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The Distribution of *Olivella* Grooved Rectangular Beads in the Far West

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Olivella-*shell grooved rectangular beads, or N series beads as classified by Bennyhoff and Hughes (1987), are the oldest* Olivella *wall beads in central California, dating to a narrow time-frame during the mid-Holocene. This bead type, thought to have originated in the southern Santa Barbara Channel islands, has been identified across a wide geographical area, including most of central and southern California and portions of Nevada and southeastern Oregon. Used by some to argue for a Middle Holocene Uto-Aztecan socioeconomic interaction sphere, we demonstrate that their broad geographical range is simply a barometer of the widespread transmission of cultural knowledge and the establishment of extensive trade networks circa 5,000 years ago. We also present new isotopic data that suggest that at least some of these beads were manufactured from shells obtained north of Point Conception, beyond the greater Santa Barbara Channel region.*

In 1958, James Bennyhoff and Robert Heizer published *Cross-Dating Great Basin Sites by California Shell Beads*, in which they described an unusual type of rectangular *Olivella biplicata*[1] bead found at Lovelock Cave, Nevada. Bennyhoff and Heizer described it as a "grooved rectangle with a sawed perforation" (1958:69).[2] The 16 specimens they reported lacked detailed provenience, but they assumed that they represented "the Early and Transitional Lovelock Periods" and speculated that they were a "local attempt to replace the early drilled rectangles when the trade of the latter beads was cut off" (1958:69). In a subsequent, unpublished manuscript by Bennyhoff and Dave Fredrickson—*Olivella Shell Bead Typology* (1967), the forerunner to the classic Bennyhoff and Hughes (1987) publication—these beads were given the designation N, or grooved rectangular *Olivella*, and were thought to be "restricted in occurrence in Nevada" (Bennyhoff and Fredrickson 1967:28). By 1987, based on the work of Chester King (1990), the known geographic range had been expanded to include four southern California sites, including the Little Harbor site (CA-SCAI-17) on Santa Catalina Island, and the Nursery site on San Clemente Island (Bennyhoff and Hughes 1987). At that time, Bennyhoff and Hughes (1987:141–2) assigned the N series rectangular beads to a broad time range between about 3,900 and 580 B.P.

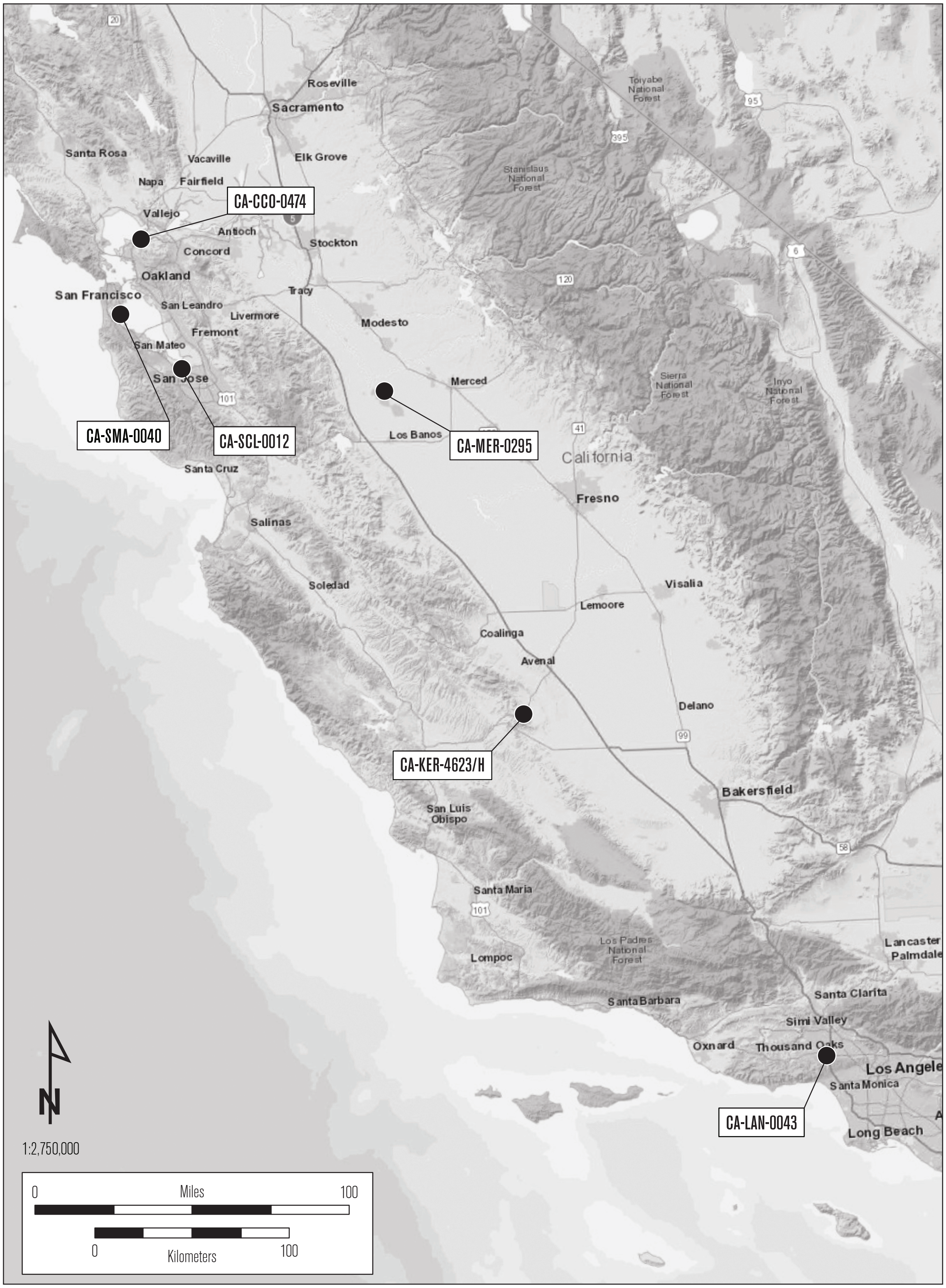

Figure 1. Location map of OGR beads recovered from archaeological sites.

Table 1

NEW DIRECT AMS RADIOCARBON DATES FOR OGR BEADS

Lab Number	Location	Site	Catalog Number	Conventional ^{14}C Age (RYBP)	Max $\delta^{13}C$ (‰, VPDB)	cal B.P. @ 2Σ with (Median Probability)	Reference
Beta-227551	Kern County Temblor Ranges	CA-KER-4623/H	184-011	4,850 ± 40	−0.7	5,000 (4,850) 4,695	Tiley 2008
Beta-227541	Kern County Temblor Ranges	CA-KER-4623/H	016-01	4,920 ± 50	0	5,170 (4,930) 4,795	Tiley 2008
Beta-262216	Merced County Great Valley Grassland SP	CA-MER-295	P 1171-10-682	5,090 ± 40	+0.4	5,300 (5,230) 5,020	This paper
Beta-456064	Los Angeles County (Encino)	CA-LAN-43	91724	5,000 ± 30	+1.4	5,225 (5,040) 4,875	This paper

Note: All conventional ages are calibrated with CALIB 7.1 (Stuiver and Reimer 1993) and ΔR of 225 ± 35. All eleven of the other directly dated OGR beads are listed in Table 2 of Vellanoweth et al. (2014).

After the 1980s, direct Accelerator Mass Spectrometry (AMS) radiocarbon dating of N series beads, by then commonly referred to as *Olivella* Grooved Rectangles (OGR), re-assigned their temporal range to a narrow time span within the Middle Holocene (Jenkins and Erlandson 1996; Vellanoweth 2001; Vellanoweth et al. 2014). AMS dating also revealed that the OGR was the earliest form of *Olivella* "wall" bead in central California, including the oldest directly-dated wall bead in all of California (Byrd et al. 2017). Wall beads are manufactured from the body whorl, the outermost and largest whorl of the *Olivella biplicata* shell. Throughout the 1980s and 1990s, finds of OGR beads continued to expand their geographic range to include more sites in Los Angeles County (Vellanoweth 1995; Wiley-Desautels 2013), Orange County, Santa Catalina and San Nicolas islands (Howard and Rabb 1993; Macko 1998), Kern County (Jackson et al. 1998), and southeastern Oregon (Jenkins and Erlandson 1996; Jenkins et al. 2004). Their occurrence in Fort Rock Basin, Oregon led some scholars to speculate that the distribution of OGR beads was a direct result of population migrations "by early Uto-Aztecan groups" from the northwestern Great Basin into southern California (Kennett et al. 2007). Others interpreted this widely distributed and unique bead type as demarcating a "sphere of socioeconomic interaction" (Howard and Raab 1993:7) or a "Uto-Aztecan Interaction Sphere" (Jenkins et al. 2004). The inferred association with the Uto-Aztecan language family was based on the "known" geographic distribution of OGR beads at that time, thought to be restricted to areas "historically inhabited by Uto-Aztecan speaking people" (Vellanoweth 1995:18).

More recently, Vellanoweth et al. (2014) have documented OGR beads from regions of California not previously reported, such as San Diego County (Schulz 2011) in the south, and San Mateo (Clark 1998) and Santa Clara counties (Arrigoni et al. 2008) in the San Francisco Bay area of central California. Vellanoweth et al. (2014) hypothesize that San Nicolas Island was the epicenter for OGR bead production, citing evidence for their local manufacture in conjunction with the presence there of the highest number and greatest diversity of OGR-styled beads in western North America.

In this paper, we further expand the geographic range of OGR beads in the San Joaquin Valley, report new AMS dates from beads found in Kern, Los Angeles, and Merced counties, and provide corroborating Middle Holocene radiocarbon dates from sites where OGR beads have previously been found. In addition, we present stable isotopic data that suggest the manufacture of OGR beads extended beyond the Santa Barbara channel region of southern California and included shells obtained from localities north of Point Conception.

NEW SITES AND DATES FOR OGR BEADS

In addition to the sites previously reported by Vellanoweth et al. (2014:Table 5), we have identified three additional central California sites that contain OGR beads, CA-KER-4623/H (Tiley 2008), CA-MER-295 (Bethard and Basgall 2000), and CA-CCO-474/H (Estes et al. 2002; Fig. 1). We have directly dated two OGR beads from KER-4623/H and one bead from MER-295 (Table 1). A fourth directly-dated OGR bead comes

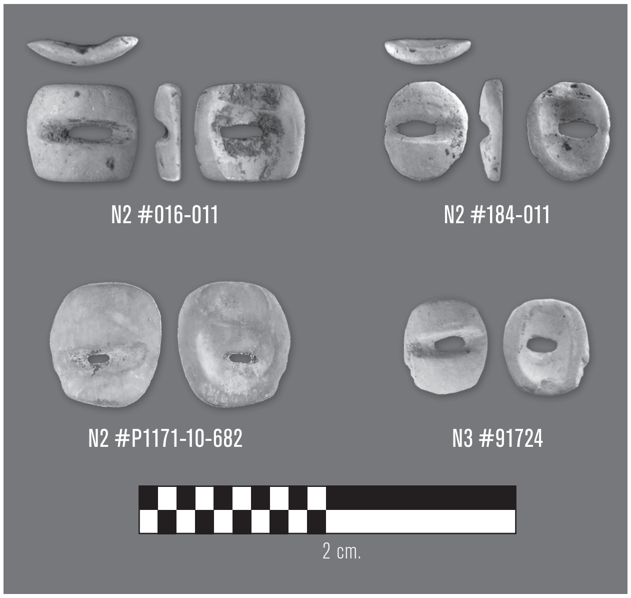

Figure 2. OGR beads from CA-KER-4623/H, CA-MER-295 and CA-LAN-43.

from LAN-43, where Vellanoweth (2001) also reported a Middle Holocene age for this bead type (Fig. 2). Supporting Middle Holocene radiocarbon dates from sites with OGR beads, including CA-CCO-474/H and CA-SMA-40 on San Francisco Bay, and CA-MER-295 in the northern San Joaquin Valley, are listed in Table 2. Dates from CA-CCO-474/H and CA-MER-295 are reported here for the first time, while Clark (1995) originally reported the two dates from CA-SMA-40. Table 3 presents metrical information available for the four directly-dated OGR beads.

The new AMS dates obtained for this study were analyzed by two different laboratories, including Beta Analytic Inc. (BETA) and Eckert-Ziegler Vitalea Arch-lab (Vitalea), using similar methods. At both labs, shell was acid etched prior to graphitization. The resulting ages were corrected for natural isotopic fractionation by split sample measurement on a mass spectrometer (BETA) or direct measurement in the BioMICADAS AMS unit (Vitalea) to account for both natural and machine fractionation (these values are unique to each sample and not reported). All radiocarbon dates discussed here were calibrated to years before present (cal B.P.) using CALIB version 7.1 and (where applicable) the IntCal13.14c dataset (Reimer et al. 2013; Stuiver and Reimer 1993). Radiocarbon dates are given in Table 1 (direct dates on OGR beads) and Table 2 (dates on materials directly associated with OGR beads) under their original lab number and are reported as the calculated median probability with a 2-sigma (95%) confidence interval.

As shown in Table 1, calibrated AMS ages from the four OGR beads range between 5,230 and 4,850 cal B.P., falling entirely within the range of dates from eleven other previously-reported OGR beads (Vellanoweth et al. 2014). At MER-295, a second assay from a spire-lopped *Olivella* (A1a) bead (Table 3) returned a median probability age of 5,020 cal B.P., confirming a Middle Holocene component at the site. This age estimate is supported by a mean Napa Valley obsidian hydration value of 6.4μ (n=7) and the presence of a Middle Holocene-aged side-notched point (Bethard and Basgall 2000; Kaijankoski and Rosenthal

Table 2

CORROBORATING AMS RADIOCARBON DATES FROM SITES WITH OGR BEADS

Lab Number	Location	Site	Material	Conventional ^{14}C Age (RYBP)	cal B.P. @ 2Σ with (Median Probability)	Reference
WSU-3979	San Mateo (west shores of San Francisco Bay)	CA-SMA-40	Charcoal	4,530 ± 150	4,847 (5,178) 5,581	Clark 1998
WSU-3967	San Mateo (west Shore of San Francisco Bay	CA-SMA-40	Charcoal	5,155 ± 210	5,471 (5,920) 6,395	Clark 1998
ULN-15D011	Hercules (east shore of San Francisco Bay)	CA-CCO-474/H	Mussel	5,095 ± 35[a]	4,907 (5,080) 5,257	This paper
Beta-489924	Merced County Great Valley Grasslands SP	CA-MER-295	*Olivella* bead	4,990 ± 30[b]	4,865 (5,020) 5,210	This paper

Note: The calendar age for CA-CCO-474/H was generated using a ΔR of 299 ±35 in the CALIB 7.1 Program based on average of reservoir ages determined for the interior of San Francisco Bay.

[a] 13C/12 C ratio not reported.

[b] 13C/12C ratio +1.7.

Table 3

METRICS FOR NEW OGR BEADS

Site	Catalog #	Maximum Diameter	Minimum Diameter	Thickness	Perforation Diameter
CA-KER-4623	016-011	5.9	5.3	1.5	n/r
CA-KER-4623	184-011	5.3	4.4	1.2	n/r
CA-MER-295	P1171-10-682	6.5	5.9	1.4	1.5
CA-LAN-43	91724	4.7	4.3	1.2	3.0/1.2[a]

Note: n/r perforations not measured by original researchers.

[a]Outside length and width of perforation.

2018). At KER-4623/H, three other Middle Holocene dates were previously reported by Tiley (2008) from the lower midden, Component III, where the OGR beads were found. These include a date of 6,300 cal B.P. (Beta-227549) from a Small Barrel *Olivella* bead (Type B2a), 5,920 cal B.P. (Beta-221312) from a hearth, and 5,460 cal B.P. (Beta-221306) from unidentified organic material.

ADDITIONAL SITES WITH OGR BEADS AND THEIR ARCHAEOLOGICAL CONTEXT

Three other sites in the San Francisco Bay area have also produced OGR beads, including CA-SMA-40 and CA-SCL-12, previously reported by Vellanoweth et al. (2014), and CA-CCO-474/H (Estes et al. 2002; Rosenthal and Meyer 2004). Both CA-CCO-474 and CA-SMA-40 have yielded radiocarbon ages between 5,920 and 5,080 cal B.P. (Table 2), supporting a mid-Holocene association for OGR beads at these sites. Furthermore, the three OGR beads from CCO-474/H were found in the same burial lot (Burial 8) as two *Amphissa* spp. beads. As far as we know, these latter beads have not been reported from any other site in central California, and are rare in the Santa Barbara channel region, identified only in King's (1990:238–239, 285) Eyb phase, dated between 4,870 and 4,432 cal B.P.

Although the OGR beads from SCL-12 on the San Francisco peninsula (Fig. 2) remain undated, they were found in a single grave (Burial 35) in a discrete cemetery involving seven individuals, situated about 500 meters north of the shell midden and other burials at the site. In addition to 19 OGR beads, Burial 35 also contained 117 other *Olivella* wall beads described as "saddles," a bead type typically associated with the late Middle Period, between 1,530 and 995 cal B.P. (Groza et al. 2011). However, neither Burial 35 nor the cemetery was directly dated, and no illustrations or metrical descriptions of the so-called "saddle" beads were reported (Arrigoni et al. 2008). It is very likely that these were the same type of rectangular beads with rounded corners (Type L3?; Bennyhoff and Hughes 1987) reported from East Bay site CA-CCO-637, and directly dated to 4,670 cal B.P. (Rosenthal and Meyer 2000).

Despite the ambiguities associated with the bead lot from SCL-12, it is noteworthy that so few OGR beads have been identified among the hundreds of thousands of *Olivella* beads previously reported in the San Francisco Bay region. Likewise, of the more than 500 directly-dated *Olivella* wall-bead lots from central California (see Chapter 7 in Byrd et al. 2017:7–13 to 7–20) only Burial 14 at CCO-637 is dated older than 4,600 cal B.P. The rarity of Middle Holocene bead lots in this region is largely a product of Late Holocene landscape evolution. More than 70% of known Middle Holocene archaeological sites in the Bay Area are buried (Meyer 1996, 2011; Meyer and Rosenthal 2008; Rosenthal and Meyer 2004). All of the sites containing OGR beads in the San Francisco Bay Area and San Joaquin Valley are surface deposits associated with very ancient landforms that have been stable since the late Pleistocene or early Holocene (see Rosenthal and Meyer 2004). It is likely that buried Middle Holocene sites containing OGR beads will eventually be discovered in this region, as well.

STABLE ISOTOPE ANALYSIS

Olivella-shell calcium carbonate ($CaCO_3$) accumulates in narrow sequential bands that incorporate information about water conditions at the time of growth (Krantz et al. 1987). For example, the $^{18}O/^{16}O$ ratio ($\delta^{18}O$) of biogenic calcite and aragonite, the dominant minerals present in *Olivella* shells, is strongly correlated with water temperature at the time of growth (Grossman and Ku 1986; Kim and O'Neil, 1997). Colder temperatures produce higher $\delta^{18}O$ values in a shell, and clines in sea surface temperature along the California coast result in a $\delta^{18}O$ range of up to 5‰ in *Olivella*-shell aragonite from southern to northern California (Eerkens et al. 2005). Shell $\delta^{18}O$ also varies with salinity, with lower salinities producing lower shell $\delta^{18}O$ values. Similarly, carbon isotope ratios ($\delta^{13}C$) in shell are strongly correlated

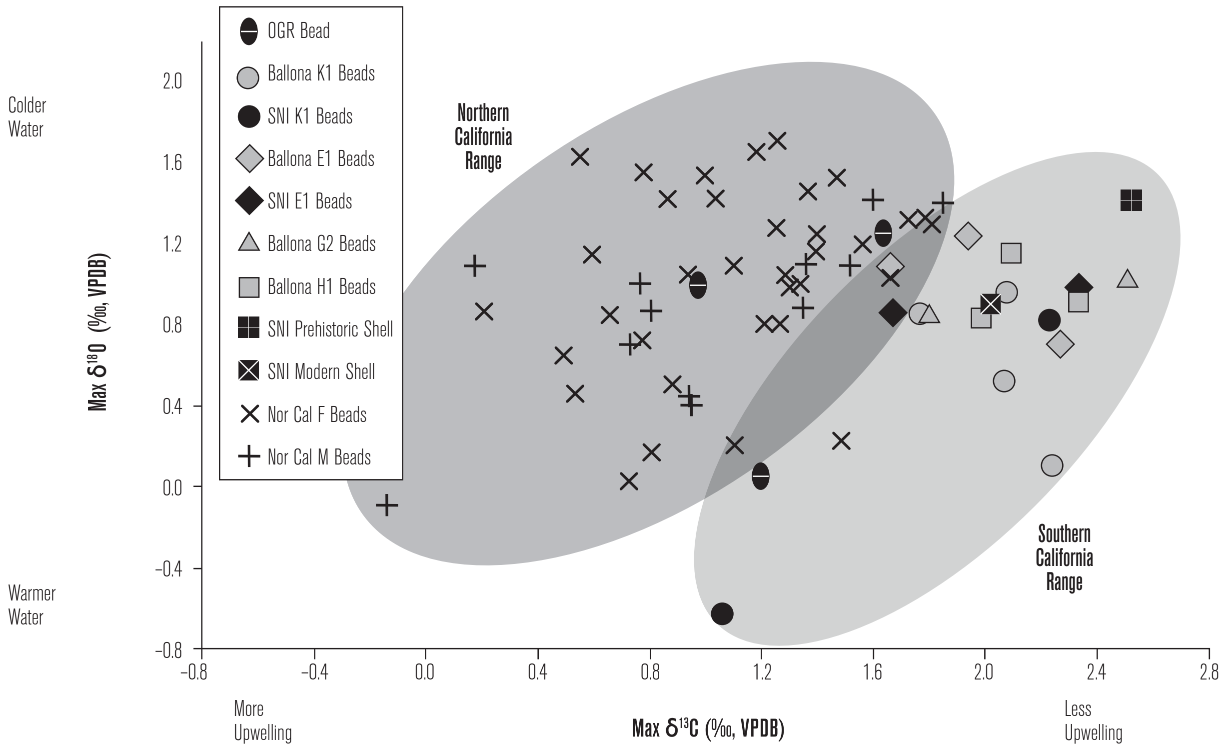

Figure 3. Maximum $\delta^{18}O$ and $\delta^{13}C$ values for six bead types recovered from Southern and Central California.

with the source of dissolved inorganic carbon (ΣCO_2) in seawater (McConnaughey et al. 1997). Along the California coast, $\delta^{13}C$ is strongly related to seasonal upwelling of ^{13}C-depleted waters, a signal which is stronger in northern than in southern California (Friederich et al. 2002; Korchagin and Lozovatsky 1998).

Because water temperatures and upwelling patterns vary in a predictable manner along the California coast, $\delta^{18}O$ and $\delta^{13}C$ signatures preserved in a shell can provide information about where a shell was growing when harvested. For shells traded to the interior of California, we can use these tracers to infer geographic information about the shells' origins. This approach has been used in California and Oregon to reconstruct certain aspects of the organization and antiquity of ancient shell-bead trade networks (Bottman 2006; Eerkens et al. 2005, 2009, 2010; Smith et al. 2016).

Because water conditions vary throughout the year, our sampling strategy includes taking multiple independent samples from each bead, from different and sequential growth rings. We can thus capture some degree of variation in the growing conditions involving a particular shell, which assists us in identifying a shell's geographic origin. The amount of time represented in these samples depends on the age of the shell (smaller shells are younger and grow faster) and the size of the bead (larger beads provide more samples and represent more ontogenetic time).

Previous studies have shown that there is a difference in the isotopic composition of modern and prehistoric shells growing north of Point Conception versus those growing south of it (Eerkens et al. 2005). This includes both modern and prehistoric *Olivella* shells collected on San Nicolas Island, which group with other shells collected south of Point Conception (Eerkens et al. 2010).

Studies of archaeological beads show a similar distinction. For example, Figure 3 plots maximum $\delta^{18}O$ and $\delta^{13}C$ values for four bead types recovered from the Ballona wetlands in Los Angeles County and from San Nicolas Island in southern California (data from Eerkens et al. 2010), including H1 (n=3; needle-drilled), E1 (n=5; Lipped), G2 (n=2; Saucer), and K1 (n=6; Callus Cup). Cannon (2006) found *Olivella* bead production debris as well as discarded bead blanks in various states of production, demonstrating that many of these bead types were produced directly on San Nicolas Island, including all of the samples included in Figure 3 (filled black symbols). Figure 3 also plots two bead types, M1/2 (n = 12; Sequin) and F2/3 (n = 33; Saddle), that are stylistically unique to central California, and were recovered from a range of archaeological sites in the San Francisco Bay area and California Delta. Each M1/2 and F2/3 bead represented in the figure, as an "x" or "+" symbol, was sampled in multiple locations, for an average of six isotopic samples per bead.

Figure 3 shows there is isotopic separation between most archaeological beads recovered in these two geographic regions, with beads from northern California displaying isotopic values consistent with colder maximum temperatures and greater upwelling. However, the non-OGR beads and shells included in Figure 3 represent only the last 2,500 years. Current estimates suggest that sea-surface temperatures along the California coast during the time of OGR bead production were approximately 0.2–0.4° C. warmer, on average, than today (Marcott et al. 2013). Such a temperature increase in the Middle Holocene should have resulted in a decrease in $\delta^{18}O$ shell aragonite of approximately 0.05–0.2‰ (Grossman and Ku 1986; Rosenheim et al. 2009), a minor amount relative to the large differences between southern and northern California.

We sampled three OGR beads for $\delta^{18}O$ and $\delta^{13}C$, two from CA-KER-4623 and one from CA-LAN-43. Full isotopic results are presented in Table 4, with maximum $\delta^{18}O$ and $\delta^{13}C$ values plotted in Figure 3.[3]

Stable isotope data from one of the OGR beads from CA-KER-4623 (184-011) clearly falls within the range of other archaeological beads from northern California. It does not plot close to the prehistoric and modern shells collected from San Nicolas Island, nor to the beads from San Nicolas Island and mainland Los Angeles County. We assign this bead to a source-zone north of Point Conception. The other CA-KER-4623 bead falls into this same isotopic range, but is closer to the zone of overlap with southern California. Given that sea-surface water temperatures were warmer in the Middle Holocene (causing the source ellipses in Fig. 3 for northern and southern California to drop slightly lower on the X-axis during this time period), we also assign this bead to a source north of Point Conception. The third bead from CA-LAN-43 also plots on the margin of the zone of isotopic overlap between southern and northern California but is closer to the southern California group. As a result, we tentatively assign this bead to the southern California source zone.

Table 4

RESULTS OF O AND C STABLE ISOTOPE ANALYSIS ON THREE OGR BEADS

Site	Bead #	Sample #	$\delta^{13}C$	$\delta^{18}O$
CA-KER-4623	184-011	1	0.97	1.00
CA-KER-4623	184-011	2	0.93	0.78
CA-KER-4623	184-011	3	0.80	0.83
CA-KER-4623	016-011	1	1.64	1.25
CA-KER-4623	016-011	2	1.53	1.09
CA-KER-4623	016-011	3	1.60	1.07
CA-KER-4623	016-011	4	1.60	1.04
CA-KER-4623	016-011	5	1.30	0.81
CA-LAN-43	91724	1	0.99	−0.36
CA-LAN-43	91724	2	1.05	−0.20
CA-LAN-43	91724	3	1.07	−0.09
CA-LAN-43	91724	4	1.20	0.05

Together, the three OGR beads display a large degree of isotopic variation, overlapping with other prehistoric beads from southern *and* northern California. This high degree of variation is most consistent with the interpretation that OGR beads were produced in a range of geographic locations, and not in a single locale.

DISCUSSION AND CONCLUSIONS

A comparatively short manufacturing period for OGR beads is indicated by the summed probability distribution of all 15 directly-dated examples from Oregon to San Diego (see Vellanoweth et al. [2014] for a list of 11 dates not reported here). The combined probability distribution (ΔR of 225+/–35; OxCal, version 4.3 [Brock Ramsey 2013, 2001]) suggests that all of these beads were manufactured within a very narrow period of time (Fig. 4), with a duration ranging between 180 years (5,130–4,950 cal B.P.; 68.5% probability) and 330 years (5,220–4,890 cal B.P.; 95.4% probability). This rate of change is commensurate with shell-bead style horizons documented for the Late Holocene (e.g., Groza et al. 2011).

The narrow manufacturing span for OGR beads during the Middle Holocene is remarkable, given their

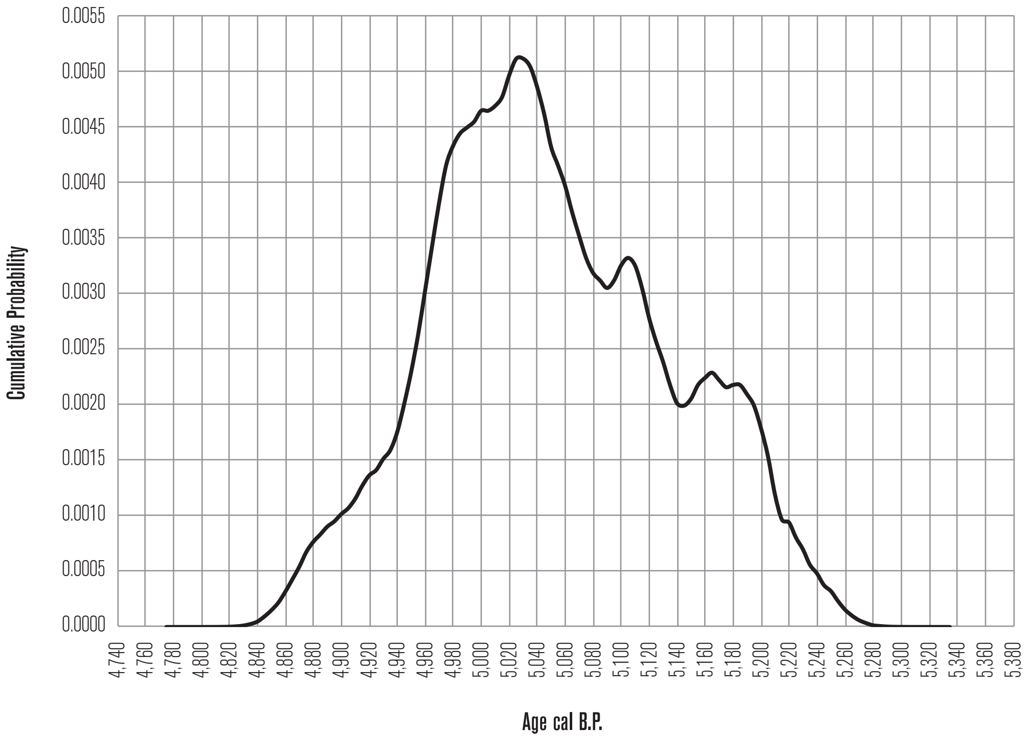

Figure 4. Probability distribution for all 15 directly dated OGR beads from Oregon to San Diego.

distribution over a large swath of western North America. As stated earlier, OGR beads are the earliest directly-dated *Olivella* wall-bead type and are among the first in a long developmental sequence of distinctive types produced in California and exchanged throughout Western North America, a process that continued into the Mission Period (Bennyhoff and Hughes 1987; Hylkema 2009; King 1990). Rosenthal's essay on the trajectory of shell-bead exchange in central California points out that OGR and other Middle Holocene wall beads represented "a substantial increase in the amount of labor devoted to [*Olivella* bead] manufacture" (Rosenthal 2011:94), which suggests they also represent the advent of incipient craft specialization. Up until now, the emergence of craft specialization has been attributed only to the area south of Point Conception (i.e., the Santa Barbara Channel area), and by extension, to San Nicolas Island, where extensive evidence for the manufacture of Middle Holocene OGR and other wall bead styles has been found (Cannon 2006; Vellanoweth et al. 2014). The importance of craft specialization for the emergence of social complexity among native people in the Santa Barbara channel region has been well-documented (Arnold 1987, 1992, 1993, 1995, 2004; Arnold and Graesch 2001; Arnold and Munns 1994; Gamble 2008; Kennett 2005; and King 1990). On the northern Channel Islands, shell bead-making reached its industrial peak during the Late Holocene, and along with plank canoe (*tomol*) construction on the adjacent coast, represents to some the apex of technological sophistication and craft specialization in pre-contact California (Gamble 2002; Heizer 1938; Jones and Klar 2005). Hence, it is not surprising that the origins of social and technological innovation have deep roots in southern California.

However, there are strong indications that *Olivella* wall beads were also manufactured in central California, beginning at least 4,000 years ago (Eerkens et al. 2009) and continuing until the time of contact (Rosenthal 2011). The regional distribution of stylistically distinct beads in central California argues for a limited number of "coastal" production centers. These manufacturing sites have yet to be located (Rosenthal 2011). Nevertheless, the limited isotopic evidence presented here suggests that the origins of this industry also began north of Point Conception in the Middle Holocene, when coastal residential mobility decreased and population densities increased (Jones et al. 2007). Assuming that the innovation of creating wall beads with a sawed perforation did originate in the southern Channel Islands (Vellanoweth et al. 2014), it is noteworthy that other prehistoric artisans quickly adopted the concept and style and retransmitted it over a large geographic and multicultural region.

The argument that OGR beads are a symbol of population migration or a socioeconomic interaction sphere of Uto-Aztecan people is not compatible with linguistic reconstructions for the Middle Holocene. Rather, linguistic data indicate Uto-Aztecan speakers arrived relatively late on the southern California coast and in the northwestern Great Basin (Golla 2007, 2011). As demonstrated both in this paper and elsewhere (e.g., Vellanoweth et al. 2014), OGR beads are found in regions such as the San Francisco Bay area and the San Joaquin Valley where there is no evidence for Uto-Aztecan speakers at any point in the distant past. Rather, it seems that—like the distribution of Early Holocene spire-lopped beads (e.g., Fitzgerald et al. 2005), or the many Late Holocene wall-bead types from the Pacific coast (e.g., Bennyhoff and Hughes 1987)—the distribution of OGR beads is a reflection of regional economic and social interaction. As such, we believe the rapid transmission of bead production technology and the development of an extensive trade network best explain the wide appearance of OGR beads across California and the western Great Basin for a brief period during the Middle Holocene, initiating an industry and a pattern of inter-regional exchange of information and goods that continued through the Late Holocene.

NOTES

[1]The scientific name of the purple olive shell, *Olivella biplicata*, has been changed to *Callianax biplicata* (Carlton 2007). We retain the term *Olivella* here due to its historical significance within California archaeology, going back at least to the bead classification of E. W. Gifford in 1947.

[2]Bennyhoff and Hughes were not the first to recognize this unusual bead type; it had been previously described by William Orchard in 1929 in a volume entitled *Beads and Beadwork of the American Indian*, published by the Museum of the American Indian/Heye Foundation, formerly of New York but now in Washington D.C.

[3]The whole OGR bead from CA-MER-295 was used for the radiocarbon date and therefore was not available for stable isotope analysis.

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