal populations were thought to have exploited fish, shellfish, and terrestrial game with a tool kit that included scrapers, scraper planes, and bifaces, but no milling equipment. At the time it was proposed, however, the Paleo-Coastal tradition was almost wholly conjectural, as it was based on limited findings from Diablo Canyon and an 8,000-year-old deposit in San Diego County that lacked milling tools (Kaldenberg 1976).

Models envisioning a separate route of coastal colonization into California have generally not been integrated with sequences from the Pacific Northwest where distinctive coastal assemblages and lifeways have been recognized since at least 1961 when Butler proposed the "Old Cordilleran Culture." Marked by edge-ground cobbles and generalized lithics, Old Cordilleran was subsequently subsumed within the Pebble Tool tradition by Carlson (1990). The Pebble Tool tradition, marked by co-occurrence of unifacial pebble/cobble choppers and leaf-shaped bifaces, was originally thought to have developed in the interior, spreading later to the coast, but the oldest manifestations are now known from the coastal zone, and the direction of cultural flow seems to have been from the coast inland (Carlson 1995:14). The oldest coastal representations at the sites of Namu, Hidden Falls, and Ground Hog Bay in British Columbia and Alaska are thought to mark a complex that was present on the Northwest Coast as early as 10,000 years ago and was distinct from the big game/fluted point cultures of the interior. The tradition has been linked to the Nenana complex of interior Alaska, dated 9850–8750 B.C. (Carlson 1990, 1996), but Matson and Coupland (1995) suggest it post-dates and was derived from the interior Clovis fluted-point culture.

The Cross Creek Site (CA-SLO-1797)

In this paper we focus on description of findings from Cross Creek, which at a minimum reflect significant variability in adaptation at the close of the Pleistocene, possibly resulting from multiple migrations into the New World. The Cross Creek site is situated in the Edna Valley, 9 km from the present shoreline of San Luis Obispo County in central California (Figure 1). At the time of its earliest occupation it was situated approximately 17 km inland from the open coast but only 9 km from a now-extinct marine estuary. The site was discovered somewhat miraculously during trenching for a state water pipeline in the summer of 1996, following intensive reconnaissance that revealed nothing of prehistoric origin on the surface. Survey in the surrounding environs has been very limited due to a preponderance of privately held land.

The deposit was first recognized as a modest concentration of cobbles, shells, and a few grinding implements, 30–80 cm below surface in the sidewall of the pipeline trench. Salvage excavations completed during the fall of 1996 (Fitzgerald 1998, 2000) revealed a black clay loam shell midden (stratum 3) 30–50 cm below the surface, overlain by one, and in some places, two largely sterile layers (strata 1 and

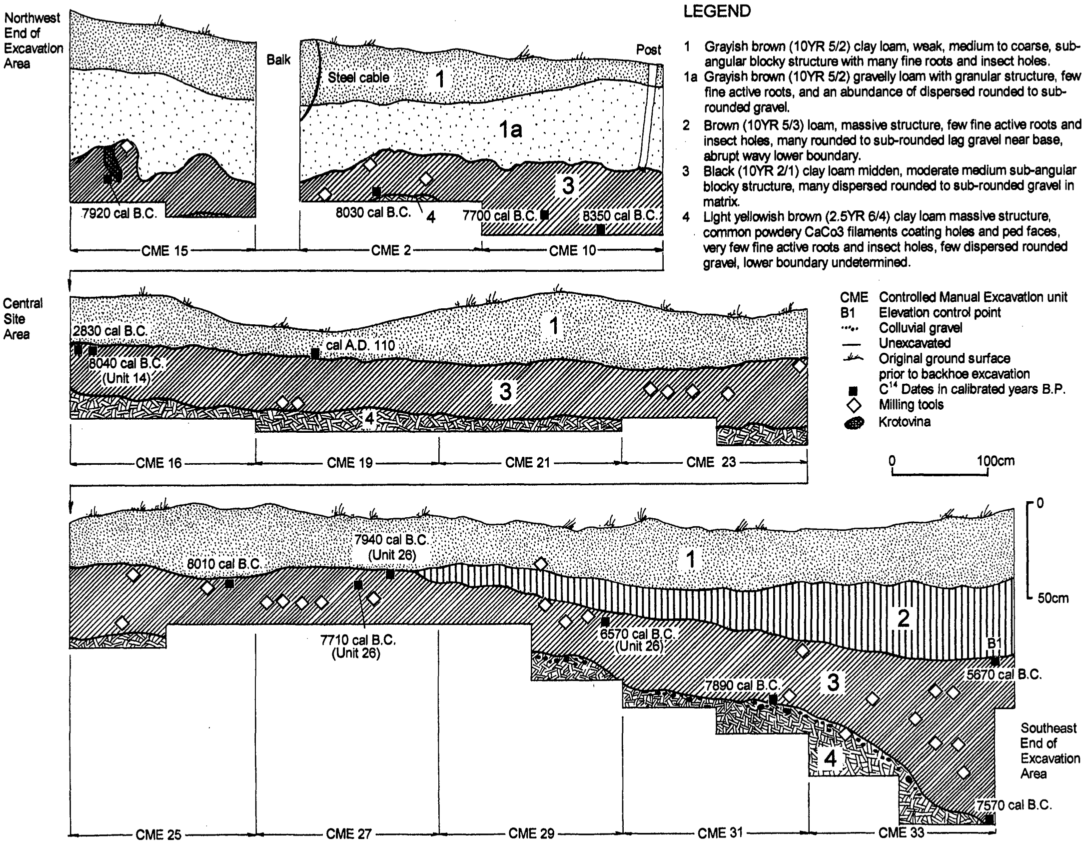

Figure 2. Statigraphic profile from Cross Creek showing location of ^{14}C dated samples. View to the northeast, from northern end of trench (top) to southern (bottom). Two other dates were from other stratigraphic profiles.

2). The midden was deposited on a low Pleistocene terrace and later buried by an accumulation of mid and late Holocene alluvium. Soil associated with the terrace (stratum 4) was a light yellowish-brown clay loam (Figure 2). Stratum 2 was a brown loam that contrasted strongly with the black midden deposit beneath it. Stratum 1 was a grayish-brown clay loam that was less distinct from stratum 3 in color and texture than strata 2 and 4. The cultural stratum lay closest to the surface at the high point of the terrace, where only 20–30 cm of stratum 1 sediments were found above it. Away from the center it dipped to as much as 80 cm below the surface. Near its center, the cultural deposit was characterized by a clay loam midden matrix with shell fragments, stone debitage, milling tools, core and flake tools, bifaces, projectile points, and very sparse vertebrate remains (stratum 3). On the periphery, where the midden dipped deeper below the ground surface, the tool inventory was very similar, but the matrix showed a heavy concentration of calcium carbonate that continued into the underlying sterile soil (stratum 4). Some artifacts and faunal remains (marine shells) were also recovered from the uppermost level of stratum 4. The layers above strata 3 and 4 were culturally distinctive in that they produced only very modest quantities of artifacts (Table 1) and faunal material that testify to later, very ephemeral occupation of the site area. Excavation also revealed two linear concentrations of cobbles with a few shells and artifacts that were recorded as features. Feature 1 was found at the interface between strata 2 and 3 near the high point of the terrace. Feature 2 was found at a depth of over 70 cm near the contact zone between stratum 3 and the underlying sterile stratum 4.

Chronology and Assemblage

Sixteen radiocarbon dates were obtained from Cross Creek strata 1, 2, 3, and 4, and their stratigraphic interfaces (Table 2). Ten dates were obtained from stratum 3, two from the strata 2/3 interface, three from the 1/3 interface, and one from the 3/4 inter-

Table 1. Stratigraphic Distribution of Artifacts from CA-SLO-1797.

Stratum	Milling Slabs	Handstones	Cobble/ Core Tools	Flake Tools	Side-notched Projectile Points	Bifaces	Hammer-Stones	Anvil Stones	Stone/ Shell Beads	Eccentric Artifact/ Fish Effigy	Bone Splinter Tool	Total
1	-	-	1	2	-	1	2	-	-	-	1	7
2	5	-	-	1	2	1	-	-	1[a]	-	-	10
3	8	9	11	6	1	1	9	1	2[b]	2	-	50
4	4	8	9	1	-	-	-	2	-	-	-	24
Other*	4	4	3	-	1	-	1		-	-	-	13
Total	21	21	24	10	4	3	12	3	3	2	1	104

*Recovered from mechanical trenching—lacking precise depth provenience.
[a]Broken, non-diagnostic steatite bead fragment.
[b]Includes one non-diagnostic spire-lopped *Olivella*, and one intrusive *Olivella* saucer bead.
Source: Fitzgerald (1998:11-3).

face. All dates were obtained from well-preserved, single marine shells. While suspicions concerning the reliability of shell dates have a long history in California and elsewhere, recent research has shown repeatedly that samples of this type provide reliable, accurate dating (see Erlandson 1994; Erlandson et al. 1996; Ingram 1998; Jones and Jones 1992; Kennett et al. 1997). All dates were corrected for isotopic fractionation and marine/atmospheric ^{14}C discrepancies using the Stuiver and Reimer (1993) calibration program with a local upwelling correction value of 290 ± 35 (Ingram and Southon 1996). Twelve dates were returned on samples of estuarine clam shell that produced calibrated dates between 8350 and 5670 cal B.C. Dated samples also included two shells from the open rocky coast (*Haliotis* sp.), and one from open sandy coast *(Tivela stultorum)*. The remaining date was obtained from an *Olivella* saucer bead, one of only three beads recovered from the deposit. One of the *Haliotis* shells returned a date of 2830 cal B.C., and the bead produced a date of cal A.D. 110.

The tool assemblage from strata 3 and 4 was typologically consistent with a temporally discrete early Milling Stone occupation. A total of 74 formal artifacts was recovered (Table 1).[2] Milling tools were the most abundant item, including 17 handstones, 12 milling slabs (3 nearly whole and 9 fragments), and 3 anvils distributed throughout strata 3 and 4. All the grinding tools were heavily modified and extremely

Table 2. Radiocarbon Dates from CA-SLO-1797.

Stratum	Laboratory Number (Beta-)	Excavation Unit	Depth (cm)	Material (Marine Shell Species)	Measured ^{14}C Age Years B.P.	$^{13}C/^{12}C$ Ratio (‰)	Corrected $^{13}C/^{12}C$ Years B.P.	Calibrated Age Range Cal. years[a]
1/3	101859	14[b]	42	*Saxidomus nuttalli*	9230 ± 70	+.3	9650 ± 70	B.C. 8250 (8040) 7920
1/3	111473	19	30-50	*Olivella* sp.	2100 ± 50	+1.4	2540 ±50	A.D. 30 (110) 250
1/3	103838	16[b]	42	*Haliotis* sp.	4400 ± 80	+.2	4820 ± 80	B.C. 2930 (2830) 2510
2/3	110795	28	46-56	*Saxidomus nuttalli*	8090 ± 80	-0.4	8410 ± 90	B.C. 6950 (6570) 6390
2/3	112549	33	80-90	*Tresus nuttallii*	7070 ± 100	+1.2	7500 ± 110	B.C. 5920 (5670) 5470
3	103837	26	50-60	*Haliotis* sp.	8910 ± 70	+.7	9340 ± 80	B.C. 7950 (7710) 7520
3	104767	10	80-100	*Saxidomus nuttalli*	9500 ± 260	-.7	9900 ± 270	B.C. 9050 (8350) 7730
3	104768	31	90	*Saxidomus nuttalli*	9020 ± 110	+.4	9440 ± 110	B.C. 8060 (7890) 7540
3	104769	2[c]	90	*Saxidomus nuttalli*	9230 ± 100	-.2	9640 ± 100	B.C. 8320 (8030) 7880
3	110793	15	80-90	*Saxidomus nuttalli*	9070 ± 80	-.3	9480 ± 90	B.C. 8060 (7920) 7640
3	110794	25	40-50	*Saxidomus nuttalli*	9180 ± 70	+.7	9600 ± 70	B.C. 8160 (8010) 7890
3	111349	10	80-100	*Tivela stultorum*	8900 ± 60	+.8	9330 ± 50	B.C. 7910 (7700) 7540
3	112548	26	40-50	*Saxidomus nuttalli*	9100 ± 120	+.1	9510 ± 130	B.C. 8190 (7940) 7570
3	120346	30	60-70	*Saxidomus nuttalli*	9130 ± 40	+.6	9550 ± 40	B.C. 8050 (7970) 7880
3	120347	1	80-90	*Saxidomus nuttalli*	9070 ± 70	.0	9480 ± 70	B.C. 8040 (7920) 7690
3/4	106533	33	140-150	*Tresus nuttalli*	8810 ± 50	+.8	9230 ± 50	B.C. 7830 (7570) 7480

[a]Calibrated with the program CALIB 3.0.3 (Stuiver and Reimer 1993). Rounded calendar ages include midpoint (in parentheses) and age range at two sigma.
[b]Associated with Feature 1.
[c]Associated with Feature 2.

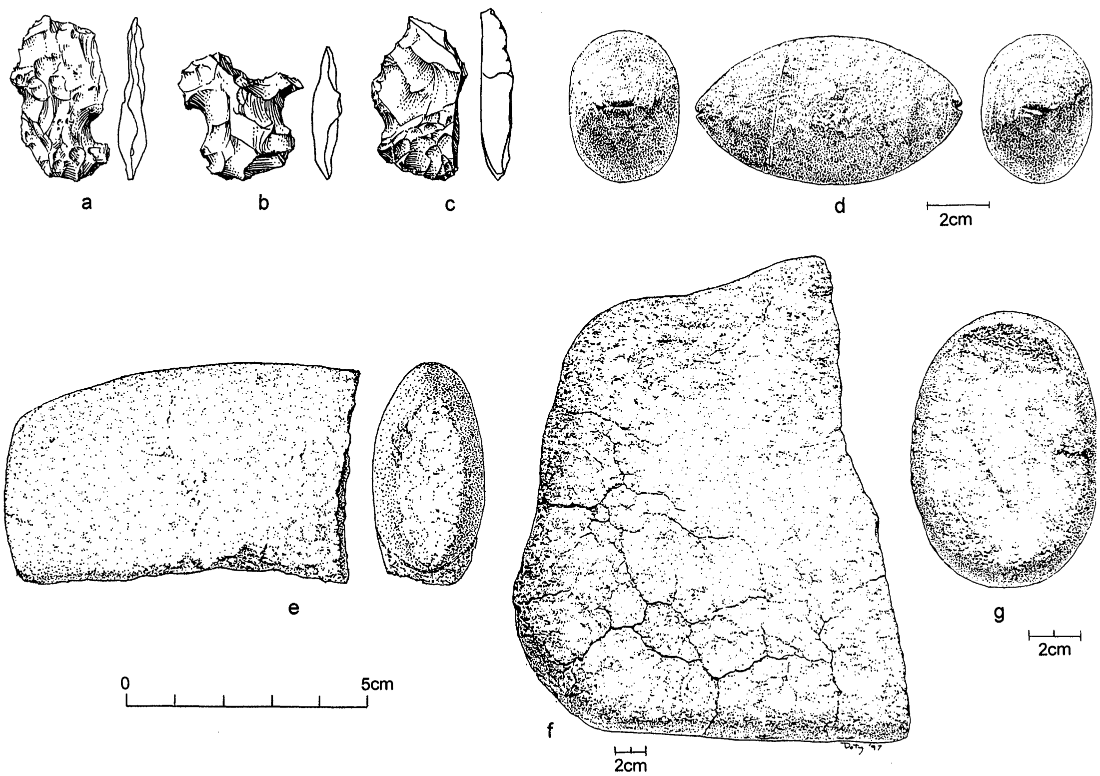

Figure 3. Formal artifacts from the Cross Creek site: side-notched projectile points: a) #329; b) #292; c) #568; fish effigy: d) #289; sandstone object of unknown function: e) #19; milling slab: f) #315; handstone: g) #249.

well made (Figure 3f and g); the slabs were shaped on their exterior and show consistency in size and material (siltstone and sandstone). Other abundant artifacts were crude core/cobble tools (n = 20), and hammerstones (n = 9) made from a variety of stone including chert, quartzite, and basalt. The core tools were scraping and chopping implements with heavily battered and rounded edges that were classified as choppers (Figure 4a and b), domed scrapers (Figure 4c and d), and hammers (Figure 4e). Similar examples of all types are known from Milling Stone sites in southern California where domed scrapers have been linked with processing tough fibrous or pulpy plants (Kowta 1969). Core hammers (n = 7) are also common in Milling Stone sites and are usually interpreted as tools used for making and maintaining milling equipment (Erlandson 1994; King 1967). Less abundant in strata 3 and 4 were flake tools (n = 7) (Figure 5) that included informal edge-modified flakes (Figure 5a), formal unifacial scrapers (Figure 5a, 5d), and both bifacial (Figure 5c) and unifacial ovoid scrapers (Figure 5e).

The core tools show similarities in form and inferred function with implements ascribed to the Pebble Tool tradition, defined by Carlson (1983, 1990, 1996) on the basis of a high frequency of "choppers and scrapers made from large pebbles (cobbles in the geological sense)" (1996:8). The choppers and scrapers are generally unifacial, with variable edge shape, and they often exhibit small flake scars that appear to be the result of use for cutting. Scrapers generally show steep scraping edges smoothed from wear, a pattern of use not associated with cutting. The core tools from Cross Creek (Figure 4) share many of these morphological traits, particularly the domed scrapers that exhibit conspicuous steep-angled edge flaking with rounded or battered facets and little formal shaping (Fitzgerald 2000). Although less abundant in the assemblage, the flake tools from Cross Creek share with the Pebble Tool tradition steep-angled flake detachments, retouch that often extends around the entire edge of the flake, and/or denticulate edges. The pecked and battered cobbles classified as hammerstones also have analogs in Pebble Tool assemblages. Battered cobbles and cores used as hammers are prevalent in Cal-

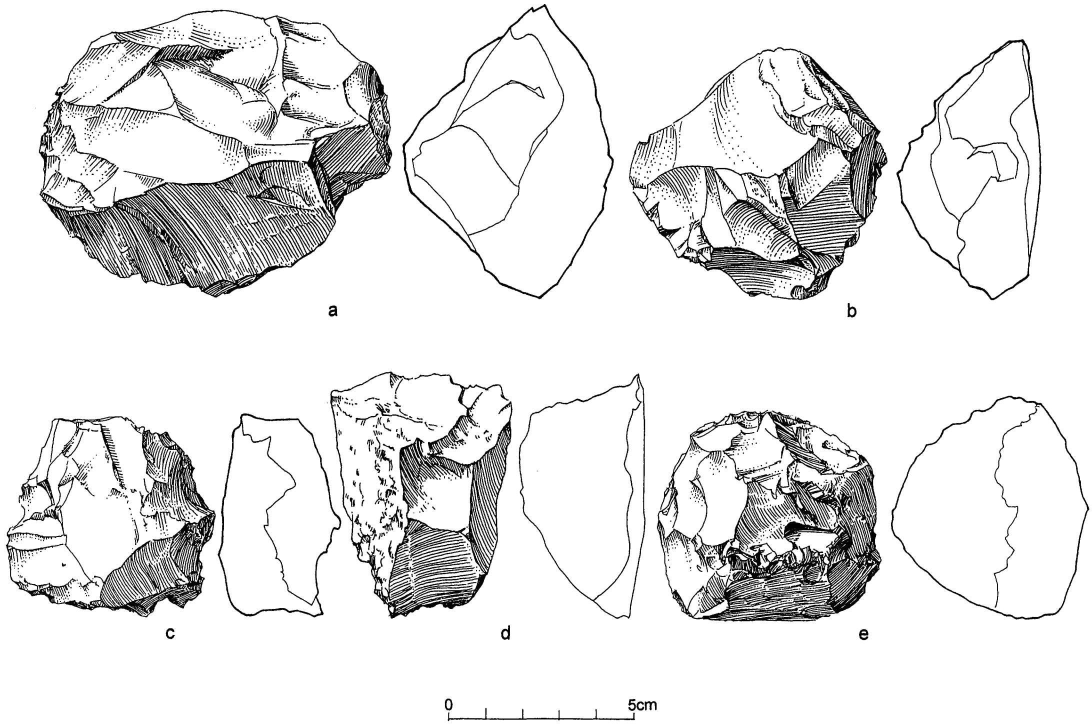

Figure 4. Core tools from the Cross Creek site: core choppers: a) #213; b) #386; domed scrapers: c) #143; d) #308; core hammer: e) #275;

ifornia Milling Stone deposits and, along with handstones and milling slabs, are diagnostic traits of the Milling Stone culture.

The remaining flaked stone artifacts from strata 3 and 4 included one biface, and one side-notched projectile point (Figure 3a–c). Two additional side-notched points were found at the base of stratum 2. Significant antiquity for this type was also suggested at nearby Diablo Canyon, where this was the only point represented in meaningful numbers in the Milling Stone levels of the deposit (Greenwood 1972). Side-notched points are associated with the Milling Stone culture in San Diego County (True 1958; True and Beemer 1982) and are increasingly recognized as dating to at least the early Holocene in the southwestern and northern Great Basin (Basgall et al. 1995; Hanes 1977). At Cross Creek, these points were associated with the upper levels of stratum 3 and the base of stratum 2 and appear to date no younger than 5670 cal B.C.

Two enigmatic artifacts also recovered from deep within the paleo-midden are associated with the earliest site occupation. The most intriguing was a palm-sized quartzite pebble, delicately shaped into a symmetrical form with minute incisions at opposing ends (Figure 3d). The resulting shape loosely resembles a fish, and similar objects found in the Santa Barbara area are commonly classified as fish effigies (Hudson and Blackburn 1986). This heavily patinated object provides possible evidence of representational stone art among the early inhabitants at Cross Creek. The second unusual object is a piece of finely shaped, elongated and curved sandstone of unknown function (Figure 3e). Similar pieces were found at the Browne site, an undated but clearly Milling Stone site on the southern California coast (Greenwood 1969), and CA-SLO-2 at Diablo Canyon (Greenwood 1972).

Chronostratigraphic Synthesis

Marked variation in the color and composition of soils and constituent frequency across stratigraphic boundaries suggests a depositional sequence and measure of stratigraphic integrity unusual for central California. This is a region where burrowing rodents have impacted virtually all middens, and reconstructions of past human behavior have been reliant on findings from single-component sites and/or horizontally segregated temporal components. The vertical distribution of radiocarbon dates

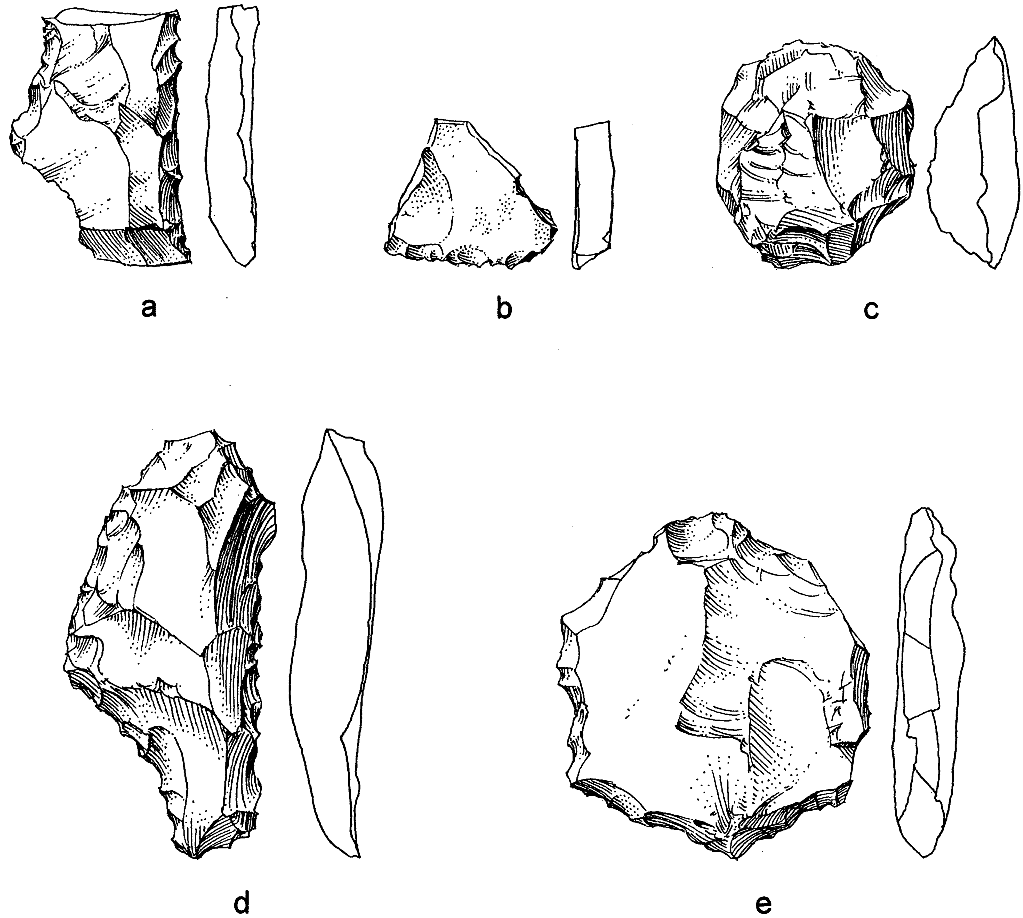

Figure 5. Flake tools from the Cross Creek site: a) #1; b) #359; c) 494; d) #303; e) #569.

at Cross Creek clearly indicates some post-depositional sorting of artifactual and faunal materials, and the presence of bones from small burrowing animals in the deposit suggests the likely cause of this mixing. Krotovina were also recorded in some profile walls, but not in large numbers. Blurred interfaces, 5–10 cm thick, between stratigraphic units were probably products of post-depositional soil movement caused at least in part by rodent activities. All three of the more recent radiocarbon dates obtained from the site were recovered from these interfaces (Table 2). The vertical movement of materials evident at the stratigraphic interfaces was also the likely cause of linear rock concentrations that were recorded as features. Such concentrations, common among Milling Stone sites, are recognized as complex products of both cultural and natural processes (Erlandson and Rockwell 1987; Johnson 1989; Pierce 1992). In particular, the activities of burrowing rodents cause large objects to sort into linear concentrations that can potentially mix residues from different temporal periods. Most compromised from these activities are multicomponent sites where artifacts from different time periods become intermingled and stratigraphic divisions blurred, and only sites occupied for relatively brief periods or buried beneath accumulated sediments can be relied upon to define artifact or faunal assemblages with any degree of confidence. Radiocarbon dates of 8040 and 2830 cal B.C. recovered from feature 1 indicate the co-mingling of materials from different occupational components within this linear concentration, suggesting that it represents a random collection of materials that accumulated at the high point of the old landform and the post-depositional movement of these materials by rodents.

Artifact inventories and dating results outside of feature 1 and beneath the stratigraphic interfaces,

Table 3. Vertebrate Faunal Remains from CA-SLO-1797.

	Strata 1 and 2		Strata 3 and 4		Totals	
Class	No.	Weight (g)	No.	Weight (g)	No.	Weight (g)
DIETARY REMAINS						
Artiodactyl	-	-	1	17.7	1	17.7
Large mammal	1	1.3	6	11.4	7	12.7
Mammal	13	.8	5	1.1	18	1.9
Rockfish (Sebastes spp.)	-	-	1	.4	1	.4
Unidentifiable	-	-	-	-	-	-
Subtotal	14	2.1	13	30.6	27	32.7
INTRUSIVE REMAINS						
Large mammal	2	3.4	1	.6	3	4.0
Mammal	-	-	-	-	-	-
Rodent	48	3.1	41	6.9	89	10.0
Unidentifiable	6	.2	-	-	6	.2
Subtotal	56	6.7	42	7.5	98	14.2
Grand total	70	8.8	55	38.1	125	46.9

however, indicate a relatively brief terminal Pleistocene/early Holocene occupation marked by stratum 3. All ten dates from within stratum 3 were between 8350 and 7700 cal B.C., although these dates do not show superposition throughout the layer. This is consistent with the lack of observable microstratigraphy within the stratum as well as vertical movement of materials in the layer during and after site occupation. Stratum 3 was essentially a homogeneous unit with little internal stratigraphy, particularly in the portion away from the high point of the old terrace. Following the occupation marked by stratum 3, there appears to have been an interval of flood-plain aggradation in the Edna Valley that resulted in the lower margins of the terrace and midden being covered by alluvium (strata 1 and 2). The high point of the midden, however, was capped by only a thin veneer of sediments (stratum 1) which were witness to some limited human occupation during deposition. The thin alluvium rendered the central portion of the deposit more accessible to rodents, leading to the post-depositional sorting that created feature 1. The lower portions of the deposit (excavation units 29, 31, and 33), covered by two alluvial layers, were effectively protected from significant post-depositional disturbances. The very minor inter-component mixing apparent in the vicinity of feature 1 does not detract from overall cohesion of stratum 3, which produced a large and typologically nondiverse tool assemblage with a tight cluster of chronometric readings.

All of the more recent dates were obtained from stratigraphic interfaces in the portion of the site where the midden lay closest to the surface and inter-component mixing was apparent. They represent minor, later use of the site area when stratum 1 was deposited and intrusions into the late Pleistocene/early Holocene midden. Away from the top of the terrace and feature 1, all dates from strata 3, 4, 1/3, and 2/3 were in excess of 5670 cal B.C., and 12 of 14 were clustered between 8350 and 7570 cal B.C. Samples yielding these dates were spread throughout the midden along with milling stones and other tools (Figure 2).

Faunal and Floral Remains: Dietary and Environmental Implications

In contrast with Paleoindian big-game hunting sites, vertebrate remains were very sparse at Cross Creek. Despite a total hand-excavation volume of 30.2 m^3, only 13 bone fragments (30.6 g) from strata 3 and 4 were considered representative of prehistoric diet (Table 3). A total of 55 bone fragments was recovered from strata 3 and 4 (38.1 g), but the bulk of these were clearly intrusive; most were rodent bones that exhibited distinctively fresh color and texture, and were all unburned. Non-rodent bones with the same appearance were likewise considered intrusive, while bones associated with strata 3 and 4 were nearly all splintered, burned, or calcined long-bone fragments. The specimens were so small that only one, an antler fragment, could be identified as representing an artiodactyl (either black-tailed deer *[Odocoileus hemionus]* or a tule elk *[Cervus elaphus]*). Only a single fish bone, a vertebra from a rockfish (*Sebastes* spp.), was recovered from strata 3 and 4. Soil acid-

Table 4. Invertebrate Remains from CA-SLO-1797.

			Weight of shell (g) per stratum							
Taxon	Common name	Habitat	1/2	2/3	2/3	2/3	3	4	Total (g)	%
Protothaca staminea	Pacific littleneck	Various but most common in embayments	76.9	161.3	175.1	113.9	58.8	43.5	629.5	53.5
Saxidomus nuttalli	Washington clam	Protected embayments	12.9	14.4	169.7	35.2	3.8	4.0	240.0	20.4
Mytilus californianus	California mussel	Rocky open coast	6.8	19.2	37.2	20.2	3.0	6.9	93.3	7.9
Tresus nuttalli	Gaper clam	Protected embayments	2.0	9.8	4.8	5.5	.8	2.3	25.2	2.1
Tivela stultorum	Pismo clam	Sandy open coast	.7	4.7	6.6	4.0	.2	4.4	20.6	1.8
Clinocardium nuttalli	Basket cockle	Protected embayments	—	.1	—	2.0	—	.6	2.7	.2
Balanus glandula	Acorn barnacle	Various	—	2.0	—	—	—	—	2.0	.2
Unidentified			18.1	13.3	69.7	32.3	16.8	13.4	163.6	13.9
Total			117.4	224.8	463.1	213.1	83.4	75.1	1176.9	100.0

Note: Remains from Unit 28, 1-x-2 m in dimension, excavated with 3-mm mesh. Total recovery volume 1.9 m^3. Unit was excavated in arbitrary 10-cm level cross-cutting strata. Most of the recovery volume in levels designated 2/3 reflects stratum 3.

ity often causes poor bone preservation in California, leading to under-representation of vertebrate fauna, but strata 3 and 4 at Cross Creek showed a pH value of 8.0, which is favorable for faunal preservation. Large animals simply were not a major focus of subsistence for the inhabitants of Cross Creek, which is typical of Milling Stone sites on the mainland coast dating later in time (see Erlandson 1994; Fitzgerald and Jones 1999; Wallace 1955, 1978), as well as early Channel Island sites (Erlandson et al. 1999; Rick et al. 2001).

Despite the inland location of Cross Creek, shellfish remains dominated the faunal assemblage. A total of 5.7 kg of shell was obtained overall, a tiny fraction of which came from strata 1 and 2 (10-cm levels in 1-x-2-m units processed with 6-mm [¼"] mesh produced between 1.1 and 16.9 g). In contrast, strata 3 and 4, along with the strata 2/3 interface, produced the bulk of the shell remains with as much as 169 g of shell per 10-cm level (1-x-2-m unit processed with 6-mm mesh) (Fitzgerald 1998:9–6). A single 1-x-2-m control unit processed with 3-mm (⅛") mesh produced 1176.9 g of shell from a recovery volume of 1.9 m^3, mostly from strata 3 and 4 (Table 4). The assemblage was dominated by taxa most commonly found in estuarine embayments including Pacific littleneck (*Protothaca staminea*; 53.5 percent by weight), Washington clam (*Saxidomus nuttalli*; 20.4 percent), and gaper clam (*Tresus nuttalli*; 2.1 percent). Open rocky coast species were limited to California mussel (*Mytilus californianus*; 7.9 percent) and trace amounts of red abalone *(Haliotis rufescens).* The open sandy coast taxon, Pismo clam *(Tivela stultorum),* represented only 1.8 percent of the shell by weight. This predominately estuarine assemblage appears to reflect exploitation of a now-extinct paleo-estuary, situated in the vicinity of the town of Halcyon, 9 km south of Cross Creek (Figure 6). The representation of extinct estuaries in early Holocene archaeological shell assemblages is common in this region. Erlandson (1994) identified no fewer than five sites dating between 7600 and 6960 cal B.C. that reflect exploitation of extinct estuarine embayments (Figure 1). Low-lying wetland sediments and several small lakes in the vicinity of Halcyon have been suspected of marking such an environment for several decades (Dills 1981). Diaries written by the first Spanish explorers in 1769 clearly indicate the presence of an estuary *(estero)* in this locality historically (Teggart 1911). Prehistorically, this embayment was connected to the ocean via Pismo Creek, but during the historic period this outlet was blocked by dunes that created a predominately freshwater environment (Jones et al. 2001:10). Other archaeological sites around Halcyon have produced shellfish assemblages with radiocarbon dates that testify to the existence of protected embayment habitats (e.g., mudflats suitable for *Protothaca, Saxidomus,* and *Tresus*, and protected euryhaline settings with firm substrates suitable for oysters [*Ostrea conchaphila* formerly *O. lurida*]) (Table 5). CA-SLO-1764 (Lebow et al. 2001) and CA-SLO-832 (Jones et al. 2001), both situated in hills overlooking ancient Halcyon Bay, produced shell assemblages dominated by oysters and clams radiocarbon dated between 7960 and 6990 cal B.C. (Table 5, Figure 6). At the time Cross Creek was first occupied, the sea was about 25–40 m below its present level (Inman 1983), and Halcyon would have been the backwater of a system whose connection to the open

Table 5. Shell Radiocarbon Dates from Halcyon Bay.

Site	Lab Number	Unit & Depth (cm)	Material	Measured ^{14}C Age Years B.P.	$^{13}C/^{12}C$ Ratio ‰	Corrected $^{13}C/^{12}C$ Years B.P.	Calibrated Age Range Cal. Years[a]
CA-SLO-394	Beta-053105	Test pit; 0-15	*Tresus* sp.	2880 ± 70	-	3290 ± 70	B.C. 980 (800) 700
CA-SLO-404	Beta-044749	12	*Protothaca* sp.	3420 ± 70	-	3730 ± 70	B.C. 1520 (1370) 1150
CA-SLO-433	Beta-037383	Surface	*Polinices* sp.	4070 ± 90	-	4480 ± 90	B.C. 2560 (2310) 2020
CA-SLO-832	Beta-056969	-	*Macoma* sp.	6990 ± 100	-	7400 ± 100	B.C. 5780 (5580)5420
CA-SLO-832	UCR-1341	Auger M-1; 60-90	*Protothaca* sp.	6530 ± 130	-	6940 ± 130	B.C. 5430 (5210) 4890
CA-SLO-832	UCR-1342	Auger M-1; 130-150	*Macoma* sp.	8520 ± 140	-	8930 ± 140	B.C. 7570 (7310) 6980
CA-SLO-832	UCR-1343	Auger M-1; 190-230	*Protothaca* sp.	8140 ± 250	-	8550 ± 250	B.C. 7450 (6770) 6200
CA-SLO-832	Beta-146600	N10/W6; 100-110	*Saxidomus nuttalli*	7810 ± 130	-2.0	8190 ± 140	B.C. 6660 (6370) 6040
CA-SLO-832	Beta-146603	S32/W19; 170-180	*Saxidomus nuttalli*	7900 ± 80	-1.4	8290 ± 80	B.C. 6640 (6450) 6300
CA-SLO-832	Beta-146595	S27.5/W14; 80-90	*Clinocardium nuttalli*	8070 ± 90	-1.9	8450 ± 90	B.C. 6690 (6610) 6420
CA-SLO-832	Beta-146599	N8/W11; 130-140	*Tresus nuttalli*	8120 ± 80	+.7	8450 ± 80	B.C. 6980 (6610) 6430
CA-SLO-832	Beta-146594	N10/W6; 50-60	*Tresus nuttalli*	8310 ± 70	+.5	8730 ± 70	B.C. 7280 (7030) 6780
CA-SLO-832	Beta-146597	S32/W19; 140-150	*Tresus nuttalli*	8370 ± 70	-.2	8780 ± 70	B.C. 7360 (7080) 6940
CA-SLO-832	Beta-146598	N8/W11; 70-80	*Protohaca staminea*	8360 ± 70	+.6	8780 ± 70	B.C. 7360 (7080) 6940
CA-SLO-832	Beta-146601	S32/W19; 60-70	*Saxidomus nuttalli*	8400 ± 70	-.1	8810 ± 70	B.C. 7400 (5150) 6980
CA-SLO-832	Beta-141920	N10/W6; 70-80	*Saxidomus nuttalli*	8410 ± 70	+.4	8820 ± 70	B.C. 7400 (7200) 6990
CA-SLO-832	Beta-146602	S32/W19; 120-130	*Saxidomus nuttalli*	8490 ± 70	+2.4	8950 ± 70	B.C. 7490 (7360) 7090
CA-SLO-1420	Beta-146608	S9/E4; 100-110	*Saxidomus nuttalli*	8410 ± 60	+1.0	8840 ± 60	B.C. 7400 (7230) 7010
CA-SLO-1420	Beta-141922	S9/E4; 130-140	*Protohaca staminea*	9120 ± 170	+.6	9540 ± 180	B.C. 8370 (7960) 7530
CA-SLO-1420	Beta-141921	S9/E4; 60-70	*Macoma nasuta*	3120 ± 90	+.3	3540 ± 90	B.C. 1370 (1110) 840
CA-SLO-1420	Beta-146606	S28/E4; 140-150	*Macoma* spp.	3090 ± 70	-.8	3480 ± 70	B.C. 1250 (1010) 820
CA-SLO-1764	Beta-93199	-	*Saxidomus nuttalli*	8300 ± 60	+.4	8720 ± 60	B.C. 7260 (7030) 6860
CA-SLO-1764	Beta-93200	-	*Saxidomus nuttalli*	8240 ± 70	-.5	8650 ± 70	B.C. 7200 (6990) 6660
CA-SLO-1764	Beta-93201	-	*Saxidomus nuttalli*	8340 ± 60	+.5	8760 ± 60	B.C. 7290 (7050) 6940
CA-SLO-1764	Beta-94480	-	*Saxidomus nuttalli*	8420 ± 70	+.4	8830 ± 80	B.C. 7420 (7210) 6980
CA-SLO-1764	Beta-94481	-	*Saxidomus nuttalli*	8260 ± 190	+.1	8670 ± 200	B.C. 7470 (7000) 6430

[a]Calibrated with CALIB 3.0.3 (Stuiver and Reimer 1993). Rounded calendar ages include midpoint (in parentheses) and age range at two sigma. Sources: Fitzgerald (1998:11-3), Jones et al. (2001), Lebow et al. (2001).

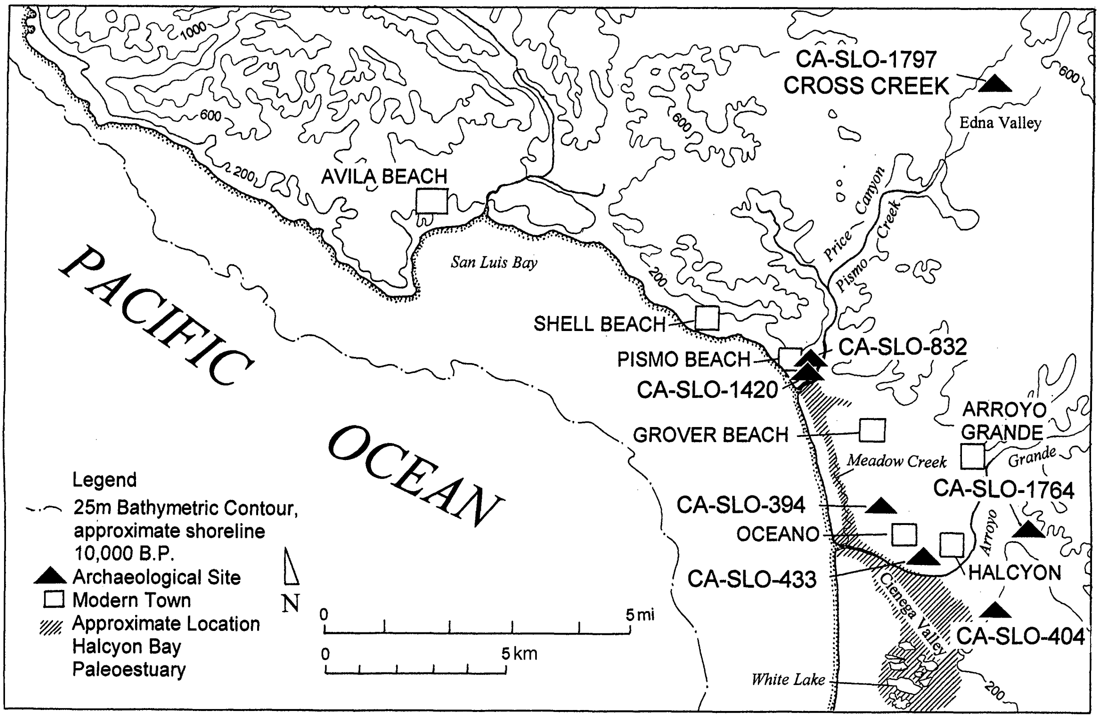

Figure 6. Approximate location of paleo-estuary, Halcyon Bay.

ocean was approximately 3–5 km west of the current shoreline. Dunes that front the shoreline today are probably remnants of a former sand spit that sheltered the embayment from the open ocean.

Although shellfish were important to the inhabitants of Cross Creek, the inland site location and assemblage of well-formed milling tools indicates that vegetal resources were of equal if not greater significance to the diet. Flotation analysis of samples from strata 3 and 4 revealed charred seeds of seven edible taxa (bentgrass [*Agrostis* sp.], fescue [*Vulpia* sp.], ryegrass [*Elymus* sp.], needlegrass [*Stipa* sp.], plantain [*Plantago* sp.], verbena [*Verbena* sp.], and farewell-to-spring [*Clarkia* sp.]), along with fragments of yucca (*Yucca* sp.) heart. Yucca processing has long been linked with the types of chopping and scraping tools common at Cross Creek and other Milling Stone sites (Kowta 1969). The archaeobotanical remains also included charcoal from yucca, pine (*Pinus* sp.), manzanita (*Arctostaphylos* sp.), and live oak (*Quercus wislizenii* or *agrifolia*), which are not found in the immediate vicinity of the site today, suggesting possible changes in local vegetation. Differences in the proportions of various charcoal types across strata further suggest that the site retained stratigraphic integrity (Miksicek 2000).

Flaked Stone Technology

A total of 411 pieces of debitage from two excavation units processed with 3-mm (⅛") mesh was analyzed to determine the stone-reduction technology associated with the site's earliest occupation. Flakes were classified into nine morphological categories: early and late biface percussion, bipolar, early and late core percussion, early and late pressure, thermal (potlids), and undetermined percussion. Four raw materials were identified: Monterey and Franciscan cherts distinguished by different colors and derived from discrete geological formations for which they are named, and quartzite and basalt. Specific sources were not identified for any of the stone, due to the incompleteness of local survey data, but the Monterey Formation that accounted for most of the debitage (97.1 percent) occurs within 2 km of Cross Creek. Undifferentiated percussion flakes dominated the collection (39.4 percent). The remaining debitage was evenly divided between early (11.7 percent) and late biface percussion (14.6 percent), and

Table 6. Summary of Debitage from CA-SLO-1797 (3-mm Mesh Recovery).

Flake Type	Cryptocrystal-line Silicate	Franciscan Chert	Monterey Chert	Quartzite	Total
Biface percussion early	0	3	45	0	48
Biface percussion late	0	3	57	0	60
Bipolar	0	0	1	0	1
Core percussion early	1	0	12	0	13
Core percussion late	1	1	53	1	56
Undetermined percussion	0	1	161	0	162
Pressure early	0	0	13	0	13
Pressure late	0	1	37	0	38
Thermal (potlid)	0	0	20	0	20
Total	2	9	399	1	411

late core percussion (13.6 percent) (Table 6). Pressure flakes were the next most abundant class with 3.2 percent early and 9.2 percent late. The flake-distribution profile suggests an emphasis on late-stage percussion core and biface reduction activities and late-stage pressure flaking, from which it can be inferred that flake blanks were used for production of bifacial tools, and that bifacial tools were sharpened and rejuvenated through pressure flaking. The assemblage is consistent with a location where locally available raw materials, procured from quarries and secondary sources and partially reduced, were used for the production of flake blanks, expedient flake tools, and bifacial tools. It showed no resemblance with classic Paleoindian technology in that evidence for production of large bifaces was absent.

Seasonality and Mobility

Although no domestic features (floors, postholes, etc.) were identified at Cross Creek, the array of implements represented—milling equipment, core tools, flake tools, bifaces—suggests a diversity of tasks consistent with an entire social group living at one location for an extended portion of the year. Evidence for the manufacture of both flaked and ground stone tools supports this notion as well. Shellfish fragments indicate that site inhabitants foraged over a fairly broad area since wetlands marking the former Halcyon Bay are separated from the site by a distance of no less than 9 km across low hills. Charred seeds recovered from stratum 3 indicate that, at a minimum, the site was occupied during the spring and early summer (Miksicek 2000).

To explore the season of site occupation further, an oxygen-isotope seasonality study was conducted on *Saxidomus nuttalli* shells from undisturbed portions of stratum 3. Oxygen-isotopic analysis of molluscan shell carbonate is a well-established technique for reconstructing changes in water salinity and sea surface temperature and the season of prehistoric shellfish harvesting (Kennett and Voorhies 1996; Shackleton 1969). The ratio of ^{18}O to ^{16}O in calcareous fossils, such as mollusks, is dependent upon water temperature and salinity (Epstein et al. 1951, 1953; Kennett and Voorhies 1996; Wefer and Berger 1991). Incremental samples taken along the shell's growth axis enable reconstruction of oxygen isotopic ratios, and hence, seasonal temperature or salinity changes through the life of a mollusk. A total of 105 isotopic measurements was made: 86 from 22 archaeological specimens from stratum 3, and 19 from two modern shells collected from Morro Bay, a present-day estuary 27 km northwest of CA-SLO-1797. Sixteen samples were taken incrementally from the growth axis of one archaeological specimen to determine the seasonal range of inferred sea surface temperature. Carbonate samples were extracted and processed using methods described elsewhere (Glassow et al. 1994; Kennett and Voorhies 1995, 1996).

Based on comparison with readings obtained from the modern specimens collected from Morro Bay (Figure 7a), the incremental growth of *S. nuttalli* shells accurately records seasonal changes in sea surface temperature. Salinity fluctuations in Morro Bay appear to contribute less to the oxygen-isotopic signal. Compared to the modern sample, the archaeological specimen incrementally sampled showed a similar oxygen-isotopic range (Figure 7b), but an overall positive shift likely reflects differences in the isotopic composition of the ocean prior to the stabi-

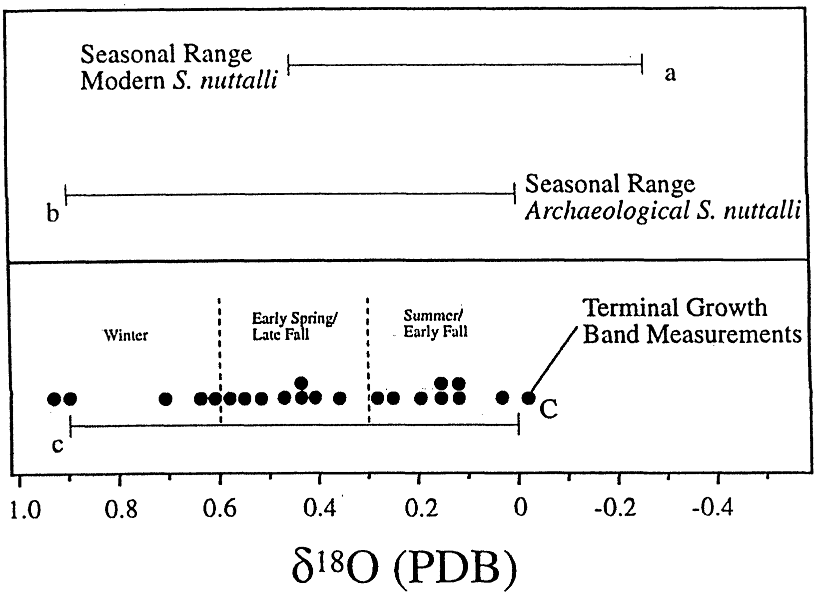

Figure 7. Oxygen isotopic measurements of shell margin samples from Cross Creek (*n* = 22) plotted against the full isotopic range determined from the modern and archaeological studies (one dot represents each shell margin).

lization of sea level approximately 6,000 years ago (Fairbanks 1989). Conversion of the oxygen-isotope readings directly into temperature values is not possible because the oxygen-isotopic composition of ocean waters during the terminal Pleistocene/Holocene was not the same as today. However, the inferred sea surface temperature range for the terminal growth band measurements of the archaeological specimens suggests that most of the shellfish analyzed were collected during the early spring/late fall and summer/early fall months (Figure 7c). A few specimens also appear to have been collected and transported to the site during the winter months when inferred sea surface temperatures were cooler. Because sea surface temperatures in the early spring and late fall are the same, shellfish collected during these different seasons cannot be distinguished from one another. Based on macrobotanical evidence, the most conservative interpretation of the findings is that shellfish were harvested and transported to the site during the spring rather than the late fall. Evidence for shellfish collection during winter months, however, suggests the site may have served as a residential base for a substantial amount of time annually, an observation that is consistent with insights provided by the artifact assemblage. Occupations nearly contemporaneous with Cross Creek at CA-SBA-931 (Glassow 1991, 1996) and CA-SLO-2 (Greenwood 1972) occur on the immediate coastline (Figure 1), and it is possible that terminal Pleistocene/early Holocene foragers in this region divided their time between coastal settings and pericoastal valleys. Nonetheless, the extended occupation represented at Cross Creek suggests relatively low mobility that is antithetical to many conceptualizations of terminal Pleistocene/early Holocene foraging. Most researchers suspect that the earliest hunter-gatherers in western North America were highly mobile (e.g., Beaton 1991; Glassow 1997; Jones 1991; Kelly and Todd 1988).

Summary and Discussion

Cross Creek is the only mainland shell midden from the west coast of North America to yield terminal Pleistocene/early Holocene dates in association with a sizable assemblage of formal artifacts. Several sites, including nearby Diablo Canyon, have produced single radiocarbon dates as old or slightly older, but no other mainland shell midden has produced suites of dates and artifacts as extensive or old as Cross Creek. The site is marked by a stratigraphically discrete midden that produced a typologically homogeneous assemblage of handstones, milling slabs, crude core tools, hammerstones, and flake scrapers. This collection is typical of California's Milling Stone culture, but the Cross Creek radiocarbon results appear to extend the antiquity of Milling Stone back to the terminal Pleistocene. The assemblage of well-made ground stone tools and crude flaked stone implements exhibits no stylistic or technological similarities with the sophisticated fluted-point technologies associated with big-game hunting and Paleoindian colonization of interior North America. If there was a separate Paleo-Coastal culture along the northern Pacific coast, distinct from Paleoindian as suggested by Moratto (1984), Meighan (1989), and others, findings from Cross Creek suggest that its southern manifestation may be marked by a variant of the distinctive Milling Stone tool kit. On a broad scale, true Milling Stone sites also show a coastal or pericoastal distribution pattern, as the culture is known only from within 150 km of the shoreline and is clearly absent from the interior deserts and mountain ranges (Erlandson 1994; Fitzgerald and Jones 1999).

The preponderance of cobble-based choppers and scrapers in the Cross Creek assemblage clearly suggests ties with the Pebble Tool Tradition of the Northwest that is thought to reflect a very early coastal occupation by people who eventually expanded their settlements inland along major rivers (Carlson 1990, 1996). A recently reported component on the southern Oregon coast (the Indian Sands site) produced a typical Pebble Tool Tradition assemblage of crude cobble tools, some showing incipient grinding (Moss and Erlandson 1998). Dating to 8600 cal B.C., this component narrows the spatial gap between the Pebble Tool Tradition and the California Milling Stone culture in northern California (see Fitzgerald and Jones 1999). Meighan (1989) suggested that the early coastal adaptation of western North America may have had its ultimate origin in the late Pleistocene littoral cultures of northeast Asia, but others (e.g., Yesner 1996:249) have argued that the persistence of ice barriers along the coast of extreme northwestern North America prohibited such a movement. Recent findings of glacial geology and paleo-sea levels, however, suggest that an ice-free coastal corridor into North America was open by 14,000 years ago (Dixon 2001; Mandryk et al. 2001).

It remains possible that the early coastal inhabitants of Cross Creek and Daisy Cave represent an outgrowth from Clovis hunting people who first colonized the interior, and then migrated coastward and developed a littoral adaptation. Fluted projectile points have been found in abundance in the Tulare Lake area of interior California, east of the south central California coast (Hopkins 1991; West et al. 1991), and one specimen is known from the Santa Barbara area (Erlandson et al. 1987). None of these has been directly dated, nor have any been unequivocally associated with the remains of extinct megafauna. The findings from Cross Creek and Daisy Cave, however, add technological, economic, and typological dimensions to the terminal Pleistocene coastal adaptation that are difficult to reconcile as simple adaptive outgrowths from an ancestral hunting culture. Shell and charcoal dates from Daisy Cave indicate that foraging populations were using boats, collecting shellfish, and fishing as early as 11,700 years ago. At Cross Creek, charred seed and shellfish remains and abundant milling tools (outnumbering projectile points by a ratio of 6:1) testify to a nearly sedentary economy focused heavily on gathering, not hunting. Such a lifeway is the antithesis of the late Pleistocene, fluted-point adaptation. The stone-tool technology manifest at Cross Creek, emphasizing crude core and flake tools, also contrasts markedly with the advanced biface-oriented technology of Clovis.

Until now, most explanations for an early Holocene gathering focus in southern coastal California have envisioned the Milling Stone culture as a logical adaptive outgrowth from late Pleistocene hunting (e.g., Chartkoff and Chartkoff 1984), but the Cross Creek and Daisy Cave findings seem to reflect something other than simple adaptation by incoming hunting populations to the habitat parameters of coastal California. The Milling Stone culture as represented at Cross Creek and dozens of other later southern and central California sites (see Erlandson 1994; Fitzgerald and Jones 1999; Glassow 1996) effectively represents a gathering specialization that might be more logically derived from a broad-based foraging adaptation rather than highly specialized hunting. Early Channel Islands sites appear to be consistent with this gathering focus despite some limited evidence for fishing and sea mammal hunting (Rick et al. 2001). Large and medium-sized game animals (tule elk and deer) were almost certainly present along the central California coast at the end of the Pleistocene, since their remains are abundant in later deposits, and they are known from archaeological sites dating ca. 7000–6000 cal B.C. north and south of CA-SLO-1797. The broadening of diet that would be associated with adjustment to new environments would certainly show retention of hunting and use of hunted foods. The variation from a linear trajectory of adjustment reflected at Cross Creek suggests a coastal gathering adaptation distinct from interior big-game hunters. Such a tradition may reflect a separate coastal migration into western North America marked also by the Pebble Tool tradition of the Northwest Coast.

None of the alternative models can be refuted on the basis of the data currently available from Cross Creek, Daisy Cave, or other early California coastal sites, but the age, tool assemblage, and lifeway identified at Cross Creek and the evidence for early maritime adaptation represented on the California Channel Islands demonstrate marked variability in adaptive poses in North America at the end of the Pleistocene. While the California Milling Stone culture has long been regarded as relevant only to the regional prehistory of southern California, its greater antiquity as defined at Cross Creek and the coastal gathering specialization that it represents should be kept in mind in the development of alternative models for New World colonization.

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Notes

1. A single radiocarbon date from the base of CA-SLO-2 of 9320 ± 140 (UCLA-1686A) (Greenwood 1972:86), when corrected for isotope fractionation and calibrated, produces a calendric date of 8420 cal B.C. (2-sigma range 9020–8040 cal B.C.), which is slightly older than the oldest calibrated date from Cross Creek. Because the date was obtained from a sample of human bone at a time when collagen extraction techniques were unreliable, there is some uncertainty about its precision.

2. The Cross Creek collection was permanently curated at the Santa Barbara Museum of Natural History, Santa Barbara.

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