REPORTS

THE AGE AND ORIGIN OF OLIVELLA BEADS FROM OREGON'S LSP-1 ROCKSHELTER: THE OLDEST MARINE SHELL BEADS IN THE NORTHERN GREAT BASIN

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Beads manufactured from marine shells originating along the Pacific Coast have been found at numerous sites in the western United States. Because they were conveyed across substantial distances and widely exchanged during ethnographic times, researchers generally assume that shell beads were also traded prehistorically. By examining the spatial and temporal distribution of beads, researchers have reconstructed prehistoric exchange networks. In this report, we present stable isotope data and accelerator mass spectrometer (AMS) radiocarbon dates for six Callianax (previously Olivella) biplicata beads from the LSP-1 rockshelter in southcentral Oregon. Most of the beads were deposited during the early Holocene during a series of short-term occupations and the shells used to manufacture them were procured along the northern California, Oregon, or Washington coasts.

Cuentas manufacturadas a partir de valvas de moluscos marinos han sido halladas en numerosos sitios del oeste de los Estados Unidos de América. Debido a que han sido transportados a distancias significativas y ampliamente intercambiados durante tiempos etnográficos, los investigadores han asumido que las cuentas de valvas han sido también intercambiado en momentos prehistóricos. Examinando la distribución espacial y temporal de las cuentas, algunos investigadores han reconstruido las redes de intercambio. En este trabajo presentamos datos de isótopos estables y fechados radiocarbónicos (AMS) para seis cuentas realizadas en valvas de Callianax biplicata (anteriormente denominadas Olivella) procedentes del abrigo rocoso LSP-1 en el centro-sur de Oregon. Los resultados indican que las cuentas fueron depositadas durante el Holoceno temprano, cuando LSP-1 fue utilizado durante una serie de ocupaciones de corto plazo. Por lo tanto, son las cuentas de concha marina más antiguas de la Gran Cuenca y probablemente fueron hechos de concha adquiridas en las costas de California, Oregon o Washington.

Researchers have long recognized that many shell beads found at Great Basin sites originated along the Pacific Coast (Gifford 1947; Heizer 1951; Jennings 1957; Loud and Harrington 1929; Sample 1950). Although various taxa were used to produce beads, dwarf olive snails (formerly *Olivella sp*., now *Callianax biplicata*, *C. baetica*, and *C. dama*) were especially popular (Bennyhoff and Hughes 1987); we shall retain the familiar "Olivella" as the informal name of *Callianax* shell ornaments unless referencing particular species. Ethnographically, the Northern Paiute strung Olivella shells on necklaces and used them as ear or hair ornaments (Fowler 1992; Stewart 1941) while the Klamath and Modoc decorated clothing with them (Stern 1998). Shells also adorn moccasins, feather plumes, and wooden wands at archaeological sites in western Nevada (Hattori 1982; Loud and Harrington 1929).

Great Basin groups first obtained Olivella beads during the early Holocene, if not before. Fitzgerald et al. (2005) report direct AMS dates on 11 beads from California's Mojave Desert that cluster ca. 10,300–10,000 calendar years before present (cal B.P.), suggesting that exchange networks between coastal and inland populations were established early. This possibility is supported by the presence of obsidian from inland

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sources at coastal sites in California and Oregon (Davis et al., 2004; Erlandson et al. 2011; Lebow et al. 2016). In Oregon's Fort Rock Basin, Jenkins et al. (2004) report nine Olivella beads from components dated to ca. 8600–6100 cal B.P. and one bead directly dated to ca. 8500 cal B.P.[1] Beyond the Great Basin in southeastern Washington, 12 Olivella beads were recovered from deposits at Marmes Rockshelter dated to ca. 11,500–8900 cal B.P. (Rice 1972). These early dates from interior sites correspond with the earliest dates for Olivella beads from coastal California, which similarly suggest that bead production dates to at least the early Holocene (Erlandson et al. 2005; Fitzgerald et al. 2005; Lebow et al. 2016; Morris and Erlandson 1993).

Bennyhoff and Hughes (1987) proposed four major exchange networks through which shell beads were conveyed to Great Basin consumers from production centers in the Gulf of California, and southern, central, and northern California. They speculated that beads at interior sites in Oregon and Washington originated in different production centers: the early Holocene Olivella beads from Marmes Rockshelter probably came from coastal Oregon or Washington; later in time, beads in the northern Great Basin likely originated in one or more of the Californian locations (Bennyhoff and Hughes 1987). Due to the small number of shell beads ($n = 8$) known from the northern Great Basin at the time of their study, Bennyhoff and Hughes (1987) suggested that Oregon was peripheral to the western Great Basin, which served as a major redistribution center. Working with a larger dataset, Jenkins et al. (2004) dismissed that idea, highlighted similar late Holocene peaks in shell bead use in both areas, and suggested that middle Holocene trade routes associated with the Western Idaho Archaic Burial Complex, which may have followed the Columbia River (Galm 1994; Pavesic 1992), brought beads into south-central Oregon. Conversely, Vellanoweth (2001:946) suggested that Olivella beads (in particular, Olivella Grooved Rectangle [OGR] beads) were conveyed from southern California to the Fort Rock Basin during the Middle Holocene. Finally, based on the bead types found in the region, Largaespada (2006) suggested that northern Great Basin populations obtained beads from the Oregon, Washington, and California coasts.

Reconstructions of how and when shell beads were conveyed into the Great Basin are based on: (1) the fact that some taxa occupy discrete ranges along the Pacific Coast; (2) the distribution of those taxa at interior sites; (3) age estimates of particular bead types based on stratigraphic associations with dated features; and (4) the use of morphologically distinct bead types as index fossils at other undated sites. While these approaches have contributed greatly to our understanding of California and Great Basin archaeology, they have several shortcomings. First, bead production often removes diagnostic features of shells that permit species identification (Eerkens et al. 2010). Second, some species (e.g., *C. biplicata*) occupy vast stretches of coastline, which limits their utility in identifying source regions (Eerkens et al. 2010). Finally, the ages of different bead types are based on stratigraphic associations with other dated materials, which can be problematic due to stratigraphic mixing (Bennyhoff and Hughes 1987; Vellanoweth 2001).

Over the past 20 years, two new techniques have addressed questions of how, when, and from where shell beads were conveyed inland. First, AMS radiocarbon dating is now routinely used to directly date beads (e.g., Erlandson et al. 2005; Fitzgerald et al. 2005; Vellanoweth 2001). Although shellfish produce radiocarbon dates that appear older than the ages of the event(s) we seek to understand, marine reservoir correction rates (ΔR) exist for different coastal regions (e.g., Ingram and Southon 1996). Second, stable isotope analysis can identify likely stretches of coastline from which shells originated. Eerkens et al. (2005, 2007, 2009, 2010) demonstrated that $\delta^{18}O$ values in Olivella shells are dictated by sea surface temperature (SST) and salinity. Because salinity is relatively consistent along the Pacific Coast (Eerkens et al. 2009), $\delta^{18}O$ values primarily reflect SST, which is strongly correlated with latitude and seasonality. The effects of seasonality, as well as short-term El Niño events, may be controlled for by sampling shells across multiple growth lines (Eerkens et al. 2005, 2009). Eerkens and colleagues also showed that $\delta^{13}C$ values reflect differences in ocean upwelling, such as those present between different coastal areas, and when considered together with $\delta^{18}O$ values may be used to assign beads to broad source regions—generally north or south of California's Point Conception. Finally, they demonstrated that strontium isotope ratios ($^{87}Sr/^{86}Sr$) can differentiate shellfish that lived in the ocean (which is uniform in its strontium composition with a ratio of .7092) from those that lived in estuarine systems, where freshwater input enriched in ^{87}Sr produces lower $^{87}Sr/^{86}Sr$ values (Eerkens et al. 2010). Using these techniques, Eerkens et al. (2010:115) argued that Olivella beads found at southern California sites were obtained from multiple open coast locations south of Point Conception. In his study of Olivella beads from the Fort Rock Basin, Bottman (2006) used Eerkens et al.'s methods to argue that most but not all specimens probably came from southern California.

Here, we describe our application of AMS radiocarbon dating and oxygen, carbon, and strontium analysis to six *C. biplicata* shell beads from the LSP-1 rockshelter, located in Oregon's Warner Valley ca. 400 km from the Pacific Coast. We build on Bottman's (2006) study, which to the best of our knowledge represents the only other isotope analysis of shell beads from the northern Great Basin. Our results indicate that Olivella beads from LSP-1 were conveyed inland primarily during the early Holocene. The beads originated north of Point Conception, most likely along the Oregon or Washington coasts. We consider these results within the broader context of marine shell bead exchange in the northern Great Basin.

Materials and Methods: Olivella Beads from the LSP-1 Rockshelter

LSP-1 (35HA3735) is a rockshelter in Oregon's Warner Valley that formed when Pleistocene Lake Warner was at or near its highstand and subsequently infilled with alluvial and aeolian sediment intermixed with roof fall (Figure 1). Crews from the University of Nevada, Reno, excavated ca. 25 m^2 of deposits to depths of ca. 1.5 to 2 m between 2010 and 2015. We recorded 10 distinct strata and grouped them into three major sediment packages reflecting different time periods and depositional regimes (see Smith et al. 2014 for more on LSP-1's stratigraphy). Forty-two AMS dates on features, isolated charcoal and bone fragments, and organic artifacts provide age ranges for the three sediment packages: (1) the upper package postdates ca. 3000 cal B.P.; (2) the middle package spans ca. 3000 to 9650 cal B.P.; and (3) the lower package, which was generally sterile, predates ca. 9650 cal B.P. (Table 1). The middle package (in particular, Stratum V) is the primary artifact bearing layer at LSP-1, producing rich lithic and faunal assemblages (Pellegrini 2014; Smith et al. 2014). Projectile points recovered include Western Stemmed, foliate, Gatecliff, Elko, Humboldt, and Rosegate types. The lack of Northern Side-notched points and a gap in radiocarbon dates strongly suggest that following its initial occupation ca. 9650 cal B.P., LSP-1 was abandoned during much of the middle Holocene.

We recovered nine *C. biplicata* beads and bead fragments from LSP-1 (Table 2). We classified these using Bennyhoff and Hughes' (1987) original typology and Milliken and Schwitalla's (2012) updated typology as follows: (1) two A1a (small, simple, spire-lopped) beads; (2) two probable A1b (medium, simple, spire-lopped) beads; (3) two A2a (small, oblique, spire-lopped) beads; (4) two A2c (large, oblique, spire-lopped) beads; and (5) one unidentifiable bead fragment. Most of the beads were recovered from sifted Stratum V (i.e., middle package) sediment excavated in 5-cm levels ranging in depth from 51 to 126 cm below datum. Based on their stratigraphic association with dated terrestrial samples, we suspected that the beads were between ca. 3,000 and 9,650 years old, and most likely from the earlier part of that range based on their recovery deep within the shelter's deposits.

We selected six beads for AMS dating and stable isotope analysis based on the depths from which they were recovered and their completeness to determine their antiquity and source region (Figure 2). Because Olivella snails live up to 15 years, their shells form over multiple seasons and years during which time ocean conditions (e.g., temperature, upwelling) can vary (Eerkens et al. 2005). Furthermore, individual shells may possess variable ^{14}C content in different growth bands (Culleton et al. 2006; Hadden and Cherkinsky 2015; Jones et al. 2010). To account for these short-term fluctuations, we sampled each bead at multiple points along the shell's growth rings and in two cases (1374 and 2478) dated the same bead multiple times.

We manually cleaned the shells and placed them in an ultrasonic bath for 40 minutes to remove superficial contaminants. The two large beads (1374 and 2478) also were sonicated with

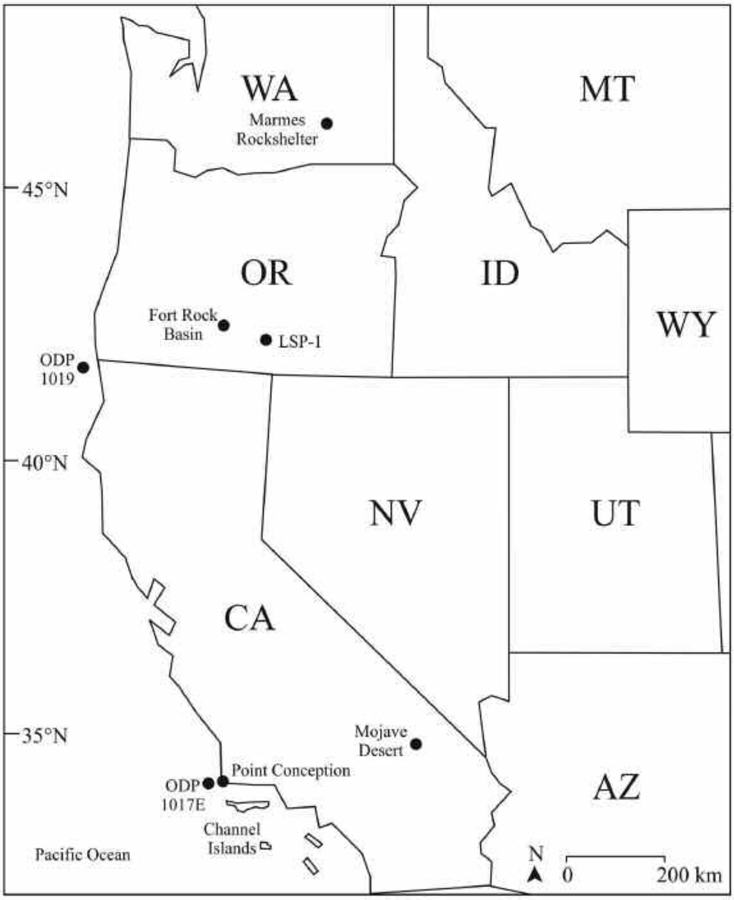

Figure 1. The western United States, with locations of the LSP-1 rockshelter and other places mentioned in the text.

diluted HCl for 15 minutes to leach surface contamination, rinsed, and dried at 105°C. We drilled cleaned shells using a Dremmel tool with a .5-mm carbide drill bit. We drilled sample aliquots for $\delta^{13}C$ and $\delta^{18}O$ analyses in transects parallel to the shells' growth lines at 1- to 2-mm intervals. Carbonate samples ranged from .8 to 2.8 mg in size. Samples were reacted under vacuum with 100-percent H_3PO_4 to recover CO_2. We measured stable isotope ratios on a MAT 253 mass spectrometer with .1‰ precision. We report results with reference to PDB.

We collected carbonate samples for AMS analysis after $\delta^{13}C$ and $\delta^{18}O$ analyses were completed. From the large shells, we drilled ca. 15-mg samples from three points: (1) the lip; (2) the spire; and (3) a point approximately mid-way between the lip and spire. We crushed small shells and collected 15-mg bulk samples for AMS analysis. Samples were reacted under vacuum with 100-percent H_3PO_4 to recover CO_2. The resulting CO_2 was cryogenically purified from the other reaction products and catalytically converted to graphite (Cherkinsky et al. 2010). We measured graphite $^{14}C/^{13}C$ ratios using the CAIS 0.5 MeV accelerator mass spectrometer. We compared sample ratios to measurements of the NBS SRM 4990 standard.

For Sr isotope ratio analyses, we collected aliquots of ca. 30 mg from each bead. We sampled large shells from the callus region to obtain a time-averaged sample. For small shells, we reserved aliquots of the bulk crushed shells for Sr analyses. We measured Sr isotope ratios on a Sector 54 multi-collector mass spectrometer in dynamic mode. The external reproducibility of our $^{87}Sr/^{86}Sr$ analyses is better than 25 ppm. The $^{87}Sr/^{86}Sr$ of NBS 987 over that time period averaged .710246 ± .000011 (2σ).

Table 1. Radiocarbon Dates from LSP-1 Arranged from Youngest to Oldest.

Sample ID	FS Number	Excavation Unit	Cm Below Datum	Stratum	Dated Material	^{14}C Age	2σ cal B.P. Range	Comments	Reference(s)
Beta-283901	45	N105E99	62	IV	Unidentified charcoal	880 ± 40	915–706		Smith et al. 2014
D-AMS 0010587	n/a	N104E99/100	50	II/III	*Juniperus* seeds	1013 ± 29	976–803	Feature 11-14 (hearth)	Kennedy and Smith 2016
UGA-16860	427	N103E102	82	V	Catlow Twine textile	1160 ± 20	1175–989	Woodrat nest	Smith et al. 2016
D-AMS 0010596	CS25B	N104E99	128–131	VIII	*Artemesia* charcoal	1173 ± 25	1179–1000	Column sample	Kennedy and Smith 2016
UGA-16859	426	N103E101	81	V	Catlow Twine textile	1200 ± 20	1180–1063	Woodrat nest	Smith et al. 2016
AA-103861	n/a	n/a	n/a	n/a	Textile fragment	1230 ± 36	1264–1065	Woodrat nest	Kennedy and Smith 2016
D-AMS 0010590	CS8A	N104E99	41–44	III	*Artemesia* charcoal	1255 ± 24	1277–1088	Column sample	Kennedy and Smith 2016
UGA-18238	1302	N102E103	66	n/a	Sagebrush sandal	1300 ± 20	1287–1183	Feature 14-10 (storage pit)	Smith et al. 2016
UGA-18237	1298	N102E103	59	n/a	Sagebrush bark bundle	1340 ± 20	1302–1190	Feature 14-10 (storage pit)	Smith et al. 2016
UGA-18239	1309	N102E103	62	n/a	Sagebrush sandal	1760 ± 20	1721–1610	Feature 14-10 (storage pit)	Smith et al. 2016
UGA-18235	1293	N101E103	52	n/a	Catlow Twine textile	1790 ± 20	1813–1625	Feature 14-10 (storage pit)	Smith et al. 2016
UGA-16803	712	N102E99	33	IV	Unidentified charcoal	1850 ± 25	1865–1716		Kennedy and Smith 2016
UGA-18236	1297	N102E103	62	n/a	Sagebrush sandal	1860 ± 20	1865–1729	Feature 14-10 (storage pit)	Smith et al. 2016
UGA-18240	1311	N102E103	76	n/a	Sagebrush sandal	1880 ± 20	1879–1737	Feature 14-10 (storage pit)	Smith et al. 2016
UGA-15596	715	N105E99	123	VII	*Artemesia* charcoal	2070 ± 25	2122-1951		Kennedy and Smith 2016
UGA-16800	709	N104E99	57	IV	Unidentified charcoal	2490 ± 25	2723–2473	Feature 11-05/15 (hearth)	Kennedy and Smith 2016
Beta-317155	n/a	N104E99	72	IV	Unidentified charcoal	2910 ± 30	3158–2960	Feature 11-19 (hearth)	Smith et al. 2012
D-AMS 0010591	CS12	N104E99	61–66	IV	*Artemesia* charcoal	3038 ± 26	3343–3166	Column sample	Kennedy and Smith 2016
D-AMS 0010593	CS16	N104E99	81–86	V	*Artemesia* charcoal	3046 ± 31	3350–3170	Column sample	Kennedy and Smith 2016
D-AMS 0010592	CS13	N104E99	66–71	IV	*Artemesia* charcoal	3090 ± 26	3371–3231	Column sample	Kennedy and Smith 2016
UGA-15593	706	N105E99	67	IV/V	cf. *Rhus* charcoal	3140 ± 25	3444–3257		Kennedy and Smith 2016
Beta-406150	1251	N102E102	72	IV	*Salix* charcoal	3160 ± 30	3450–3272	Feature 14-06 (hearth)	Smith et al. 2016
D-AMS 0010588	n/a	N102E100/101	66	IV	Cordage	3987 ± 26	4522–4415	Feature 14-02 (hearth)	Kennedy and Smith 2016
D-AMS 0010589	982	N102E99/100	74–75	IV	*Artemesia* charcoal	3990 ± 26	4522–4416	Feature 14-04 (hearth)	Kennedy and Smith 2016
UGA-14917	476	N103E101	96	V	*Artemesia* charcoal	4000 ± 25	4522–4420		Smith et al. 2014
UGA-16801	710	N102E99	68	V	Unidentified charcoal	4010 ± 20	4522–4425	Feature 11-07 (hearth)	Kennedy and Smith 2016
UGA-15260	409	N104E101	82	V	*Bison* femur	4010 ± 25	4525–4422		Smith et al. 2014
D-AMS 0010595	CS22	N104E99	111-116	VII	*Artemesia* charcoal	5238 ± 26	6174–5921	Column sample	Kennedy and Smith 2016
UGA-15595	714	N105E99	45	III/IV	Unidentified charcoal	6550 ± 20	7490–7425		Kennedy and Smith 2016
Beta-306418	38	N105E99	142	VII	Unidentified charcoal	7310 ± 40	8186–8021		Smith et al. 2012
D-AMS 0010597	CS26	N104E99	131-136	VIII	*Artemesia* charcoal	7944 ± 35	8980–8644	Column sample	Kennedy and Smith 2016
D-AMS 0010594	CS20	N104E99	101-106	V	*Artemesia* charcoal	8263 ± 38	9408–9124	Column sample	Kennedy and Smith 2016
Beta-282809	46	N105E99	120	VI	Unidentified charcoal	8290 ± 40	9427–9137		Smith et al. 2012
UGA-18011	1129	N107E99	131	VIII	*Lepus* ulna	8290 ± 25	9420–9143	Presumably non-cultural	Kennedy and Smith 2016
UGA-15594	707	N105E99	106	V/VII	cf. *Rhus* charcoal	8300 ± 20	9422–9252		Kennedy and Smith 2016

Table 1 (continued). Radiocarbon Dates from LSP-1 Arranged from Youngest to Oldest.

Sample ID	FS Number	Excavation Unit	Cm Below Datum	Stratum	Dated Material	^{14}C Age	2σ cal B.P. Range	Comments	Reference(s)
Beta-287251	48	N105E99	103	V	Unidentified charcoal	8340 ± 40	9470–9261		Smith et al. 2012
PRI-14-069	1130	N107E99	124	VI/VII	Artemesia charcoal	8341 ± 27	9449–9289		Kennedy and Smith 2016
UGA-14916	431	N103E101	86	V	*Artemesia* charcoal	8350 ± 30	9462–9296		Smith et al. 2014
Beta-297186	47	N105E99	131	VI/VII	Unidentified charcoal	8400 ± 50	9520–9301		Smith et al. 2012
Beta-306419	158	N102E99	97	V	Unidentified charcoal	8670 ± 40	9731–9540		Smith et al. 2012
UGA-15142	n/a	N103E100	125	V	*Artemesia* charcoal	8700 ± 30	9735–9550	Feature 13-01 (hearth)	Smith et al. 2014
UGA-15259	716	N105E99	141	VIII/IX	*Sylvilagus* humerus	9100 ± 30	10293-10200	Presumably non-cultural	Smith et al. 2014

Note. All dates calibrated using OxCal 4.2 (Ramsey 2009) and the IntCal 13 Curve (Reimer et al. 2013).

AMS Dates, Radiocarbon Calibration, and Stable Isotope Values

Table 3 presents the AMS determinations for the six shell beads. Five beads date to the early Holocene and one dates to the late Holocene. Due to their isotope signatures, which we discuss below, the beads came from north of Point Conception and perhaps as far north as the Oregon or Washington coasts. Given the broad stretch of coastline from which the shells may have originated, we applied three regional Δ*R* rates when calibrating the dates: (1) 240 ± 50 years, developed by Moss and Erlandson (1995) for the Oregon Coast; (2) 290 ± 35 years, developed by Ingram and Southon (1996) for the northern California Coast; and (3) 365 ± 35 years, developed by Ingram and Southon (1996) for San Francisco Bay. The 2σ calibrated age ranges produced using each Δ*R* rate differ slightly; however, they are each consistent with the calibrated age ranges of AMS dates on terrestrial samples collected from similar depths in LSP-1 (Figure 3; also see Table 1), suggesting that there is no "old shell" problem (Ricks et al. 2005) at the site. Together, radiocarbon dates on terrestrial and marine samples point to five periods during which shell beads were discarded at LSP-1: (1) ca. 9735–9550 cal B.P.; (2) ca. 9520–9120 cal B.P.; (3) ca. 8980–8650 cal B.P.; (4) ca. 8186–8021 cal B.P.; and (5) ca. 4525–4415 cal B.P. (not shown in Figure 3).

During the periods when the Olivella beads were produced, SST temperatures along northern California were comparable to today. Barron et al.'s (2003) data from Offshore Drilling Program (ODP) Site 1019 near the California-Oregon border indicate that between ca. 9700 and 8100 cal B.P., as well as ca. 4,450 cal B.P., SST was ± 1°C of today. Similarly, Seki et al.'s (2002) data from ODP Site 1017E near Point Conception suggest that SST was ± 1°C of today when the beads were produced. A ca. 1°C difference in SST translates to a .2‰ difference in δ^{18}O values (Eerkens et al. 2007)—not enough to significantly alter the source region assignment for any of the beads.

Table 4 summarizes the isotope values for the six beads (see Supplemental Table S1 for individual measurements). Average δ^{18}O values range from 1.41 to 2.63‰. None possess individual δ^{18}O readings of < .6‰, which reflect warm water

Table 2. *Callianax biplicata* Beads from LSP-1.

Accession Number	Excavation Unit	cm Below Datum	Length (mm)	Diameter (mm)	Description
3191	N107E99	51–56	7.5	4.4	A2a: Small Oblique Spire-lopped
3200	N107E99	56–61	-	8.1[a]	Probable A1b: Medium Simple Spire-lopped
2104	N102E100	86–91	6.0	5.6	A2a: Small Oblique Spire-lopped
1374	N104E101	107	20.5	12.7	A2c: Large Oblique Spire-lopped
760	N105E100	111–116	-	-	Unknown fragment
761	N105E100	111–116	9.1	5.7	A1a: Small Simple Spire-lopped
2477	N102E102	121–126	7.8	5.6	A1a: Small Simple Spire-lopped
2883	N106E98	116–121	-	-	Probable A1b: Simple Spire-lopped
2478	N102E102	121–126	20.8	12.7	A2c: Large Oblique Spire-lopped

[a] Diameter estimated using chord length and segment height.

sources, and all six possess one or more individual $\delta^{18}O$ readings of 1.7‰, which reflect cold water sources (Eerkens et al. 2007). Average $\delta^{13}C$ values range from .87 to 1.89‰. As noted earlier, while $\delta^{13}C$ values do not track latitude in the same manner as $\delta^{18}O$ values, when used in conjunction with $\delta^{18}O$ they can help discriminate Olivella shells from north of Point Conception from Olivella shells from south of Point Conception (Eerkens et al. 2005). Figure 4 shows both the individual readings for LSP-1 beads as well as the range of $\delta^{18}O$ and $\delta^{13}C$ values for modern Olivella shells used by Eerkens et al. (2005) to delineate the northern and southern source regions. The LSP-1 beads align closely with the northern source region defined using shells collected between Big Sur and southern Oregon by Eerkens et al. (2005). Furthermore, three of the beads (1374, 2104, and 2478) produced multiple individual $\delta^{18}O$ readings more enriched than modern shells from the northern source region, suggesting that they came from points further north than southern Oregon—perhaps as far north as Washington.

Table 4 also shows the $^{87}Sr/^{86}Sr$ ratios for the LSP-1 beads, which range between .7086 and .7089. These values are substantially lower than the $^{87}Sr/^{86}Sr$ ratio of Northeastern Pacific Seawater, which has remained constant at .7092 throughout the Holocene (Capo and DePaolo 1990; Ingram and DePaolo 1993). These lower $^{87}Sr/^{86}Sr$ values suggest that the snails lived at least part of their lives in estuaries (Bryant et al. 1995), which are more common along northern California than southern California (Eerkens et al. 2009). Thus, along with the $\delta^{18}O$ values discussed above, the $^{87}Sr/^{86}Sr$ values strongly point to the beads originating in the northern source region, perhaps along the Oregon or Washington coasts.

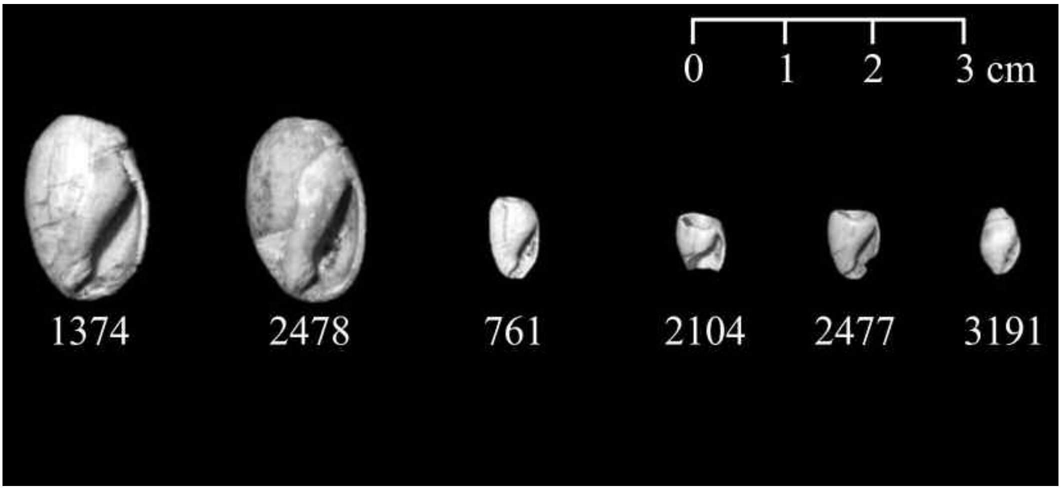

Figure 2. *Callianax* shell beads from the LSP-1 rockshelter.

Table 3. AMS Dates and Calibrated Age Ranges for Callianax Beads from LSP-1.

Accession Number	Lab Number	Corrected ^{14}C Age	2σ cal B.P. range (ΔR = 240 ± 50)[a]	2σ cal B.P. range (ΔR = 290 ± 35)[b]	2σ cal B.P. range (ΔR = 365 ± 35)[b]
3191	21830	4560 ± 25	4618–4273 (4446)	4508–4244 (4376)	4406–4147 (4277)
2104	21827	7890 ± 30	8258–7972 (8115)	8161–7956 (8059)	8113–7879 (7996)
1374	21826 (lip)	9010 ± 30			
	21826 (mid)	8920 ± 30			
	21826 (spire)	8860 ± 30			
	21826 averaged	8932 ± 17	9477–9232 (9355)	9426–9190 (9308)	9356–9073 (9215)
761	21825	8870 ± 30	9435–9119 (9277)	9384–9080 (9232)	9265–9000 (9133)
2477	21828	9200 ± 30	9815–9489 (9652)	9687–9466 (9577)	9580–9405 (9493)
2478	21829 (lip)	8520 ± 30			
	21829 (spire)	8740 ± 30			
	21829 averaged	8630 ± 21	9142–8765 (8954)	9021–8746 (8884)	8960–8643 (8802)

Note: Dates in parentheses represent midpoints of 2σ calibrated age ranges.

[a] Regional marine reservoir correction rate of 240 ± 50 developed by Moss and Erlandson (1995) for the Oregon Coast.

[b] Regional marine reservoir correction rate of 290 ± 35 developed by Ingram and Southon (1996) for the Northern California Coast.

[c] Regional marine reservoir correction rate of 365 ± 35 developed by Ingram and Southon (1996) for San Francisco Bay.

[d] Multiple dates on individual beads averaged following Long and Rippeteau (1974).

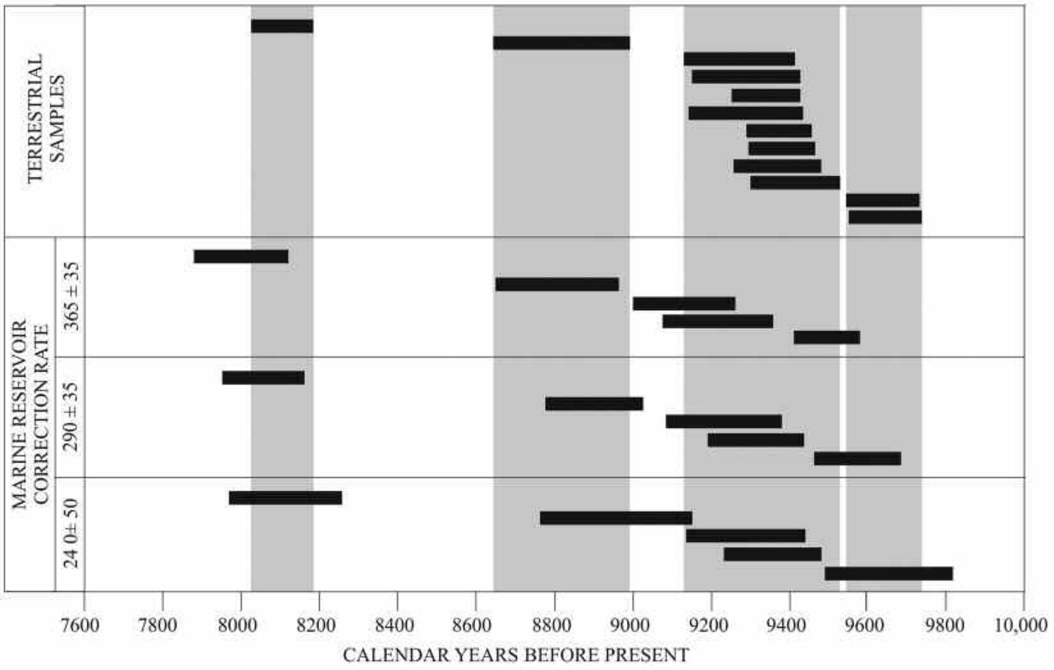

Figure 3. 2σ calibrated age ranges of terrestrial (top row) and marine shell bead samples (bottom rows). Shaded areas represent four distinct periods of occupation at LSP-1 during the early Holocene. A fifth period of occupation between ca. 4525 and 4415 cal B.P. is not shown.

Table 4. Summary of $\delta^{18}O$, $\delta^{13}C$, and $^{87}Sr/^{86}Sr$ Values for Callianax Beads from LSP-1.

Accession Number	2σ cal B.P. range (ΔR = 240 ± 50)[a]	No. of Isotope Analyses	$\delta^{18}O$ ‰ Average and Range[b]	$\delta^{13}C$ ‰ Average and Range[b]	$^{87}Sr/^{86}Sr$ Ratio
3191	4618–4273 (4446)	4	1.41 (1.23–1.77)	.98 (-.38–1.77)	.7089
2104	8258–7972 (8115)	6	2.63 (2.33–3.06)	1.89 (1.63–2.33)	.7086
1374	9477–9232 (9355)	18	2.16 (1.73–2.76)	.94 (.38–1.35)	.7089
761	9435–9119 (9277)	6	1.45 (.99–2.20)	1.66 (.42–2.25)	.7087
2477	9815–9489 (9652)	6	1.76 (.99–2.27)	.87 (-.26–1.33)	.7087
2478	9142–8765 (8954)	13	2.53 (1.55–3.16)	1.51 (.35–2.24)	.7086

[a] Regional marine reservoir correction rate of 240 ± 50 developed by Moss and Erlandson (1995) for the Oregon Coast. Dates in parentheses represent midpoints of 2σ calibrated age ranges.

[b] Individual isotope values and distance from lip presented in Table S1 (available online).

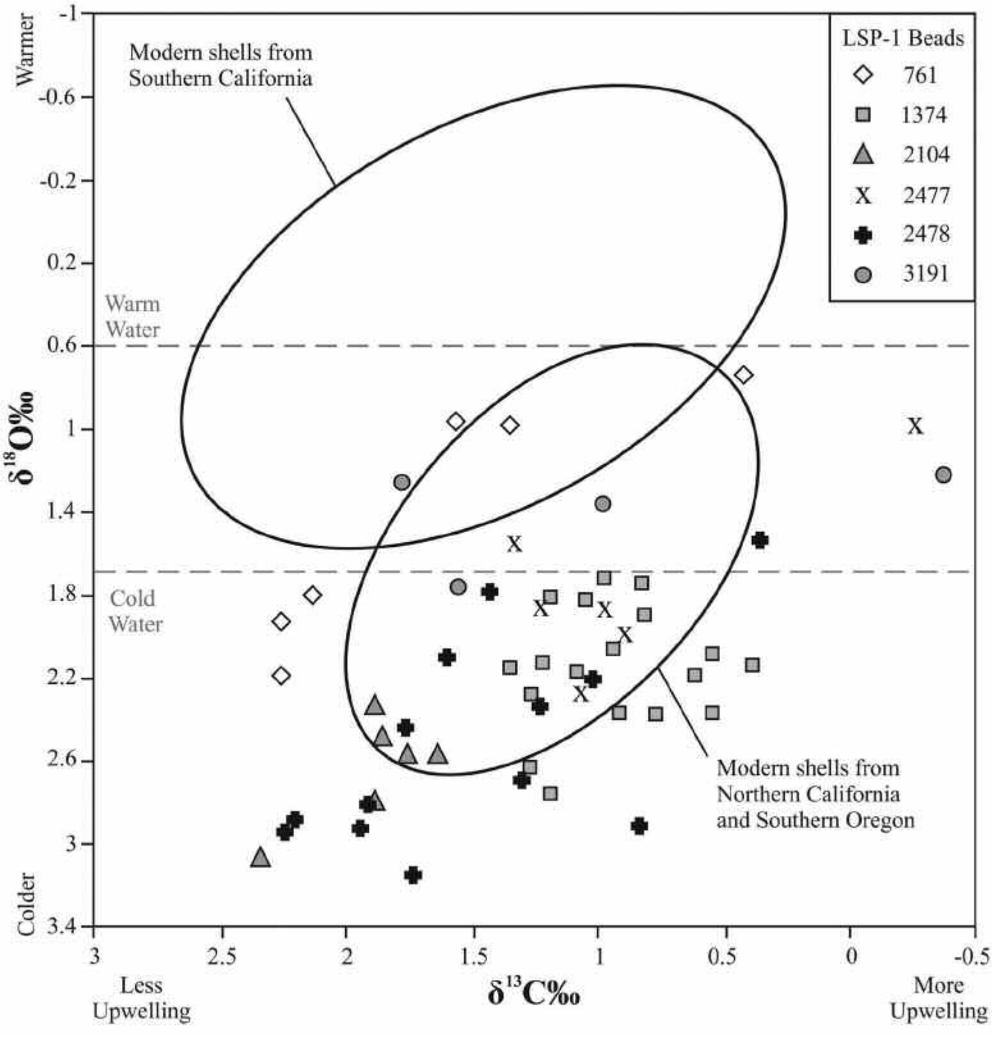

Figure 4. Carbon and oxygen isotope values of sampled *Callianax* beads from LSP-1. The ovals represent the range of values obtained on modern *Callianax* shells from points between Big Sur and southern Oregon (northern source region) and locations south of Point Conception (southern source region). The upper dashed line illustrates the cutoff (<.6‰) in $\delta^{18}O$ values above which one or more individual readings indicates growth south of Point Conception. The lower dashed line illustrates the cutoff (>1.7‰) in $\delta^{18}O$ values below which one or more individual readings indicates growth north of Point Conception.

Discussion

The sample of Olivella beads from LSP-1 is small but significant for several reasons. First, four of them are the oldest directly dated marine shell beads in the northern Great Basin and among the oldest known shell beads in the western United States. They support previous claims of early Holocene bead use in the northern Great Basin based on less secure stratigraphic associations (Jenkins et al. 2004). Second, together with the other directly dated early Holocene shell beads from inland sites (e.g., Fitzgerald et al. 2005) and obsidian from inland sources at coastal sites in California and Oregon (e.g., Davis et al. 2004; Erlandson et al. 2011; Lebow et al. 2016), the LSP-1 beads suggest that far-reaching exchange networks were established relatively early in humans' tenure in western North America. Although many lithic artifacts from early Holocene assemblages in the Great Basin often display substantial transport distances, researchers generally do not emphasize exchange as a primary conveyance mechanism, instead favoring direct procurement (Beck and Jones 2011; Jones et al. 2003; Smith 2010, but see Newlander 2015). In light of the growing number of early Holocene inland sites with shell beads, it seems increasingly likely that exchange was more common during that period than traditionally assumed. Third, although they were discarded during separate occupations (see Figure 3) Olivella beads from LSP-1 were consistently obtained from the northern source region, suggesting that socioeconomic connections between coastal populations and groups visiting Warner Valley were fairly consistent across time.

Finally, the LSP-1 beads provide only the second sample of sourced Olivella beads from the northern Great Basin. Bottman (2006) analyzed 23 Olivella beads from middle and late Holocene components in the Fort Rock Basin, more than 100 km from northern Warner Valley. Isotope values were most variable for the middle Holocene samples, which he suggests is evidence of multiple exchange networks or increased diversity resulting from the larger sample size. Most beads, however, appear to have come from southern California. The late Holocene beads from Bottman's (2006) sample all returned values consistent with a southern California origin. Bottman's (2006) results support Vellanoweth's (2001) and Jenkins and Erlandson's (1996) earlier contentions that OGR beads from the Fort Rock Basin likely originated in southern California. When considered together, the Fort Rock Basin and Warner Valley data suggest that while the exchange systems through which shell beads were acquired may have been fairly regular within particular basins for significant spans of time, they may have varied considerably in different parts of the northern Great Basin. Direct AMS dating and isotope analysis of additional beads from the region will undoubtedly help further identify potential variability.

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Supplemental Materials. Supplemental materials are linked to the online version of this paper, which is accessible via the SAA member login at www.saa.org/member-login:

Supplemental Tabl~~e S1. Individual isotope valu~~es.

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Notes

1. This bead was directly AMS dated (Beta-101739) and returned a 2σ calibrated age range of 8673–8325 cal B.P. using a marine reservoir correction rate of 240 ± 50 developed by Moss and Erlandson (1995) for the Oregon Coast.

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