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A Refined Shell Bead Chronology for Late Holocene Central California

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In central California, a sequence of late Holocene cultural phases has long been recognized through the seriation of different shell-bead types. Calendrical dating of this sequence has, however, been in doubt. Based on the direct accelerator mass spectrometry (AMS) dating of 140 stylistically distinct Olivella *shell beads, we present a refined late Holocene cultural chronology for central California that replaces Bennyhoff and Hughes' (1987) Scheme B. This study uses an empirically-derived ΔR value of 260±35 to calibrate marine shell dates, revealing a series of short 125- to 620-year-long shell-bead style horizons from cal A.D. 200 through approximately cal A.D. 1835, following a 1,500-year-long period where little change in shell-bead styles is apparent. The new chronology supports long-recognized shifts in hunter-gatherer culture, and identifies an unexpected delay in the acceptance of bow and arrow technology in lowland central California until cal A.D. 1020–1265.*

Beginning in the middle Holocene (ca. 3,500 cal B.C.), stylistically distinct beads made from the shell wall of purple olive snail (*Olivella biplicata*) became one of the most common burial accompaniments in prehistoric central California, and they were widely traded, reaching as far east as the central Great Basin (e.g., Bennyhoff and Heizer 1958; Bennyhoff and Hughes 1983, 1987; Hughes and Bennyhoff 1986; Vellanoweth 2001). Over millennia, the number and type of *Olivella* shell beads placed in central California graves varied greatly, and specific combinations of bead types (i.e., *shell-bead style horizons*[1]) have proven to be particularly good indicators of different time periods and cultural phases (Bennyhoff and Hughes 1987).

Because *Olivella* beads from the Pacific coast of California are found as far inland as eastern Nevada, Utah, and New Mexico, they have traditionally been important for cross-dating regional site components across much of far western North America (e.g., Bennyhoff and Heizer 1958; Bennyhoff and Hughes 1987; Hughes and Bennyhoff 1986). However, calendrical dating of shell beads from late Holocene central California has been imprecise, despite over one hundred years of formal archaeological study and fifty years of site-by-site radiocarbon dating (Groza 2002). Moreover, the presumed ages of different combinations of shell beads in central California (Bennyhoff and Heizer 1958; Bennyhoff and Hughes 1987; Elsasser 1978; Milliken and Bennyhoff 1993) do not conform to the accepted timing of equivalent shell-bead style horizons in the Santa Barbara Channel area, just 250 kilometers to the south (cf., King 1990). This is especially troubling, as many of the shell bead types found in central California are thought to have originally been manufactured in the Santa Barbara Channel region (Arnold 1987; Arnold and Graesch 2001; Bennyhoff and Hughes 1987; Eerkens et al. 2005; Hughes and Milliken 2007; King 1990; Vellanoweth 2001).

Lacking well-founded evidence for the age of shell-bead style horizons in central California, archaeologists have been constrained in their efforts to understand the precise timing of cultural changes and the processes responsible for these transformations. Further, without proper chronological control, inter-regional cross-dating using shell beads will ultimately prove unreliable. To remedy this situation, we have constructed a chronology for central California based on direct AMS dating of 140 *Olivella* beads, derived primarily from discrete mortuary features. The new chronology incorporates 299 observations on the ages of different shell-bead types and recognizes various combinations of *Olivella* shell-bead styles as diagnostic of at least 10 separate shell-bead style horizons in central California after 1,750 cal B.C.

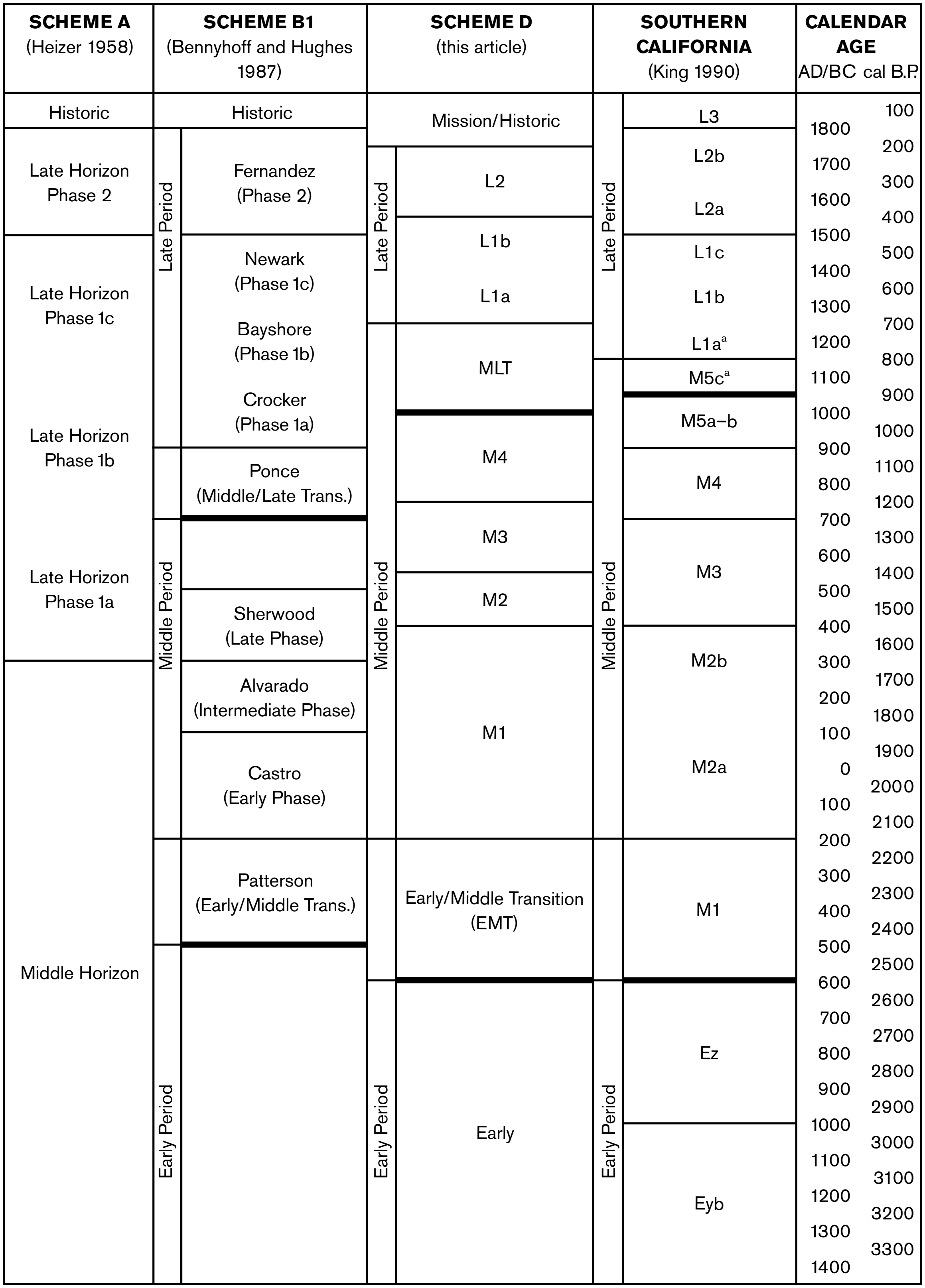
ALTERNATIVE DATING SCHEMES IN CENTRAL CALIFORNIA

In the 1930s, Lillard, Heizer, and Fenenga (1939) identified artifact types that marked a succession of prehistoric "cultural horizons" in central California's lower Sacramento Valley—the Early, Middle, and Late horizons. In that same publication, Lillard, Heizer, and Fenenga (1939:12) developed the first formal typology for California shell beads. Beardsley (1948, 1954:11) later demonstrated basic similarities between artifact types found in the San Francisco Bay area and the lower Sacramento Valley, extending the three-horizon sequence across a large portion of central California. He also modified Lillard et al.'s *Olivella* bead typology, distinguishing 14 time-diagnostic types. Although these researchers were among the first to recognize differences in artifact styles and other traits as evidence for cultural changes in central California, they did not speculate on the actual dates of those changes.

It was not until the late 1940s that Robert Heizer (1949; Cook and Heizer 1947:218) constructed the first timeline of culture change in central California, based on inferred deposition rates in shell mounds around San Francisco Bay. Just prior to the widespread use of radiocarbon dating, Heizer (1949:39) predicted that the beginning of the Middle Horizon would fall at 1,500 B.C. and the beginning of the Late Horizon at A.D. 500. Between 1950 and 1957, Heizer sent charcoal and calcined human bone from this region to various newly-founded radiocarbon labs. Based on 17 resultant dates, Heizer (1958) argued for the general confirmation of the Early-Middle-Late period chronology he had published in 1949. Bennyhoff and Hughes (1987:147) later labeled Heizer's chronology Dating Scheme A, now considered the "long" chronology (Fig. 1).

During the 1960s and 1970s, James A. Bennyhoff refined the central California shell bead typology and conducted detailed seriations of grave lots in the San Francisco Bay and lower Sacramento Valley-Delta regions. Changes over time in *Olivella* bead types that accompanied burials allowed Bennyhoff to discern a series of successive phases and sub-phases within the stratigraphically-complex mound sites from these areas. By the mid-1970s, Bennyhoff had developed an alternative "short" chronology, termed Scheme B, based on 180 radiocarbon dates derived primarily from terrestrial charcoal, but including dates on bone collagen and—rarely—marine shell. Scheme B distinguished twelve phases and sub-phases associated with the Early, Middle, and Late periods of the Late Holocene, some only 200 to 300 years in duration (Fig. 1). This scheme further refined major period breaks, and indicated that the Early Period lasted until 500 B.C., the Middle/Late Period Transition began at A.D. 700, and the Late Period did not begin until A.D. 900. Bennyhoff's final *Olivella* bead typology and Dating Scheme B were eventually published in 1987 (Bennyhoff and Hughes 1987).[2]

Although Dating Scheme B has been widely accepted and employed throughout central California and the Great Basin, several problems exist with this chronology. Most significantly, the majority of radiocarbon dates used by Bennyhoff lacked a clear association with the shell-bead lots he was attempting to place in time. Instead, most of these dates were derived from charcoal samples, either recovered near mortuary features or within associated depositional strata, but not clearly related to the burial event. This created a great deal of uncertainty in the timing of important phase shifts, and led Bennyhoff to reject a number of dates he thought were either too early or too late to be associated with a particular cultural phase (Groza 2002). Further, none of the radiocarbon dates used by Bennyhoff to construct Scheme B was ever subjected to $\delta^{13}C$ correction or calibrated. Additional discrepancies also existed between bone collagen dates used by Bennyhoff



Note: [a]Southern California M5c and L1a *Olivella* beads are comparable to those of Northern California's Middle/Late Transition.

Figure 1. Comparison of Alternate Dating Schemes

and dates from the same bone obtained decades later (see Bouey 1995). Our investigation was designed to clarify these ambiguities.

METHODS

The current study examines the age of *Olivella* shell beads recovered from 36 archaeological sites in the wider San Francisco Bay region of central California (Fig. 2). Bead classes and types were identified based on the Bennyhoff and Hughes (1987) *Olivella* shell-bead typology, as well as revisions to the Class F Saddle-bead typology described in the recently published *Olivella* shell-bead guide developed by Milliken and Schwitalla (2009). Study results were derived from more than 37 different *Olivella* bead types and sub-types, ranging in age from the Early Period of the late Holocene to the historical Early Mission Period. Included are 120 AMS dates obtained from individual *Olivella* beads, sampled as part of the current study by the Center for Accelerator Mass Spectrometry (CAMS) at Lawrence Livermore National Laboratory (Groza 2002; Ruby 2007), as well as 20 dates from beads sampled by Beta Analytic, Inc. for several recent cultural resource mitigation projects (Milliken 2008; Thompson 2002; Thompson et al. 2003; Wiberg 2005). Also included are five standard radiometric dates obtained on multiple beads of the same type recovered from burials at SCL-690 (Hylkema 2007). Many of the directly-dated beads originated from discrete grave lots that also contained other bead styles. Because of these direct associations, our study includes an additional 154 observations on the ages of different bead types in circulation at the time of burial. This co-association elevates the total number of dated bead types to nearly 300, forming a substantial basis for the revised chronology presented below.

Factors Guiding Bead Sample Choice

The 120 *Olivella* beads sampled at CAMS were carefully chosen to include a broad range of important central California types thought by Bennyhoff to be the most temporally diagnostic (see Bennyhoff and Hughes 1987). The majority of beads were selected from discrete burial contexts that also contained other time-sensitive artifact types or additional bead styles, or had previously been radiocarbon-dated by other means. Only a small number of the dated beads originated as unassociated midden finds. *Olivella* beads were obtained from six central California academic institutions and from private consulting companies. Beads sampled by Beta Analytic, Inc. were chosen to date specific contexts for the purposes of individual site investigations.

Sample Pretreatment and AMS Procedure

Each bead analyzed by CAMS was pretreated with hydrochloric acid and rinsed with deionized water to remove surface contaminants. The remaining shell material was dried, weighed, and converted to CO^2 by reaction with phosphoric acid. Samples were then reduced to graphite and subjected to AMS analysis (Taylor 1997:78–91). Beta Analytic, Inc.'s (2010) pretreatment and AMS procedures are very similar to CAMS.

The resultant dates (^{14}C ages) were determined following the conventions of Stuiver and Polach (1977). Based on two samples from the first suite of ten beads tested at CAMS, a value of 1.0 for $\delta^{13}C$ was applied to generate the conventional dates. CAMS ran $\delta^{13}C$ ratios for five samples; measurements ranged from 0.9 to 1.7, resulting in an average of 1.4 $\pm$0.4. Beta Analytic tested $\delta^{13}C$ for each sample; their results averaged 0.7$\pm$0.5. Therefore, an assumed ratio of 1. 0 appears adequate for all samples.

Calibrating Local Marine Carbon Reservoir Effect

The current study employs Marine04 (Hughen et al. 2004) with CALIB 5.0.2 to calibrate all of the resultant dates (Stuiver and Reimer 1993; Stuiver et al. 2005). Groza (2002) originally calibrated the first 104 CAMS dates with CALIB 4.4 using a ΔR of 225$\pm$35 (see Stuiver and Reimer 1993). A comparative value of 290$\pm$35 was also applied, after Ingram and Southon (1996). However, the ΔR of 290 produced dates much more modern than expected (Groza 2002:105) given the known manufacturing date for Needle-drilled *Olivella* disk beads, Class H. These beads were made by the Chumash of the Santa Barbara Channel region between cal A.D. 1770 and 1816 (Bennyhoff and Hughes 1987:135) and are the most recent type in the *Olivella* sequence. The application of a ΔR of 225$\pm$35 (Groza 2002) generated dates for Needle-drilled beads that were almost 100 years too old. The current study employs a ΔR of 260$\pm$35,

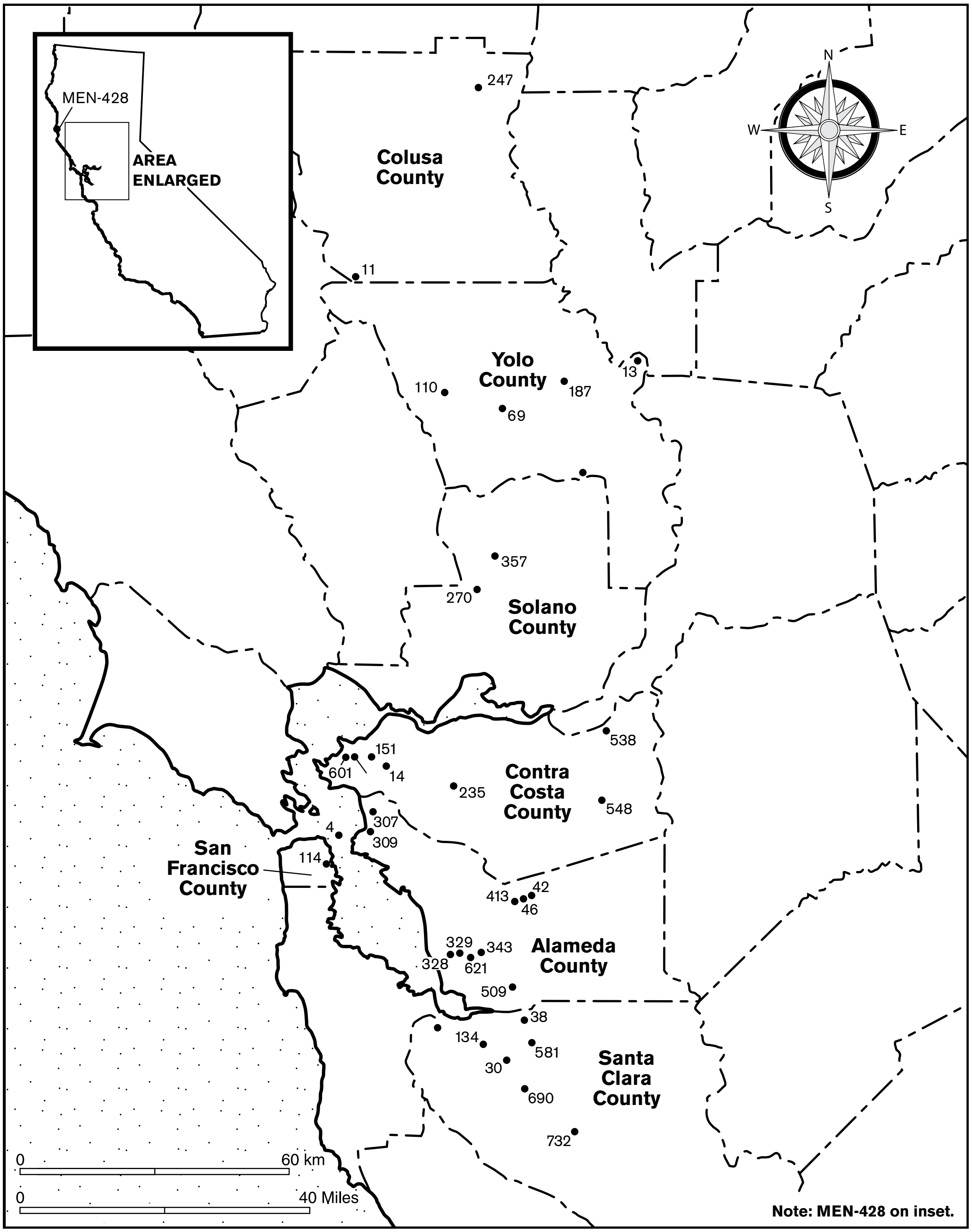


Figure 2. Location of Central California Sites Where Dated *Olivella* Beads Were Recovered

which reconciles the calibrated AMS date and the known age of Needle-drilled disk beads.

RESULTS: DATING SCHEME D SHELL-BEAD STYLE HORIZONS

A new chronology based on the calibrated AMS results from 140 individual *Olivella* beads and standard radiometric dates from five mass bead-lots is shown as Dating Scheme D in Figure 1 and detailed in Tables 1 through 4.[3] Also enumerated in Tables 1 through 4 are all associated beads and bead types, as well as all other artifacts from each dated context. Because individual grave lots often included more than a single bead style, the age of the dated bead could be applied to all associated bead types from that lot. This provided 299 observations on the temporal duration of use. As many as 50 dates are associated with some bead types (e.g., Type F3a, Square Saddles; Table 5), whereas others are associated with as few as five dates (e.g., Type K, Callus; Table 5).

As indicated in Figure 3, most bead types provide a very tight and continuous cluster of dates marking their main period(s) of use. However, some notable deviations occur. For example, a single Type E Lipped bead is associated with a date of cal A.D. 1273 from Burial 127 at ALA-329, about 300 years earlier than all other Lipped beads. In this context, the single Lipped bead was associated with an otherwise pure lot of 456 M2 Pendants. The radiocarbon date originated from one of these latter beads. It appears the odd Lipped bead is intrusive in this context, as 18 other burial lots dating between cal A.D. 1265 and cal A.D. 1520 contained no Lipped beads. Likewise, three Saddle bead variants (i.e., F3a, F2cd, and F2b), all from the same burial lot (i.e., Burial 2, SOL-270), are associated with a date of 83 cal B.C. This is about 530 years older than the next oldest date associated with this same bead type. In this instance, the actual specimen dated from the bead lot was a Type C3 Split Oval bead, which appears to have a much earlier period of manufacture than the Saddles, a fact borne out by numerous other dates from both bead classes. We interpret the dated specimen as a possible heirloom, included in a much younger bead lot; however, it could have been introduced into the burial matrix by rodent burrowing or redeposited with the original burial fill. The combination of types in this particular burial assemblage would otherwise place it in Horizon 2 of the Middle Period, dating between cal A.D. 420 and 585 (Fig. 3).

Despite these few problems, the combined results indicate that certain bead styles were used for as little as 65 to 200 years (Class H Needle-drilled and Class E Lipped), while others were used for as long as 800 to 850 years (Type G Saucers and Type F3a Narrow Saddles [previously known as Square Saddles]). As indicated in Figure 3, the current data set reveals unique combinations of bead types in circulation over comparatively short time-spans in central California, providing temporal resolution on the order of 120 to 260 years for phases dating after cal A.D. 420 (Fig. 1). The current results also indicate that Horizon 1 of the Middle Period (200 cal B.C.–cal A.D. 420) lasted for more than 600 years, while the Early/Middle Period Transition could have been as short as 300 years (500–200 cal B.C.) or as long as 680 years (i.e., 880–199 cal B.C.). The timing of the Early Period continues to be the least understood, but it lasted a minimum of 865 years (i.e., 880–1,746 cal B.C.). The overall duration of these horizons seems to indicate that the pace of cultural change—at least as it relates to new shell-bead types—increased substantially after cal A.D. 420 in central California (see also White 2003).

Our data generally confirm the sequence of shell-bead types reported by Bennyhoff and Hughes (1987), but some significant differences in the ages of shell-bead style horizons and their associated cultural phases are apparent, including some shifting of the Middle Period phase order. Below we interpret these results, including discussions of bead-type assemblages, the sites from which they were derived, other insights, and continuing problems with the exact timing of period shifts. For current purposes, we continue to refer to each period as bead style-horizons, rather than cultural phases, as we did not consistently evaluate the changes in other artifact styles that are inherent in Bennyhoff's phase definitions (e.g., Elsasser 1978).

Early Period Bead Horizon: Possibly 2,100–600 cal B.C.

The anticipated results for Early Period Thick Rectangle beads based on Scheme B (Bennyhoff and Hughes 1987:149) are 3,000–500 cal B.C. Our four earliest dates, 1,746–1,591 cal B.C. (Table 4), derive from midden

Table 1

RADIOCARBON DATES ON TIME-SENSITIVE *OLIVELLA* SHELL BEADS FROM THE HISTORIC/MISSION PERIOD THROUGH LATE PERIOD BEAD HORIZON 1A

Lab Number	Site (CA-)[a]	Feature[b]	Dated Bead	$\delta^{13}C$[c]	^{14}C Age	CALIB 5.0.2[d] Median	CALIB 5.0.2[d] 2-sigma Range	Count of *Olivella* Bead Types Associated with Dated Bead: H	E	K	M2	M1	D	C7	C2/3	G1	F3b	F3a	F4	Other Time-sensitive Artifacts
Historic/Mission Period Bead Horizon (A.D. 1770–1835)																				
B-177327	YOL-069	B. 06	G1	0.7	750±40	A.D. 1836	A.D. 1712–1949	49	–	–	–	–	–	–	–	1	–	–	–	CSDB (830); *H.* beads (45)
C-78745	SCL-030	Pit	H1b	1*	780±40	A.D. 1803	A.D. 1693–1910	1	–	–	–	–	–	–	–	–	–	–	–	–
C-79487	SCL-030	Pit	H1b	1*	790±40	A.D. 1792	A.D. 1684–1908	1	–	–	–	–	–	–	–	–	–	–	–	–
B-179712	YOL-069	B. 03	H2	1.4	790±40	A.D. 1792	A.D. 1684–1908	74	–	–	–	–	–	–	–	–	–	–	–	CSDB (12)
B-177337	YOL-069	B. 84	H1b	0.5	800±40	A.D. 1783	A.D. 1674–1905	2676	–	–	–	–	–	–	–	–	–	–	–	CSDB (44); *H.* beads (9)
B-177331	YOL-069	B. 16	H1a	0.8	810±40	A.D. 1774	A.D. 1665–1904	56	–	–	–	–	–	–	–	–	–	–	–	CSDB (653); magnste bds (58)
Late Period, Bead Horizon 2 (A.D. 1520–1770)																				
C-80287	ALA-329	B. 24	E2a2	1*	815±30	A.D. 1766	A.D. 1664–1897	–	555	–	–	–	–	–	–	–	–	–	–	–
B-191548	YOL-197	Midden	E2a3	0.9	840±40	A.D. 1745	A.D. 1628–1900	–	1	–	–	–	–	–	–	–	–	–	–	–
C-80288	ALA-329	B. 37	E1b1	1*	850±30	A.D. 1729	A.D. 1624–1883	–	5	–	–	–	–	–	–	–	–	–	–	–
C-79710	ALA-509	Feat. 2	E1b1	1*	870±30	A.D. 1698	A.D. 1565–1833	–	12	–	–	–	–	–	–	–	–	–	–	Human/dog co-cremation
C-82182	COL-011	Pit	E3a	1*	870±30	A.D. 1698	A.D. 1565–1833	–	1	–	–	–	–	–	–	–	–	–	–	–
C-80299	ALA-329	B. S-123	E1b1	1*	920±30	A.D. 1639	A.D. 1515–1725	–	?	–	–	–	–	–	–	–	–	–	–	(notes unavailable)
C-80907	ALA-329	B. 45	E3b1	1*	955±30	A.D. 1604	A.D. 1506–1688	–	99	–	–	–	–	–	–	–	–	–	–	–
B-191545	YOL-197	Midden	E3a	0.8	1000±30	A.D. 1570	A.D. 1479–1662	–	1	–	–	–	–	–	–	–	–	–	–	–
Late Period, Bead Horizon 1b (A.D. 1390–1520)																				
C-80286	ALA-329	B. 78	M2a	1*	1090±30	A.D. 1488	A.D. 1418–1594	–	–	–	58	380	–	–	–	–	–	–	–	*H.* square ornaments
C-80302	CCO-235	B. 19	K1	1*	1095±30	A.D. 1484	A.D. 1413–1591	–	–	36	–	–	–	–	–	–	–	–	–	*H.* effigy ornaments
C-80293	CCO-235	B. 22/39	K1	1.7	1145±30	A.D. 1449	A.D. 1380–1522	–	–	9	–	–	–	–	–	–	–	–	–	–
C-80303	CCO-235	B. 35/36	K1	1*	1150±40	A.D. 1445	A.D. 1338–1524	–	–	68	–	9	–	–	–	–	–	–	–	–
C-79703	YOL-187	B. 02	M2a	1*	1160±30	A.D. 1438	A.D. 1341–1504	–	–	–	60	3	–	–	–	–	–	–	–	Serrate arrow point
C-80906	ALA-329	B. 023	M2a	1*	1160±30	A.D. 1438	A.D. 1341–1504	–	–	–	76	–	–	–	–	–	–	–	–	Serrate arrow point
C-79711	ALA-329	B. 126	K1	1*	1180±30	A.D. 1424	A.D. 1331–1486	–	–	78	–	–	–	–	–	–	–	–	–	–
C-79486	YOL-187	B. 02	M2a	1*	1200±80	A.D. 1405	A.D. 1270–1548	–	–	–	60	3	–	–	–	–	–	–	–	Serrate arrow point
C-80904	CCO-235	B. 24/25	K1	1*	1205±35	A.D. 1403	A.D. 1317–1471	–	–	7	–	–	–	–	–	–	–	–	–	–
Late Period, Bead Horizon 1a (A.D.1265–1390)																				
C-80903	SCL-038	B. 51	M2a	1*	1225±40	A.D. 1388	A.D. 1306–1461	–	–	–	1042	–	–	–	–	–	–	–	–	*H.* effigy ornaments
B-044244	SCL-690[e]	B. 24	A1	1*	1250±60	A.D. 1372	A.D. 1300–1441	–	–	–	–	282	1	–	–	200	–	–	–	Wide rectangle *H.* pendant
C-80285	ALA-329	B. 49	M1a	1*	1255±30	A.D. 1370	A.D. 1300–1441	–	–	–	45	509	–	–	–	–	–	–	–	*H.* effigy ornaments
C-80682	CCO-235	B. 21	M1a	1*	1270±45	A.D. 1361	A.D. 1281–1446	–	–	–	–	2151	–	–	–	–	–	–	–	*H.* effigy ornaments
C-80905	ALA-329	B. 79	M2a	1*	1330±30	A.D. 1316	A.D. 1239–1408	–	–	–	50	276	–	–	–	–	–	–	–	*H.* effigy ornaments
C-79482	ALA-329	B. 226	M1a	1*	1380±40	A.D. 1274	A.D. 1174–1387	–	–	–	–	1880	–	–	–	–	–	–	–	Serrate arrow point
C-79479	ALA-329	B. 127	M2a	1*	1380±50	A.D. 1273	A.D. 1159–1400	–	1	–	456	–	–	–	–	–	–	–	–	Corner-notched arrow point
C-80292	CCO-235	B. 32	M1a	1*	1385±30	A.D. 1271	A.D. 1170–1349	–	–	–	–	585	–	–	–	–	–	–	–	*H.* bar-scored ornaments
C-80902	SCL-038	B. 166	M1a	1*	1390±25	A.D. 1267	A.D. 1176–1334	–	–	–	–	455	–	–	–	–	–	–	–	–

Notes: [a]County-based site trinomial identifications assigned by the California Historic Resources Survey; [b]Burial feature references designated by "B.", other provenances variously indicated; [c]Inferred $\delta^{13}C$ corrections (always 1.0) are marked with "*"; [d]Dates calibrated with CALIB 5.0.2 (Marine04), with $\Delta R = 260 \pm 35$; [e]SCL-690 dates are radiometric, based on lots of up to 30 beads of a single type; CSDB = clam shell disk bead; magnste bds = magnesite beads; *H.* = *Haliotis*

Table 2

RADIOCARBON DATES ON TIME-SENSITIVE *OLIVELLA* SHELL BEADS FROM THE MIDDLE/LATE TRANSITION PERIOD AND MIDDLE PERIOD BEAD HORIZON 4

Lab Number	Site[a]	Feature[b]	Dated Bead	$\delta^{13}C$[c]	^{14}C Age	CALIB 5.0.2[d] Median	CALIB 5.0.2[d] 2-sigma Range	Count of *Olivella* Bead Types Associated with Dated Bead: H	E	K	M2	M1	D	C7	C2/3	G1/5	F3b	F3a	F4	Other Time-sensitive Artifacts with Dated Bead
Middle/Late Transition Bead Horizon (A.D. 1020–1265)																				
C-82179	YOL-013	B. 03	C2	1*	1395±30	A.D. 1263	A.D. 1165–1337	–	–	–	–	–	1	20	77	–	–	–	–	–
B-046645	SCL-690[e]	B. 55	A1	1*	1450±50	A.D. 1212	A.D. 1069–1308	–	–	–	–	359	4	–	–	–	–	39	–	–
C-79480	ALA-329	B. 239	M1a	1*	1460±40	A.D. 1206	A.D. 1076–1296	–	–	–	–	3154	–	–	–	–	–	–	–	Serrate arrow point
B-044250	SCL-690[e]	B. 39	D1	1*	1460±60	A.D. 1200	A.D. 1053–1310	–	–	–	–	3	1693	66	23	1575	–	–	–	–
C-82178	YOL-013	B. 02	G5	1*	1475±35	A.D. 1192	A.D. 1070–1284	–	–	–	–	66	2	–	123	122	–	72	–	Ear spools (2)
C-82177	YOL-013	B. 02	M1a	1*	1555±30	A.D. 1113	A.D. 1021–1224								(repeat feature)					
C-79705	ALA-042	B. 236	C7	1*	1480±30	A.D. 1188	A.D. 1071–1279	–	–	–	–	20	–	50	50	–	–	–	–	–
C-79709	ALA-042	B. 280	C3	1*	1490±30	A.D. 1178	A.D. 1063–1272	–	–	–	–	–	–	–	163	–	–	–	–	–
C-79706	ALA-042	B. 055	D2	1*	1510±30	A.D. 1156	A.D. 1051–1258	–	–	–	–	–	24	–	–	–	–	–	–	Dart point
C-79704	ALA-042	B. 066	M1a	1*	1520±30	A.D. 1146	A.D. 1044–1250	–	–	–	–	264	–	–	–	–	–	–	–	–
B-169840	CCO-538	B. 02-12	F3a1	0.8	1530±40	A.D. 1136	A.D. 1031–1253	–	–	–	–	546	–	–	–	55	921	726	100	Ear spools
C-79712	ALA-046	B. 08	F3a1	1*	1530±40	A.D. 1136	A.D. 1031–1253	–	–	–	–	–	–	–	–	–	–	91	35	–
C-79483	ALA-329	B. 251	D1	1*	1540±40	A.D. 1127	A.D. 1023–1247	–	–	–	–	–	5	33	3	–	–	–	–	–
C-80899	ALA-042	B. 192	C2	1*	1545±30	A.D. 1122	A.D. 1028–1229	–	–	–	–	–	190	67	6	–	–	–	–	–
C-78738	ALA-042	B. 259	M1a	1*	1550±30	A.D. 1118	A.D. 1025–1226	–	–	–	–	900	–	100	–	–	–	–	–	Ear spools (2)
C-78737	ALA-042	B. 259	M1a	1.5	1560±40	A.D. 1110	A.D. 1002–1229								(repeat feature)					
C-78739	ALA-042	B. 259	M1a	1*	1560±40	A.D. 1110	A.D. 1002–1229								(repeat feature)					
C-79708	ALA-042	B. 259	C3	1*	1560±40	A.D. 1110	A.D. 1002–1229								(repeat feature)					
C-78736	ALA-042	B. 259	M1a	1*	1580±40	A.D. 1092	A.D. 983–1219								(repeat feature)					
B-44247	SCL-690[e]	B. 41	M1a	1*	1570±50	A.D. 1102	A.D. 977–1240	–	–	–	–	1433	7	–	–	–	–	260	–	Bar-scored *H.* orns.
B-169839	CCO-538	B. 02-3	F3a1	0.7	1580±40	A.D. 1092	A.D. 983–1219	–	–	–	–	4	–	–	–	24	30	21	–	–
C-79707	ALA-042	B. 111	M1a	1*	1610±30	A.D. 1058	A.D. 950–1179	–	–	–	–	162	–	–	25	–	–	10	–	–
B-44245	SCL-690[e]	B. 31	G1	1*	1640±70	A.D. 1025	A.D. 845–1208	–	–	–	–	3	3	144	1	2748	–	–	–	–
Middle Period, Bead Horizon 4 (A.D. 750–1020)																				
C-79713	ALA-046	B. 07	F3a1	1*	1650±40	A.D. 1013	A.D. 895–1154	–	–	–	–	–	–	–	–	–	–	44	13	*H.* wide-rectangle orns.
C-80294	ALA-329	B. 250	F4d	1.1	1665±30	A.D. 998	A.D. 887–1116	–	–	–	–	–	–	–	–	–	–	325	403	*H.* wide-ovate orns.
C-80295	ALA-329	B. 250	F3a2	1*	1735±30	A.D. 929	A.D. 810–1029								(repeat feature)					
C-80915	SCL-134	B. 24	G5	1*	1680±30	A.D. 983	A.D. 859–1080	–	–	–	–	–	–	–	–	11	–	–	–	–
C-79485	ALA-329	B. 244	F4c	1*	1680±40	A.D. 981	A.D. 840–1104	–	–	–	–	–	–	–	–	–	–	103	118	–
C-79484	ALA-329	B. 244	F4d	1*	1760±40	A.D. 900	A.D. 776–1025								(repeat feature)					
B-169838	CCO-538	B. 02-1	F4c	1.4	1690±40	A.D. 971	A.D. 825–1079	–	–	–	–	–	–	–	–	480	937	693	240	Ear spools
C-79051	CCO-269	B. 37A	G5	1*	1710±40	A.D. 952	A.D. 814–1054	–	–	–	–	–	–	–	–	33	23	20	18	Ear spools; Hal. rect. orn.
C-79481	ALA-329	B. 143	F3b1	1*	1730±40	A.D. 932	A.D. 799–1039	–	–	–	–	–	–	–	–	–	6	1	–	*H.* wide-rect. orns.
C-80910	ALA-329	B. 240	F3b2	1*	1750±40	A.D. 911	A.D. 784–1027	–	–	–	–	–	–	–	–	–	150	391	60	*H.* wide ovate orns.
C-80289	ALA-329	B. 265	F3a2	1*	1760±30	A.D. 901	A.D. 785–1012	–	–	–	–	–	–	–	–	106	128	404	–	–
C-122454	SOL-357	B. 210	F3a1	1*	1760±35	A.D. 901	A.D. 782–1019	–	–	–	–	–	–	–	–	–	265	424	901	data unavailable
C-122453	SOL-357	B. 208	F4d	1*	1785±35	A.D. 871	A.D. 744–996	–	–	–	–	–	–	–	–	–	18	71	111	*H.* wide-rect. orns.
C-122455	SOL-357	B. 232	F4a	1*	1810±35	A.D. 844	A.D. 721–972	–	–	–	–	–	–	–	–	–	358	3222	5370	*H.* wide-rect. orns.
C-80914	SCL-134	B. 13	G5	1*	1820±35	A.D. 833	A.D. 710–960	–	–	–	–	–	–	–	–	1226	–	–	–	–
C-81892	CCO-014	B. 05	F4c	1*	1835±25	A.D. 816	A.D. 700–923	–	–	–	–	–	–	–	–	–	60	139	86	–
C-80297	ALA-343	B. 01-90	F3a1	1*	1850±35	A.D. 800	A.D. 685–916	–	–	–	–	58	–	–	–	–	96	65	–	Bone spatulae
C-81893	CCO-014	B. 12	F4d	1*	1855±30	A.D. 793	A.D. 689–904	–	–	–	–	–	–	–	–	–	103	334	463	Ear spools; *H* rect. orns.

Notes: [a]County-based site trinomial identifications assigned by the California Historic Resources Survey; [b]Burial feature references designated by "B.", other provenances variously indicated; [c]Inferred $\delta^{13}C$ corrections (always 1.0) are marked with "*"; [d]Dates calibrated with CALIB 5.0.2 (Marine04), with $\Delta R = 260 \pm 35$; [e]SCL-690 dates are radiometric, based on lots of up to 30 beads of a single type; *H.* = *Haliotis*; rect. orns. = rectangular ornaments

Table 3

RADIOCARBON DATES ON TIME-SENSITIVE *OLIVELLA* SHELL BEADS FROM THE MIDDLE PERIOD BEAD HORIZON 3 AND MIDDLE PERIOD BEAD HORIZON 2

Lab Number	Site[a]	Feature[b]	Dated Bead	$\delta^{13}C^{c}$	^{14}C Age	CALIB 5.0.2[d] Median	CALIB 5.0.2[d] 2-sigma Range	Count of *Olivella* Bead Types Associated with Dated Bead: M1	D	C7	C2/3	G5	F3b	F3a	F2cd	F2a	F2b	F4	G2/3	Other Time-sensitive Artifacts with Dated Bead
Middle Period, Bead Horizon 3 (A.D. 585–750)																				
C-80296	ALA-343	B. 01-168	F3b2	1*	1905 ± 40	A.D. 747	A.D. 654–879	–	–	–	–	–	14	–	–	–	–	–	–	–
B-177104	SFR-004	B. 06	F3a2	0.7	1910 ± 40	A.D. 742	A.D. 649–874	87	–	–	–	–	50	231	45	–	–	–	–	*Haliotis fulgens* tear drop orns.
B-177103	SFR-004	B. 06	F3a2	0.6	1960 ± 40	A.D. 696	A.D. 591–810	(repeat feature)												
C-89448	MEN-428	Midden	M1a	0.8	1920 ± 30	A.D. 731	A.D. 646–844	1	–	–	–	–	–	–	–	–	–	–	–	–
C-80684	SFR-114	B. 02	F3a1	1*	1935 ± 35	A.D. 718	A.D. 621–830	–	–	–	–	–	489	2769	–	–	–	–	–	Mica; bone spatula; dart pt
C-89443	ALA-343	B.86-12	M1a	1*	1940 ± 35	A.D. 714	A.D. 617–824	2	–	–	–	6	88	8	–	–	–	–	–	*H.* rectangle orns.
C-89444	ALA-343	B.86-12	F3b1	1*	1965 ± 35	A.D. 691	A.D. 592–795	(repeat feature)												
C-89446	ALA-343	B.86-26	F3b1	1*	1970 ± 30	A.D. 686	A.D. 597–785	–	–	–	–	1	471	–	–	–	–	–	–	Mica; *H.* rectangle orns.
C-89445	ALA-343	B.86-19	F3b1	1*	1970 ± 30	A.D. 686	A.D. 641–729	33	–	–	–	–	574	110	–	–	–	–	–	Mica
C-89447	ALA-343	B.86-28	F3b1	1*	1995 ± 30	A.D. 664	A.D. 573–765	–	–	–	–	–	328	36	–	–	–	–	–	Mica; bone spatula
C-80683	ALA-343	B.01-97	F3a1	1*	2010 ± 35	A.D. 651	A.D. 549–753	71	–	–	–	2	9	160	–	–	–	–	–	–
C-80685	SFR-114	B. 10	F3a1	1*	2020 ± 35	A.D. 642	A.D. 534–744	–	–	–	–	–	110	2098	–	–	–	–	–	–
C-81897	CCO-151	B. 60	F3a1	1*	2035 ± 30	A.D. 630	A.D. 525–720	–	–	–	–	–	–	116	–	–	–	9	–	–
C-81896	CCO-151	B. 27	F3b2	1*	2055 ± 30	A.D. 613	A.D. 491–695	–	–	–	–	–	367	–	–	–	–	–	–	Mica
Middle Period, Bead Horizon 2 (A.D. 420–585)																				
C-80913	SCI-581	B. Gr-5	F3a1	1*	2085 ± 35	A.D. 584	A.D. 540–652	–	–	–	–	76	–	307	42	–	–	–	75	–
C-79049	CCO-269	B. 29	F3a1	1.1	2090 ± 40	A.D. 578	A.D. 529–651	–	–	–	–	–	–	31	14	2	10	–	–	–
C-80912	SCI-581	B. So-9	F3a2	1*	2095 ± 30	A.D. 575	A.D. 530–643	–	–	–	–	–	–	37	–	–	–	10	–	–
C-89449	ALA-413	U.5 130 cm.	F3a2	1*	2095 ± 35	A.D. 574	A.D. 525–645	–	–	–	–	–	–	1	–	–	–	–	–	–
B-197489	SFR-004	B. 28	F2d	1.0	2110 ± 40	A.D. 557	A.D. 492–623	–	–	–	–	–	–	–	65	21	15	–	–	–
B-197490	SFR-004	B. 28	F2d	0.7	2120 ± 40	A.D. 546	A.D. 492–623	(repeat feature)												
C-79056	ALA-413	B. 34	G2a	1*	2120 ± 30	A.D. 548	A.D. 486–607	–	–	–	–	–	–	–	–	–	–	–	5660	*H.* nacrous disks
C-122459	ALA-413	B. 34	G2a	1*	2170 ± 35	A.D. 497	A.D. 436–557	(repeat feature)												
C-122458	ALA-413	B. 22	G2a	1*	2130 ± 35	A.D. 536	A.D. 472–597	–	–	–	–	–	–	–	–	–	–	–	148	*H.* nacrous disks
C-78742	ALA-413	B. 23	G2a	1*	2130 ± 40	A.D. 536	A.D. 469–599	–	–	–	–	–	–	–	–	–	–	–	108	
C-78741	ALA-413	B. 23	G2b	1*	2160 ± 40	A.D. 506	A.D. 441–568	(repeat feature)												
C-78743	ALA-413	B. 23	G2b	1*	2190 ± 40	A.D. 476	A.D. 415–548	(repeat feature)												
C-78740	ALA-413	B. 23	G2b	1*	2210 ± 40	A.D. 451	A.D. 391–535	(repeat feature)												
C-89450	ALA-413	U.5 150 cm.	F3a2	1*	2150 ± 35	A.D. 516	A.D. 451–573	–	–	–	–	–	–	1	–	–	–	–	–	–
C-79055	ALA-413	B. 25A	F2b	1*	2150 ± 40	A.D. 515	A.D. 448–576	–	–	–	–	–	–	5	2	3	4	–	23	–
B-197487	SFR-004	B. 22	F2c	-0.2	2150 ± 40	A.D. 515	A.D. 448–576	–	–	–	–	–	–	2	39	14	20	–	–	–
B-197488	SFR-004	B. 22	F2d	-0.5	2200 ± 40	A.D. 464	A.D. 404–542	(repeat feature)												
C-81895	CCO-151	B. 28	F3a2	1*	2160 ± 30	A.D. 506	A.D. 446–561	–	–	–	–	–	–	35	–	–	–	7	–	Bone spatula
C-79057	ALA-413	U.5 100 cm.	F4c	1*	2160 ± 40	A.D. 506	A.D. 441–568	–	–	–	–	–	–	–	–	–	–	1	–	–
C-122456	ALA-413	B. 25	G2b	1*	2170 ± 35	A.D. 497	A.D. 436–557	–	–	–	–	–	–	–	–	–	–	–	28,335	Bone wands
C-79054	ALA-413	B. 25	G2b	1*	2240 ± 40	A.D. 413	A.D. 336–485	(repeat feature)												
C-122457	ALA-413	B. 25	G2a	1*	2275 ± 35	A.D. 370	A.D. 301–434	(repeat feature)												
C-89452	ALA-413	U.5 150 cm.	G2a	1*	2175 ± 40	A.D. 491	A.D. 429–558	–	–	–	–	–	–	–	–	–	–	–	1	–
C-89451	ALA-413	U.5 130 cm.	G2a	1*	2180 ± 30	A.D. 487	A.D. 431–548	–	–	–	–	–	–	–	–	–	–	–	1	–
C-79053	ALA-413	B. 24	F2a	1*	2180 ± 40	A.D. 486	A.D. 424–554	–	–	–	–	–	–	288	352	128	512	–	–	–
C-79478	ALA-329	B. 104	F2a	1*	2180 ± 40	A.D. 486	A.D. 424–554	–	–	–	–	–	–	3	2	2	2	–	–	–
C-78744	ALA-413	B. 60	F2a	1*	2190 ± 40	A.D. 476	A.D. 415–548	–	–	–	–	–	–	109	784	720	567	–	–	–
C-79050	CCO-269	B. 34	F2a	1*	2190 ± 40	A.D. 476	A.D. 415–548	–	–	–	–	–	–	10	18	67	21	–	–	–
C-81894	CCO-151	B. 41	F2a	1*	2205 ± 30	A.D. 458	A.D. 404–531	–	–	–	–	–	–	8	117	52	23	–	–	–
C-79048	CCO-269	B. 11	F2b	0.9	2210 ± 40	A.D. 451	A.D. 391–535	–	–	–	–	3	–	4	20	2	20	–	–	Mica

Notes: [a]County-based site trinomial identifications assigned by the California Historic Resources Survey; [b]Burial feature references designated by "B.", other provenances variously indicated; [c]Inferred $\delta^{13}C$ corrections (always 1.0) are marked with "*"; [d]Dates calibrated with CALIB 5.0.2 (Marine04), with $\Delta R = 260 \pm 35$; *H.* = *Haliotis*; rect. orns. = rectangular ornaments

Table 4

RADIOCARBON DATES ON TIME-SENSITIVE *OLIVELLA* SHELL BEADS FROM MIDDLE PERIOD BEAD HORIZON 1 AND EARLY PERIOD BEAD HORIZON

Lab Number	Site[a]	Feature[b]	Sample Bead	$\delta^{13}C$[c]	^{14}C Age	CALIB 5.0.2[d] Median	CALIB 5.0.2[d] 2-sigma Range	Count of *Olivella* Bead Types Associated with Dated Bead: M1	D	C7	C2/3	G5	F3b	F3a	F2cd	F2a	F2b	G2/3	L	Other Time-sensitive Artifacts with Dated Bead
Middle Period, Bead Horizon 1 (200 B.C.–A.D. 420)																				
C-80686	ALA-621	B. 01-10	C3	1*	2250 ± 30	A.D. 400	A.D. 270–533	–	–	–	63	–	–	–	35	–	10	45	–	–
C-80900	ALA-328	B. 58	C3	1*	2280 ± 30	A.D. 364	A.D. 237–491	–	–	–	15	–	–	–	–	–	–	406	–	–
C-80911	ALA-328	B. 138	C3	1*	2285 ± 40	A.D. 358	A.D. 219–512	–	–	–	209	–	–	–	–	–	34	37	–	–
C-122451	SCL-354	B. 02	G2b	1*	2285 ± 35	A.D. 358	A.D. 224–495	–	–	–	–	–	–	–	–	–	–	272	–	–
C-122452	SCL-354	B. 02	G2b	1*	2360 ± 35	A.D. 272	A.D. 140–405					(repeat feature)								
C-79052	CCO-601	B. 11	G3b	1*	2310 ± 30	A.D. 330	A.D. 198–446	–	–	–	–	–	–	–	–	–	–	1718	–	–
C-80909	ALA-328	B. 142	G3b	1*	2345 ± 35	A.D. 291	A.D. 154–418	–	–	–	–	–	–	–	–	–	–	166	–	–
C-80908	ALA-328	B. 14	G2a	1*	2355 ± 30	A.D. 278	A.D. 148–403	–	–	–	–	–	–	–	–	–	–	54	–	–
C-82183	SOL-270	B. 13	G3b	1*	2395 ± 25	A.D. 226	A.D. 107–352	–	–	–	–	–	–	–	–	–	–	38	–	Steatite disks
C-80300	SCL-732	B. 35	G2b	1*	2425 ± 35	A.D. 193	A.D. 72–334	–	–	–	–	–	–	–	–	–	–	34	–	–
C-80901	ALA-328	B. 58	C2	1*	2480 ± 30	A.D. 130	A.D. 14–253	–	–	–	15	–	–	–	–	–	–	406	–	–
C-80687	ALA-621	B. 01-04	C2	1*	2495 ± 35	A.D. 113	13 B.C.–A.D. 244	–	–	–	20	–	–	–	–	–	–	–	–	–
C-80301	SCL-732	B. 59	G2b	1*	2495 ± 30	A.D. 112	5 B.C.–A.D. 241	–	–	–	–	–	–	–	–	–	–	57	–	–
C-82184	SOL-270	B. 06	G2a	1*	2525 ± 30	A.D. 77	41 B.C.–A.D. 210	–	–	–	–	–	–	–	–	–	–	139	–	Steatite disks
C-82180	YOL-110	B. 11	G5a	1*	2640 ± 30	59 B.C.	181 B.C.–A.D. 67	–	–	–	–	104	–	–	–	–	–	–	–	Steatite disks
B-147194	ALA-309	B. 41	G2b	0.8	2640 ± 40	59 B.C.	195 B.C.–A.D. 82	–	–	–	–	–	–	–	–	–	–	212	–	(notes unavailable)
C-82186	SOL-270	B. 02	C3	1*	2660 ± 35	83 B.C.	214 B.C.–A.D. 65	–	–	–	9	–	–	4	26	–	23	–	–	–
C-82185	SOL-270	B. 15	G2a	1*	2680 ± 30	106 B.C.	252 B.C.-A.D. 35	–	–	–	–	–	–	–	–	–	–	152	–	Steatite disks; *H.* disks
C-80290	COL-247	B. 6	G2a	1*	2745 ± 35	198 B.C.	343–56 B.C.	–	–	–	–	–	–	–	–	–	–	38	–	–
Early Period/Middle Period Transition (about 600–200 B.C.)																				
(No beads tested)																				
Early Period, Bead Horizon (about 2100–600 B.C.)																				
C-81891	ALA-307	B. 62	L2b	1*	3320 ± 35	880 B.C.	1006–780 B.C.	–	–	–	–	–	–	–	–	–	–	–	30	–
C-81889	ALA-307	B. 49	L2b	1*	3565 ± 35	1204 B.C.	1358–1047 B.C.	–	–	–	–	–	–	–	–	–	–	–	162	*H.* rectangular beads
C-82181	COL-247	Unit A	L2b	1*	3585 ± 35	1232 B.C.	1376–1078 B.C.	–	–	–	–	–	–	–	–	–	–	–	1	–
C-81890	ALA-307	B. 51	L2b	1*	3735 ± 35	1408 B.C.	1524–1274 B.C.	–	–	–	–	–	–	–	–	–	–	–	71	*H.* rectangular beads
C-81888	ALA-307	B. 42	L2b	1*	3765 ± 35	1441 B.C.	1574–1315 B.C.	–	–	–	–	–	–	–	–	–	–	–	164	–
B-186026	CCO-548	Midden	L2b	1.7	3900 ± 40	1591 B.C.	1732–1453 B.C.	–	–	–	–	–	–	–	–	–	–	–	1	–
B-186024	CCO-548	Midden	L2a	0.2	3920 ± 40	1616 B.C.	1760–1471 B.C.	–	–	–	–	–	–	–	–	–	–	–	1	–
B-186025	CCO-548	Midden	L3	1.0	3940 ± 40	1641 B.C.	1786–1491 B.C.	–	–	–	–	–	–	–	–	–	–	–	1	–
B-186023	CCO-548	Midden	L2a	1.0	4020 ± 40	1746 B.C.	1894–1601 B.C.	–	–	–	–	–	–	–	–	–	–	–	1	–

Notes: [a]County-based site trinomial identifications assigned by the California Historic Resources Survey; [b]Burial feature references designated by "B.", other provenances variously indicated; [c]Inferred $\delta^{13}C$ corrections (always 1.0) are marked with "*"; [d]Dates calibrated with CALIB 5.0.2 (Marine04), with $\Delta R = 260 \pm 35$; *H.* = *Haliotis*

exposed in a creek bank at the Vineyards site (CCO-548) in eastern Contra Costa County (Wiberg and Clark 2004).

The best-documented site containing type L Thick Rectangles is the West Berkeley site (ALA-307), a bayshore shellmound. Four beads from that site produced dates between 1,440 and 880 cal B.C. Wallace and Lathrop (1975) reported five charcoal dates from the same depths as our four *Olivella* beads, and Ingram (1998) reported nine more charcoal dates from the same strata, supporting the early end of our Scheme D chronology. Three of the directly-dated L2b Thick Rectangles from equivalent depths were between 160 and 109 years younger than the midden charcoal. This is not surprising, since the beads were placed in burial pits dug into the slightly older strata.

Table 5

SUMMARY OF CALIBRATED AMS DATES ASSOCIATED WITH DIFFERENT *OLIVELLA* BEAD STYLES

Class/TypeName	Range	Mean	Median	Count
H – Needle-Drilled Disk	A.D. 1774 to A.D. 1836	A.D. 1797	A.D. 1793	6
E – Lipped	A.D. 1273 to A.D. 1766	A.D. 1628	A.D. 1668	9
K– Cupped	A.D. 1403 to A.D. 1484	A.D. 1441	A.D. 1445	5
M2 – Thin Rectangle, Pendant	A.D. 1273 to A.D. 1488	A.D. 1390	A.D. 1397	8
M1– Thin Rectangle, Sequin	A.D. 651 to A.D. 1488	A.D. 1109	A.D. 1127	36
D – Split Punched	A.D. 1025 to 1372	A.D. 1171	A.D. 1157	11
C7– Split Amorphous	A.D. 1025 to A.D. 1263	A.D. 1133	A.D. 1118	11
C2/3 – Split Drilled/Oval	83 B.C. to A.D. 1263	A.D. 797	A.D. 1086	16
G1/G5 – Tiny/Irregular Saucer	59 B.C. to A.D. 1836	A.D. 916	A.D. 962	20
F3b – Small Narrow Saddle	A.D. 613 to A.D. 1136	A.D. 807	A.D. 793	25
F3a – Large Narrow Saddle	A.D. 451 to A.D. 1212	A.D. 777	A.D. 742	49[a]
F2cd – Rough Saddles, Rectanguloid/Elliptic Symmetric	A.D. 400 to A.D. 742	A.D. 527	A.D. 501	16[a]
F2a – Rough Saddle, Rectanguloid Oblique	A.D. 451 to A.D. 578	A.D. 501	A.D. 486	12
F2b – Rough Saddle, Elliptic Oblique	A.D. 358 to A.D. 578	A.D. 483	A.D. 486	14[a]
F4 – Smooth Saddle	A.D. 506 to A.D. 1138	A.D. 862	A.D. 901	19
G2/3 – Saucer/Ring	198 B.C. to A.D. 584	A.D. 331	A.D. 432	30
L – Thick Rectangle	1746 B.C. to 800 B.C.	1440 B.C.	1516 B.C.	9

Notes: Class and type after Milliken and Schwitalla (2009); [a]Does not include associated date of 83 B.C.

Scheme D tentatively brackets the Early Period Bead Horizon at 2,100–600 cal B.C. Until additional samples are obtained, we slightly modify the beginning of the Early/Middle Transition back 100 years to 600 cal B.C.

Early/Middle Transition Bead Horizon (EMT): 600–200 cal B.C.

Beginning after the EMT, rectangular *Olivella* beads were replaced by circular forms, although there is growing evidence that few if any wall beads were used in central California during this interval (see e.g., Rosenthal 1996; Wiberg 2002). *Olivella* bead types C1 Beveled and F1 Oval Saddles are thought to be exclusive to the EMT by Bennyhoff and Hughes (1987), while types C2 Split-drilled, C3 Split Oval, G1 Tiny Saucer, and G2 Normal Saucer are thought to occur occasionally in the EMT, but are not limited to it (Bennyhoff and Hughes 1987:122–123, 129, 132; see also Elsasser 1978:39, 40).

No C1 Beveled or F1 Oval Saddle *Olivella* beads have yet been subjected to direct AMS radiocarbon dating due to their rarity. *Olivella* bead types C3 and G2 have not been found to date to the EMT, lending support to the idea that wall beads were rarely used in central California during this interval. Current data suggest a much longer transitional phase than indicated by Bennyhoff and Hughes (1987), possibly extending from ca. 880 to 199 cal B.C. However, without additional evidence, we slightly modify the Dating Scheme B time-bracketing of the EMT to 600–200 cal B.C.

Middle Period, Bead Horizon 1 (M1): 200 cal B.C.–cal A.D. 420

Bennyhoff and Hughes (1987:149) bracket the Middle Period, Phase 1, at 200 B.C.–A.D. 100. *Olivella* beads for Scheme D's comparable Bead Horizon M1 include C2 Split-drilled, C3 Split Ovals, G2 Normal Saucers, G3 Rings, and G4 Face-ground Saucers (Bennyhoff and Hughes 1987:122–123, 132–133). Additionally, poorly-shaped G5/6 Oval and Irregular Saucers occasionally date to the Early Phase, but can be present in all phases of the Middle Period.

Scheme D brackets Bead Horizon M1 between 200 cal B.C. and cal A.D. 420, significantly longer than Dating Scheme B's comparable bead horizon. Our Bead Horizon M1 sample includes 19 AMS dates from 18 features at nine sites (Table 4). The temporal distribution of dates is surprisingly long. However, it is apparent from Table 3 that pure lots of G2 Saucers continue into the subsequent phase, creating ambiguity in the seriation of

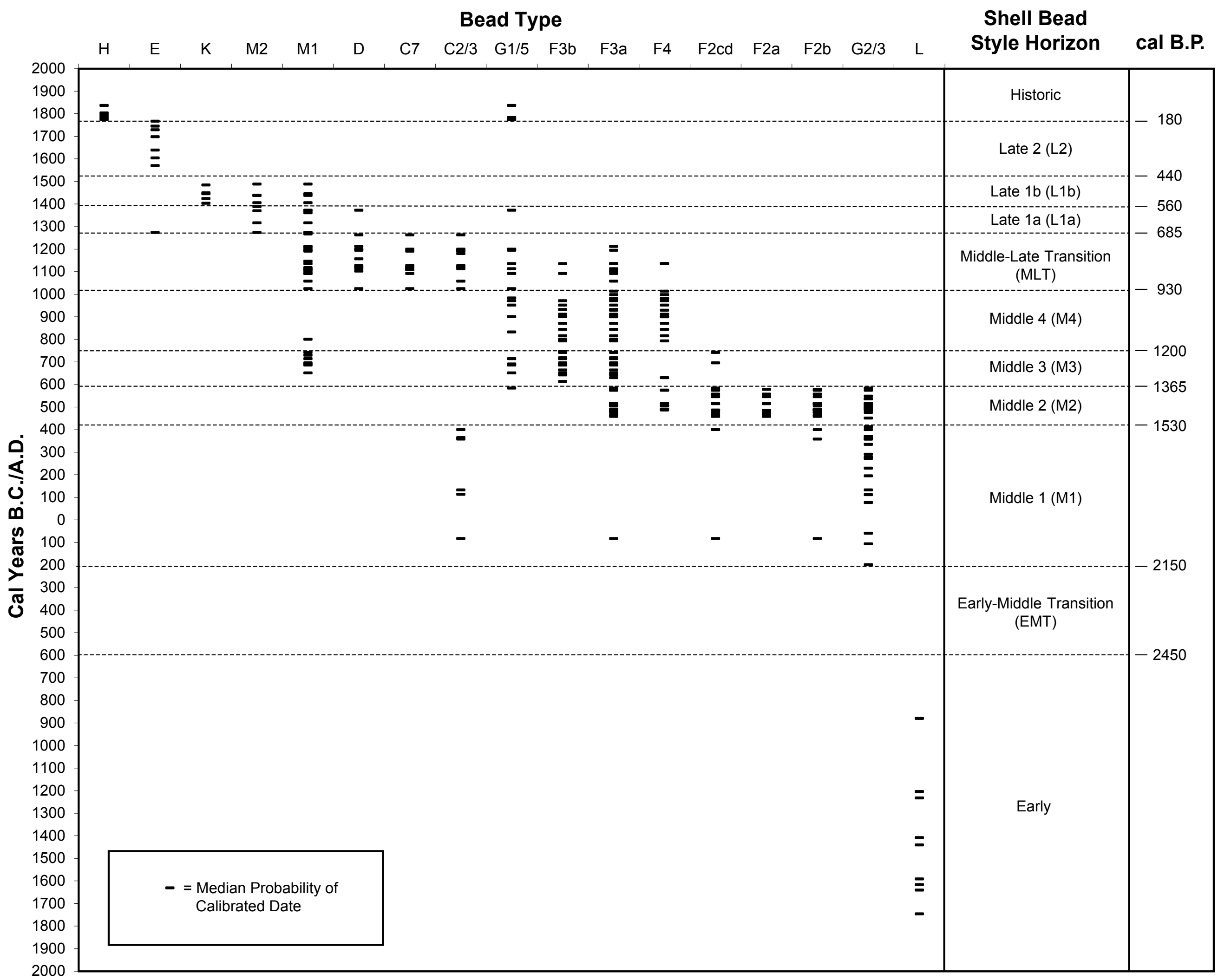


Figure 3. Seriation of AMS Dates Associated with Different *Olivella* Bead Types

these assemblages without radiocarbon dates. This overlap is expressed stratigraphically at site ALA-413, where three pure Saucer bead lots, normally assigned to Bead Horizon M1, were interred subsequent to two *Olivella* Saddle lots associated with Bead Horizon M2 (Wiberg 1988). This temporal overlap is perhaps not surprising, as G2 Saucer beads were manufactured in southern California throughout all phases of the Middle Period and into the Late Period (King 1990:120–133, 149–151, 179–184). Class F Saddle beads were made exclusively in central California (Bennyhoff and Hughes 1987:130, 155; King 1990:130; Rosenthal 2011a), beginning in the Intermediate phase (M2) of the Middle Period. Saucer beads found in central California after the early Middle Period (M1) were likely obtained from southern California.

Middle Period, Bead Horizon 2 (M2): cal A.D. 420–585

The *Olivella* bead sequence becomes more complicated in Bead Horizon M2 than Bennyhoff and Hughes (1987) realized. Their Middle Period Intermediate Phase (our M2 Bead Horizon) is distinguished by wide, chipped- and ground-edge *Olivella* Saddle beads with tiny perforations, including Type F2a Full Saddles (Bennyhoff and Hughes 1987:130) and Type F2b Round Saddles (Bennyhoff and Hughes 1987:130–131). When actual bead lots from this period are examined, bead templates vary across forms that fit Bennyhoff and Hughes' (1987) descriptions of F2a, F2b, F2c, and F2d beads; all are wide Saddles, but some are diagonally-shaped and others are quite bisymmetrical. These wide *Olivella* Saddles do not occur in southern California (King 1990:130), and represent a divergence between the southern and central California bead exchange networks (see Fig. 1) and bead-making traditions.

Bennyhoff and Hughes (1987) seriated a change from the *Olivella* F2a/F2b "wide" Saddles during their Intermediate Phase to mixed Saddle lots of F2a/F2b Wide Saddles and F3a/F3a2 Modified Saddles (renamed Narrow Saddles by Milliken and Schwitalla [2009:40]) during their subsequent Late Phase of the Middle Period. By "mixed Saddles" Bennyhoff and Hughes (1987:131) did not mean that two bead types were mixed, but that the Saddle bead template was changing to include an array of beads that varied from wide silhouettes to narrow or long silhouettes. They recognized components with mixed Saddles as representative of the Middle Period Late Phase, dated by Scheme B to A.D. 300–500, immediately following the Intermediate Phase, dated to A.D. 100–300.

Our Bead Horizon M2 sample includes 30 dated beads from 17 contexts at six sites (Table 3), ranging in age between cal A.D. 420 and cal A.D. 585. Radiocarbon-dated bead lots demonstrate that mixed Saddle-bead horizons actually appear at two separate times within the Middle Period (Groza 2002); a similar mixture of wide and narrow bead silhouettes marks Bead Horizons M2 and M4. Milliken and Schwitalla (2009:43) now make a distinction between chipped-edge wide Saddles, referred to as Rough Saddles (retaining the F2 type designation), and ground-edge, wide, bisymmetrical saddles, referred to as Smooth Saddles, reclassified as Type F4. Radiocarbon-dated bead lots demonstrate that differences in edge finish have chronological significance (Fig. 3). Type F4 Smooth Saddles (e.g., F4a, F4b, and F4c) and Type F3 Narrow Saddles occur together during Bead Horizon M4, without Rough Saddles. These two types also occur with Rough Saddles during Bead Horizon M2 (Milliken and Schwitalla 2009:49). However, mixed Saddle bead lots which include Type F2 Rough Saddles are only associated with Bead Horizon M2 (Fig. 3). Because of these newly identified differences, artifact assemblages that Bennyhoff (in Elsasser 1978:39, 40) called the Sherwood Facies on San Francisco Bay and the Brazil Facies in the lower Sacramento Valley are a combination of artifact types from these two temporally-separate *Olivella* bead horizons (i.e., bead horizons M2 and M4).

Radiocarbon dating revealed additional differences between Bead Horizon M2 and Bennyhoff and Hughes' (1987) Intermediate Middle Period. Pure lots of G2 Saucer Beads at site ALA-413 (associated with Burials 22, 23, 25, and 34), thought to be the exclusive markers for Bead Horizon M1, date well into Bead Horizon M2, as late as cal A.D. 550 (Table 3). Furthermore, Type F3a Large Narrow-Saddle beads occur throughout the period defined for Bead Horizon M2, dating as early as cal A.D. 451. This suggests that pure, Wide Saddle lots (Bennyhoff and Hughes [1987] Type F2a/F2b) are not the exclusive markers of Bead Horizon M2, as originally proposed.

As a result, we do not distinguish subdivisions of Bead Horizon M2, as do Milliken and Schwitalla (2009:8, 42–43), who identify Middle Period Phase 2A by the exclusive presence of wide Rough Saddle beads, types F2a and F2b.[4] Furthermore, no burial lot in the current sample contains F2a and F2b Rough Saddles in the absence of other bead forms. The earliest dated contexts that include Rough Saddles are Burial 138 at ALA-328 and Burial 01–w10 at ALA-621, dated cal A.D. 358 and cal A.D. 400, respectively. These latter two contexts also include C3 Split Oval and G2 Saucer beads. Dated beads in both of these burial lots are Split Ovals, which were most common in Bead Horizon M1. If the dated beads are heirlooms that remained in circulation for several decades beyond their period of manufacture, it may explain the slightly early date associated with the Rough Saddles in these lots.

Alternatively, if a Middle Period Phase 2A can be distinguished, these bead lots suggest it may have begun by cal A.D. 350, and is characterized by the earliest Rough Saddles (F2a/F2b), but also includes C3 Split Ovals and G2 Saucers. Although pure Rough Saddle bead lots at sites such as ALA-413, CCO-141, CCO-269, and SCL-581 may represent an early sub-phase of Bead Horizon M2, several examples from the current data set indicate that uniform assemblages of the same bead type can occur during any interval in which a particular bead is used. As described above, pure Saucer bead lots are associated with both bead horizons M1 and M2, and pure Sequin bead lots, Type M1a, occur in both the Middle Late Transition and Horizon 1 of the Late Period (see Tables 1 and 2). While we believe that pure lots of Rough Saddles Types F2a and F2b date to Bead Horizon M2, there is currently no radiocarbon evidence to support a sub-phase distinction for this assemblage (cf. Milliken and Schwitalla 2009).

Middle Period, Bead Horizon 3 (M3): cal A.D. 585–750

Dating Scheme D documents a pure Type F3 Narrow Saddle bead horizon immediately following the "mixed" Saddle bead horizon described in the section above. Bennyhoff (1986) argued that central California people made and traded smaller and narrower Saddle beads over time during the Middle Period. Eventually, components appeared with modified Saddle-bead lots that contained no "wide" saddles at all.

Thirteen dates for the "pure" Narrow Saddle horizon, Bead Horizon M3, come from four sites in the San Francisco Bay area (Table 3): single component SFR-114 (Yerba Buena Center); a single component area of multicomponent site ALA-343 (Fremont BART); and multicomponent sites CCO-151 (Sobrante) and SFR-4 (Yerba Buena Island). Bead lots of F3b Small Narrow Saddle beads predominate over bead lots of F3a Large Narrow Saddles. Occasionally, very rectangular Olivella Type M1a Normal Sequins appear as outliers in the saddle populations, their earliest appearance. That these Sequins represent a distinct early occurrence is confirmed by a dated M1a bead from the midden at MEN-428 on the Pacific coast near Fort Bragg, one of the earliest examples of this type (Table 3). A few bead lots also contain easily distinguishable Type G5/6 Irregular Saucers, beads probably traded north from the Monterey Bay area (Bennyhoff and Hughes 1987). The F2c/F2d Rough Saddles associated with SFR-4 Burial 6 may be heirlooms, although SFR-4 Saddle beads were stylistically different from those in any other bead lot and may represent a distinct subtype.

Dating Scheme D dates Bead Horizon M3 to cal A.D. 585-750. This pure Narrow Saddle horizon is followed by a second Middle Period mixed Saddle horizon, discussed below.

Middle Period, Bead Horizon 4 (M4): cal A.D. 750–1020

The presence of a second mixed saddle-bead horizon, not predicted in the Scheme B chronology, is probably the most striking result of our study. As mentioned previously, Bennyhoff (1986) incorrectly presumed that native central Californians gradually changed their *Olivella* bead template through time from shouldered rectangles (types F3a and F3b) to the sharp-cornered rectangles (Class M), marking the first phase of the Late Period. Bennyhoff's type site for his "mixed saddle" only bead horizon was the single-component Sherwood site (CCO-14). Based on his seriation interpretations, Bennyhoff identified the CCO-14 component as the Late Phase of the Middle Period in Scheme B, prior to the Terminal Phase with its Sobrante Facies of "pure modified saddles" (now Narrow Saddles). Under Scheme B, components of this Late Phase of the Middle Period date to A.D. 300–500 (Bennyhoff and Hughes 1987:149).

The seriation problem became evident when two AMS dates on wide, bisymmetric saddles from CCO-14 dated to a later time than beads from any of the pure Narrow Saddle bead lots of our Bead Horizon M3 (Tables 2, 3). AMS results from ALA-329, CCO-538, and SOL-357 confirmed the presence of a "mixed saddle" *Olivella* bead horizon with ear spools and rectangular abalone artifacts more recent than the "pure narrow saddle" *Olivella* bead horizon. Thus, the last two bead horizons of the Middle Period were inverted. Scheme B's "Terminal Phase" of the Middle Period is Bead Horizon M3 under Scheme D, while Scheme B's earlier "Late Phase" of the Middle Period is Bead Horizon M4 under Scheme D. Another distinction, only apparent once the phase reversal was identified, is the absence of Type F2 Rough Saddles in Bead Horizon M4. The mixed Saddle lots that characterize the end of the Middle Period include only edge-finished beads, now identified as Type F4 (i.e., F4a-d), as well as the Narrow Saddles (F3a), typical of the previous interval. Lastly, mixed Saddle bead lots of Bead Horizon M4 also include Small Narrow Saddle Type F3b, a style that occurs during Bead Horizon M3, but is not present in the earlier mixed Saddle lots of Bead Horizon M2.

In the Scheme D sequence, mixed Saddles first came into favor between cal A.D. 420 and cal A.D. 585, in Bead Horizon M2. They are followed by the pure Narrow Saddles and the Sobrante Facies artifact assemblages dated to cal A.D. 585–750, Bead Horizon M3. Finally, mixed Saddles, without chipped-edge variants, came back into use, along with the Sherwood Facies artifact assemblage, in cal A.D. 750–1020, Bead Horizon M4.

Middle/Late Transition Bead Horizon (MLT): cal A.D. 1020–1265

The MLT is characterized by a wider array of *Olivella* bead-types than any other bead horizon (Rosenthal 2011a). Marker types include C2 Split Drilled, C3 Split

Ovals, C7 Split Amorphous, D1a Shelved Punched, D2 Rectangular Punched, G1 Tiny Saucers, and M1a central-perforated Sequins (Bennyhoff and Hughes 1987; Elsasser 1978:42). Scheme B dates the MLT to A.D. 700–900 (Bennyhoff and Hughes 1987:149).

Our 23 MLT *Olivella* bead dates derive from bead lots with varying mixes of the marker types from single component site ALA-42, split-component site YOL-13, and multicomponent site ALA-329 (Table 2). We also list four standard dates obtained from multiple beads recovered in burial lots at site SCL-690; the site report includes numerous supporting charcoal dates for its MLT component (Hylkema 2007).

Our Dating Scheme D results indicate that the MLT occurred between cal A.D. 1020–1265, bringing the MLT into line with the equivalent bead horizons of the Santa Barbara Channel area, phases M5c and L1a (King 1990:28, 237; see Figure 1).

Late Period, Bead Horizon 1 (L1a and L1b): cal A.D. 1265–1520

Bennyhoff and Hughes (1987) seriated Late Period Phase 1 into three narrow sub-phases on the basis of its marker *Olivella* bead types M1a central-perforated Sequins and M2a end-perforated Pendants. They argued that central-perforated beads alone marked Phase L1a, mixed lots marked Phase L1b, and pure end-perforated lots marked Phase L1c; they also associated *Olivella* type K1 Callus Cups with phases L1b and L1c.

Our dates for Bead Horizon L1 derive from five K1 Callus cups, five M1a central-perforated Sequins, and seven M2a end-perforated Pendants. They come from four sites, including multicomponent sites ALA-329, SCL-38, CCO-235, and YOL-187. We also list one standard radiocarbon date obtained from multiple A1 spire-lopped beads recovered in a burial lot (Burial 24) at multicomponent site SCL-690. Burial 24 is also associated with G1 Tiny Saucers that appear in Middle and Late Period horizons; the single Type D1 Punched bead is intrusive in this context.

The 18 *Olivella* bead dates we assign to Horizon L1 cluster in the temporal order predicted by Scheme B (Table 1). However, our data indicate that the horizon began at cal A.D. 1265, some 365 years later than predicted by Scheme B. The range of AMS dates obtained from burial lots containing both M1a and M2a beads does not support a temporal distinction between these types, as the oldest dated context containing M2a Pendants is just 10 years younger than the oldest M1a Sequin lot. However, while we cannot justify the tripartite division of Bennyhoff and Hughes (1987), two sub-phases are apparent during Late Period Bead Horizon 1. The presence of K1 Cupped beads beginning about cal A.D. 1400 allows the second part of this period (Late Period Bead Horizon 1b, cal A.D. 1390–1520) to be distinguished from the first part (Late Period Bead Horizon 1a, cal A.D. 1265–1390). Like earlier periods, uniform lots of a single bead type do not appear to characterize discrete subphases. Pure lots of M1a Rectangles occur in both the Middle-Late Transition and Late Period Bead Horizon 1a, while pure lots of M2 Pendants occur in both Late Period Bead Horizon 1a and 1b.

Late Period, Bead Horizon 2 (L2): cal A.D. 1520–1770

The Late Period Bead Horizon 2 marker *Olivella* bead is the Class E Lipped series. Bennyhoff and Hughes (1987:127–129) seriated Class E form changes through time, from small Type E1 callus beads without much regular shell wall, through Type E2 with callus and large amounts of shell wall, to Type E3 half-shell beads that came into use in the Early Mission Period. Our key site for Bead Horizon L2 is multicomponent mound ALA-329, where four Class E bead dates derive from burials also containing large numbers of *Olivella* Class A spire-lopped beads, but little else (Table 1). All four burials were from the upper component of the mound. Another tested Class E bead came from a salvage recovery at ALA-342 (also cited as site ALA-573), not far from ALA-329 on the east shore of San Francisco Bay (Fig. 2).

Two other *Olivella* Class E beads dated for this study came from midden at YOL-197, a single component site containing large numbers of clam-shell disk beads, several Class E beads, and some type M3 and M4 Elongate and Trapezoid Pendant beads (this lower Sacramento Valley site was originally identified as SOL-197; Milliken and Shapiro [2006]). The final Class E bead dated for this study came from further north in the Sacramento Valley at COL-11, a site which also contained large numbers of clam-shell disk beads and some magnesite beads (White 2003).

Although we placed our Scheme D bracket for the beginning of the L2 Bead Horizon at cal A.D. 1520,

Table 1 shows a nearly 100-year gap between our youngest L1 bead horizon date (cal A.D. 1488) and our oldest L2 bead horizon date (cal A.D. 1570). As a result, the division between these periods needs additional refinement. However, it is possible that the shift from L1 to L2 bead horizons was marked by a relatively long period without any bead trade. Our eight *Olivella* Class E beads do not line up through time in the order predicted by Bennyhoff and Hughes (1987), from the small Type E1 to the large Type E3 (Table 1).

Historic/Mission Period: cal A.D. 1770–1835

The Mission Period in California commenced with the establishment of the first mission in San Diego in 1769, followed by the settlement of Monterey in 1770. Our samples derive from the Early Mission Period, prior to the evacuation of the last Chumash villagers from the Santa Barbara Channel Islands in 1816. We have six *Olivella* bead dates from the Early Mission context (Table 1). Four of the beads are from key site YOL-69, a single component site that contained mixes of clam-shell disk beads and tiny glass beads, with *Olivella* Class H Needle-drilled disks and abalone pink epidermis disks. Class H beads are thought to have been traded north from the Santa Barbara Channel (Eerkens et al. 2005; Wiberg 2005). Our Scheme D Early Mission Period bead assemblage matches that of Bennyhoff and Hughes' (1987) Scheme B in both composition and temporal duration.

Two Class H Needle-drilled disks came from the 1781–1818 Mission Santa Clara cemetery, SCL-30 (Hylkema 1995). Bead size, edge finish, and calibrated dates match the YOL-69 Class H beads and Class H beads in the Santa Barbara Channel region (see King 1990, 1995). In addition to the two Class H beads recovered during subsurface testing at SCL-30, several other Class H beads, Majolica pottery, and a Desert Side-Notched arrow point were found.

DISCUSSION

Presented here is a refined prehistoric chronology for late Holocene central California that replaces Bennyhoff and Hughes' (1987) Scheme B. The new chronology, Scheme D, is based upon a large sample of AMS dates from temporally-diagnostic artifacts made from a single material, the shell of the purple Olive snail (*Olivella* spp.). Scheme D's bead style-horizons were determined by calibration using ΔR 260 ± 35, a correction factor developed by cross-reference to historic beads of the 1770–1816 era. Because ocean temperature gradients have changed over the last several thousand years, it is likely that differences in carbonate upwelling and shifts in ΔR through time (Culleton et al. 2006; Ingram 1998; Ingram and Southon 1996) affect the resolution of the proposed chronology. This is particularly true for bead styles made from shells that grew in the warmer waters south of Point Conception, versus those that grew on the central and northern California coast where water temperatures are cooler and upwelling is more substantial. There are also likely to be differences in ΔR between shells that grew in open coastal waters and those that grew in estuaries or enclosed bays where ^{14}C-depleted freshwater concentrations are higher (e.g., Ingram and Southon 1996). Additional research on the geographic origins of individual beads and bead styles (e.g., Eerkens et al. 2005, 2009, 2010), in combination with local reservoir corrections, will be necessary to address these potential problems. At this point, however, current evidence supports the timing of the shell-bead horizon shifts associated with Scheme D. The known manufacturing date of the Mission Period Class H Needle-drilled disk beads correlates with dates from the most recent bead horizons described here. Likewise, AMS dates derived from Early Period *Olivella* Class L Thick Rectangles closely match a large number of calibrated terrestrial charcoal dates from the same strata at ALA-307.

As Figure 1 shows, Dating Scheme D does not alter Dating Scheme B in the Early Period and Early/Middle Transition, but departs from it at the first bead horizon of the Middle Period (M1; the *Olivella* Saucer bead horizon) by lengthening that horizon from 300 to 620 years. From then forward, Scheme D bead horizons are shorter than suggested by Scheme B. Our Dating Scheme D solves the problem of the juxtaposition of Late Middle and MLT artifacts by documenting two mixed Saddle bead horizons, one leading directly into the MLT. Furthermore, it largely reconciles central California bead horizons with King's 1990 chronology for southern California (see Fig. 1) and key portions of Jones's (1995) central California coast chronology. Based on research since 1990, King (personal communication 2011) has revised the timing of Phase M5c (i.e., A.D. 1100–1200 or A.D. 1150–1250), bringing it more in line with the age of the MLT, as defined here (i.e., A.D. 1020–1265).

Perhaps the most surprising aspect of the short Scheme D chronology is its implications for the timing of the acceptance of the bow and arrow, first documented in the lower Sacramento Valley in the MLT component at YOL-13, and now dated to post-cal A.D. 1020. The earliest arrow point in the current sample is from MLT Burial 239 at ALA-329, dated to cal A.D. 1206, while the only dart point is also associated with a MLT burial (Burial 55) at ALA-42, dated to cal A.D. 1156. The presence of dart points and the absence of arrow points at MLT site ALA-42 in the Livermore Valley (Tannam et al. 1992; Wiberg 1997), and in MLT components at SCL-690 in the Santa Clara Valley (Hylkema 2007), may suggest that this technology was adopted even later south and west of the Sacramento-San Joaquin Delta and south of the San Francisco Bay, sometime around cal A.D. 1200. This is consistent with Bennyhoff's (in Elsasser 1978) seriation of burial lots from key sites in central California, which indicates that arrow points first appear during Phase 1 of the Late Period at SFR-7 on San Francisco Bay (i.e., Bayshore Facies; Bennyhoff in Elsasser 1978:Figure 5), but are older in the western Delta region, where they co-occur with dart points at CCO-150 during the MLT (i.e., Veale Facies; Bennyhoff in Elsasser 1978:Figure 6). On the eastern side of the Delta, Bennyhoff indicates that arrow points do not occur until Early Phase 1 (Eichenberger Phase; Bennyhoff 1994). Based on our results, the bow and arrow was not widely used in the lowlands of central California until 300 to 400 years or more after this technology was adopted in the Great Basin and Sierra Nevada to the east (e.g., Bettinger and Taylor 1974; Rosenthal 2011b). Dating Scheme D improves our ability to understand the temporal dynamics of that introduction. Further refinements of the central California bead sequence will help us to distinguish gradual from punctuated culture change, internal from external sources of technological and social innovation, and allow for more precise correlations between environmental and cultural changes across much of western North America where Pacific coast shell beads are found.

NOTES

[1]We use the term 'style horizon' in the sense of Willey and Phillips' (1958:32) horizon style: "… a horizon style as the name implies, occupies a great deal of space but very little time. It may be roughly defined as a specialized cultural continuum represented by the wide distribution of a recognizable art style. On the assumption of historical uniqueness of stylistic pattern, coupled with the further assumption that styles normally change with considerable rapidity, the temporal dimension is theoretically reduced to a point where the horizon style becomes useful in equating phases or larger units of culture in time that were widely separated in space."

[2]A third dating scheme, proposed by Elsasser (1978:41) and subsequently labeled Dating Scheme C, was a compromise that split the difference between Heizer's Dating Scheme A and the initial manuscript version of Dating Scheme B (Bennyhoff and Hughes 1987:147). The Dating Scheme D chronology presented here is slightly different than previously published versions (Groza 2002; Hughes and Milliken 2007; Milliken et al. 2007; Milliken and Schwitalla 2009), which were based on different interpretations of the AMS data.

[3]Bead styles listed in Tables 1–4 follow Bennyhoff and Hughes (1987), with revisions by Milliken and Schwitalla (2009). For purposes of complete reporting, we have listed class, type, subtype, and variant information where applicable, for each sampled bead (e.g., E2a3 = Thick Lipped [E2-class], Full Lipped [a-Type], Shelf Edge [3-variant]). Our analysis, however, ignores variant classifications, relying strictly on primary class (e.g., E2 Lipped), type, and subtype designations (see Bennyhoff and Hughes 1987:88) which are shown here to have chronological utility. While it may ultimately be demonstrated that some subtype and variant distinctions originally proposed by Bennyhoff and Hughes (1987) provide additional chronological resolution, reflect separate centers of manufacturing, or reveal distinct geographic distributions, these remain undemonstrated. For complete descriptions of each bead class, type, subtype, and variant see Bennyhoff and Hughes (1987) and Milliken and Schwitalla (2009).

[4]No dates for the Milliken and Schwitalla (2009) iteration of Scheme D are presented in their publication because Table 5 was inadvertently left out. Their missing Table 5 presented the "modified CCTS [central California taxonomic system] temporal bracketing" of bead horizons as compared with other dating schemes. As described by Milliken and Schwitalla (2009:8), Table 5 was based on "Groza's (2002) direct dates, but with a compromise ΔR of 290 ± 35, rather than her original value of 225 ± 35." Their Table 1 is a modified dating scheme, originally presented in Groza (2002:95), that was calibrated with ΔR 225 ± 35, and the temporal brackets therefore are not the same as those under discussion in the Milliken and Schwitalla (2009) publication.

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