A HIGH-PRECISION CHRONOLOGY FOR TWO HOUSE FEATURES AT AN EARLY VILLAGE SITE ON WESTERN SANTA CRUZ ISLAND, CALIFORNIA, USA

Christopher S Jazwa1,2 • Lynn H Gamble3 • Douglas J Kennett1

ABSTRACT. We establish a high-precision radiocarbon chronology for 2 house depressions at CA-SCRI-333, a large prehistoric village on the western end of Santa Cruz Island, California, USA. SCRI-333 is a large mound composed of a shell midden with more than 50 house depressions evident across its surface. We develop a chronology of occupation and activity for 2 of these depressions (6 and 32) based on a stratified sequence of accelerator mass spectrometry 14C dates. Carbonized twig and marine shell (Mytilus californianus) samples were selected from well-defined stratigraphic sections. Analytical error for these measurements is ±20 14C yr. We use a Bayesian statistical framework to propose an age model for the deposition of 2 features that may be associated with house construction. These data indicated that the features were not contemporaneous and suggest that house construction may have been sequential during the site’s occupation, a hypothesis that needs to be tested further. The methodologies used in this study have the potential to increase the chronological precision of household archaeology at SCRI-333, on the northern Channel Islands, and around the world.

INTRODUCTION

One of the greatest challenges facing archaeologists working at sites with multiple residential features is determining if the features were contemporary. Sites with multiple houses occupied at the same time are different than those with houses constructed sequentially over a long period of time. Superficially, they may appear similar, but they may represent completely different economic, social, and political phenomena. The combination of high-precision accelerator mass spectrometry (AMS) 14C dating (±15–20 14C yr) with calibration and modeling within a Bayesian statistical framework can be used to determine if features were contemporaneous. Ultimately, the precision and accuracy of these chronologies hinge upon stratigraphic observations made in the field and the selection and dating of appropriate materials below, within, and above strata.

In this paper, we establish a chronology for the stratigraphy associated with 2 house depressions at El Montón (CA-SCRI-333), a large mound site on the western end of Santa Cruz Island, California, near Fraser Point (Figure 1). This site, which is situated near the highly productive Forney’s Cove, contains more than 50 depressions previously interpreted as house features. The deposits represent human activity extending from the Middle Holocene (5920–5540 cal BP, 2σ) through the Late Holocene (825–665 cal BP, 2σ; Table 1; Wilcoxon 1993; Glassow et al. 1994; Kennett 1998). We collected a combination of organic (carbonized twigs) and carbonate (California mussel shell) samples during excavation along with 3-dimensional provenience information to maintain the spatial relationships between the samples within the stratigraphic section. Analytical error of the radiocarbon dates is ±20 14C yr (Beverly et al. 2010; Kennett et al. 2011).

We use the stratigraphic relationships between samples observed in the field to model the calibrated age for a distinctive stratum interpreted previously by Wilcoxon (1993) to be associated with house construction in 2 surficial depressions. We determine that at least 285 yr separate the deposition of these 2 features. More generally, we argue that high-precision AMS 14C dating combined with Bayesian statistical modeling can be used to address chronological questions related to human settlement patterns (e.g. Kennett et al. 2011, 2012; Culleton et al. 2012; Kennett and Culleton 2012).

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BACKGROUND: CALIFORNIA’S NORTHERN CHANNEL ISLANDS AND THE EL MONTÓN SITE

Santa Cruz Island is the largest of California’s northern Channel Islands, a series of 4 offshore islands and associated islets that are separated from the California mainland by the Santa Barbara Channel. From west to east, the islands are San Miguel, Santa Rosa, Santa Cruz, and Anacapa (Figure 1). There is compelling evidence that people first visited the islands at least 13,000 yr ago, at which time sea levels were lower and the islands were all connected to form 1 superisland, Santarosae (Johnson et al. 2000; Kennett 2005; Rick et al. 2005; Erlandson et al. 2007, 2008, 2011; Kennett et al. 2008). The earliest evidence of more permanent settlement (e.g. villages) on the northern Channel Islands dates around 8000–7000 yr ago (Winterhalder et al. 2010), but earlier settlements were likely inundated by postglacial sea-level rise, and permanent occupation may have begun even earlier (see Braje et al. 2013). Permanent settlement on the northern Channel Islands is frequently defined archaeologically by the presence of substantial residential middens, the presence of cemeteries, or the presence of houses (including house depressions; Winterhalder et al. 2010:471). SCRI-333 meets these criteria.

Several meters of midden accumulation are visible at SCRI-333 and the deepest deposits contain a large number of red abalone (*Haliotis rufescens*) shells. Along with the Punta Arena site (SCRI-109) on the south coast, SCRI-333 is one of the 2 largest red abalone middens on the island (Glassow 2013). Glassow (1993, 2013; Glassow et al. 1988, 1994, 2008, 2012; also Raab 1992; Salls 1992; Braje et al. 2009) has argued that cooler water temperatures favored this species in the intertidal zone (or shallow subtidal) for a brief time during the Middle Holocene (6300–5300 cal BP). This red abalone stratum is deeply buried beneath several meters of Late Holocene deposition.

Early excavations at SCRI-333 were conducted by Olson (1930) and Van Valkenburgh (1933), but the first systematic excavations of the midden deposits and house depressions were conducted by L R Wilcoxon in the early 1980s. Wilcoxon (1993:141) was interested primarily in activity areas
Table 1 Radiocarbon dates from SCRI-333, including 2σ calibrated, unmodeled ranges. Dates are calibrated using OxCal v 4.1.3 (Bronk Ramsey 2009) and the Marine09 calibration curve (Reimer et al. 2009).

<table>
<thead>
<tr>
<th>Lab #</th>
<th>Provenience</th>
<th>Material</th>
<th>Conv. $^{14}$C age (BP)</th>
<th>2σ cal BP (unmodeled)</th>
<th>Reference</th>
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<td>Beta-35005</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>House Depression 6</strong>&lt;br&gt;UCR-1953&lt;br&gt;UCR-1954&lt;br&gt;UCR-1832&lt;br&gt;UCR-1530&lt;br&gt;UCIAMS-87889&lt;br&gt;UCIAMS-87890&lt;br&gt;UCIAMS-87891&lt;br&gt;UCIAMS-87892&lt;br&gt;UCIAMS-94051&lt;br&gt;UCIAMS-94052</td>
<td>Unit 6A, 20–30 cmbs&lt;br&gt;Unit 6A, 120–130 cmbs&lt;br&gt;Unit 6A, 220–230 cmbs&lt;br&gt;Unit 6A, 220 cmbs&lt;br&gt;Trench 6A, 29 cmbd, Stratum B&lt;br&gt;Trench 6A, 78 cmbd, Stratum D&lt;br&gt;Trench 6B, 49.5 cmbd, Stratum B/C&lt;br&gt;Trench 6C, 61.5 cmbd, Stratum C&lt;br&gt;Trench 6C, 21 cmbd, Stratum A&lt;br&gt;Trench 6C, 84 cmbd, Stratum C</td>
<td>Charcoal&lt;br&gt;H. rufescens&lt;br&gt;Charcoal&lt;br&gt;M. californianus&lt;br&gt;Charcoal&lt;br&gt;Charcoal&lt;br&gt;Charcoal&lt;br&gt;Charcoal&lt;br&gt;Charcoal</td>
<td>1410 ± 95&lt;br&gt;4590 ± 95&lt;br&gt;5190 ± 135&lt;br&gt;2485 ± 20&lt;br&gt;3080 ± 20&lt;br&gt;2540 ± 20&lt;br&gt;2970 ± 20&lt;br&gt;3000 ± 20&lt;br&gt;3555 ± 20</td>
<td>1530–1090&lt;br&gt;4780–4210&lt;br&gt;5560–4890&lt;br&gt;2715–2470&lt;br&gt;3255–3235&lt;br&gt;3275–2505&lt;br&gt;3240–3070&lt;br&gt;3250–3025&lt;br&gt; This study</td>
<td></td>
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<tr>
<td><strong>House Depression 32</strong>&lt;br&gt;UCR-1957&lt;br&gt;UCIAMS-87888&lt;br&gt;UCIAMS-94053&lt;br&gt;UCIAMS-94054&lt;br&gt;UCIAMS-94055&lt;br&gt;UCIAMS-94056</td>
<td>Unit 32B, 10–20 cmbs&lt;br&gt;Trench 32A/B, 60 cmbd, Stratum C&lt;br&gt;Trench 32A/B, 63 cmbd, Stratum C&lt;br&gt;Trench 32A/B, 75 cmbd, Stratum D&lt;br&gt;Trench 32A/B, 20 cmbd, Stratum A&lt;br&gt;Trench 32A/B, 34 cmbd, Stratum B</td>
<td>Charcoal&lt;br&gt;Charcoal&lt;br&gt;M. californianus&lt;br&gt;M. californianus&lt;br&gt;M. californianus&lt;br&gt;M. californianus</td>
<td>2300 ± 90&lt;br&gt;2510 ± 20&lt;br&gt;2920 ± 20&lt;br&gt;3720 ± 20&lt;br&gt;1465 ± 20&lt;br&gt;3460 ± 20</td>
<td>2700–2070&lt;br&gt;2725–2490&lt;br&gt;2450–2285&lt;br&gt;3425–3250&lt;br&gt;825–665&lt;br&gt;3125–2890</td>
<td>Wilcoxon 1993:148&lt;br&gt;This study&lt;br&gt;This study&lt;br&gt;This study&lt;br&gt;This study&lt;br&gt;This study</td>
</tr>
</tbody>
</table>

*cmbs = centimeters below surface; cmbd = centimeters below its unit datum.
associated with the house depressions visible on the site’s surface. He argued that the elevated areas adjacent to these depressions contained secondary refuse deposited near the perimeters of individual dwellings. Rogers (1929) observed a similar pattern during earlier excavations along the mainland coast. Wilcoxon (1993:143–5) documented houses of different sizes (Type I, II, III, and IV, from smallest to largest) and excavated in portions of 4 house features representing each of the house types (2, 6, 11, and 32). He excavated 2 × 2 m units outside each depression in what he interpreted as the secondary refuse deposits. In addition, he excavated a 1.5 × 0.5 m trench at the interface of the depression and associated secondary refuse deposit at each location. Wilcoxon’s excavations extended through the strata that he associated with house construction into the red abalone layer below, but he did not reach the base of the shell deposits.

Wilcoxon (1993:147–8) obtained a series of ¹⁴C dates from charcoal and red abalone shells collected during his excavations. The provenience information on the charcoal samples is limited to 10-cm arbitrary levels and not specifically linked to the stratigraphic units of interest here. He collected shells for ¹⁴C dating from the red abalone layer below the unit adjacent to House Depression 6 (Unit 6A). Kennett (1998:462) later obtained 6 ¹⁴C dates from 2 California mussel (Mytilus californianus) shells from Wilcoxon’s excavations of a unit adjacent to House Depression 11 (Unit 11B). The 2σ calibrated dates run by Wilcoxon and Kennett span from almost 6000 yr ago (5920–5540 cal BP) through just over 1000 yr ago (1530–1090 cal BP; Table 1).

METHODS

In the summer of 2010, a team of archaeologists led by Lynn Gamble revisited SCRI-333 and reopened 2 of Wilcoxon’s trenches (Trench 6 and 32; Figure 2). Because the focus of the investigations that year was in the house features themselves rather than the red abalone layers or other areas of the site, the trenches were reopened to approximately 10–20 cm below the stratum that Wilcoxon (1979–1980) identified as a possible house feature (Stratum C). Each trench was then extended to better understand the morphology of this stratum at each location. This was accomplished by excavating successive 50 × 50 cm units to the south of Trench 6 and north of Trench 32. Based on the stratigraphy of the walls exposed by reopening Wilcoxon’s trenches, this extended the exposed sections of Stratum C closer to what appears to be its center at House Depression 6 and toward its edge at House Depression 32. All of these units were excavated stratigraphically in 10-cm levels. Units were successively named alphabetically, with the suffix LG for Lynn Gamble to distinguish them from Wilcoxon’s units. Trench 6 was extended 150 cm at a depth of 90 cm below its unit datum (cmbd) and Trench 32 was extended 100 cm at a depth of 80 cmbd.

Samples for ¹⁴C dating were collected during these excavations with 3-dimensional provenience information. Charcoal samples were collected directly from the trench when they were uncovered, recording depth, distance from north and east walls, and the stratum from which they were recovered. Carbonate (M. californianus) samples were collected from the south wall profile of Trench 6C-LG and the east wall profile of Trench 32A-LG after excavation was completed and strata were clearly identified.

The ¹⁴C samples were processed in 2 stages. In January 2011, we analyzed 4 charcoal samples from Trench 6 and 1 charcoal sample from Trench 32. For each, we reduced the samples to carbon dioxide at the Archaeometry Laboratory at the University of Oregon (now at Pennsylvania State University). We performed an acid-base-acid (ABA) wash using 1N hydrochloric acid and 1N sodium hydroxide, vacuum-sealed the samples, and combusted them at 900 °C. Samples were then sent to the Keck Carbon Cycle AMS Facility at the University of California, Irvine (UCI), to be graphitized and ¹⁴C dated. In June 2011, we ran 2 M. californianus samples from Trench 6 and 4 M. californianus sam-
ples from Trench 32. For each of these samples, we performed a 50% acid etch on the entire shell using an appropriate amount of 1N hydrochloric acid at room temperature. We then used a Lucas Model 980H dental drill to obtain powder from each shell (~20–30 mg), drilling along the growth axis of the shell to average variations in $\Delta R$ over the lifetime of the individual (Culleton et al. 2006). These samples were reduced to CO$_2$ using phosphoric acid, graphitized, and $^{14}$C dated at UCI.

We calibrated all of the new dates and recalibrated pre-existing dates in OxCal v 4.1 (Bronk Ramsey 2009) using the most recent atmospheric calibration curve, IntCal09, and the most recent marine calibration curve, Marine09 (Reimer et al. 2009). For the marine samples, we used an updated $\Delta R$ value for the Santa Barbara Channel region (261 ± 21 $^{14}$C yr; Brendan Culleton, personal communication, 2012; see also Jazwa et al. 2012). The revised $\Delta R$ estimate incorporates 5 new AMS $^{14}$C dates on pre-bomb (AD 1925) $Olivella$ shells collected near Santa Barbara, California, with 3 existing dates on $Mytilus$ reported by Ingram and Southon (1996; see also Kennett et al. 1997; Culleton et al. 2006), and is calculated with respect to the updated marine model age of the Marine09 curve. In OxCal, we used a Bayesian statistical model to further constrain error ranges based on the relative stratigraphic position of the $^{14}$C samples.

**RESULTS**

**Stratigraphy of the El Montón Site**

The 2 house depressions examined here have similar stratigraphic profiles. At the top of the deposits is a dark, organic soil that has been identified as Stratum A. The shell density in this stratum is less than in Stratum B below it. Stratum B is dark gray, but lighter than Stratum A. Shell density is higher than in the strata immediately above and below it, with California mussel and black abalone ($Haliotis cracherodii$) the most abundant species. We divided Stratum B into multiple substrata during the 2010 excavations, and these will be discussed individually for each feature. Stratum C is distinct in all of the excavated units. The sediment in this stratum is a light tan color (Munsell 10YR 5/2) and it has an ashy texture unlike the strata above and below. Shell in this stratum tends to be burned and is highly fragmented. In the field, we noticed that there seemed to be more sea urchin ($Strongylocentrotus$ spp.)
in this stratum compared to others. In his excavation notes, Wilcoxon (1979–1980) identified this stratum as a “house floor.” However, it is not clear yet if this stratum is a floor, or even a house-related feature, so we take a more conservative stance and identify it as Stratum C. Stratum D is the deepest level investigated here and it is so similar in character to Stratum B that the boundary between the 2 is difficult to determine in the absence of Stratum C. This lends some support to the idea that Stratum C may have been associated with house construction or occupation within a larger depositional sequence. Stratum D, however, appeared to have a slightly higher density of shell than Stratum B.

**Previous Radiocarbon Dates**

Including the tests that were run as a part of this project, a total of 27 14C dates have been obtained for SCRI-333 (Table 1). Dates that Wilcoxon (1993:147–8) ran as a part of his investigations extend from the Middle (5560–4890 cal BP, 2σ) through the Late (1530–1090 cal BP, 2σ) Holocene and are interspersed throughout this range. Even though Wilcoxon did collect provenience information for the 14C samples he submitted, it is unclear exactly which stratum they are associated with, especially given the fact that we identified several substrata of Stratum B, which he may have included as part of Stratum B or C. Furthermore, the fact that there is no horizontal provenience information associated with those samples also contributes to the difficulty in assigning them to individual strata.

Exceptions to this are the red abalone samples Wilcoxon (1993:147–8) obtained from the lowest levels of Unit 6A and the California mussel samples Kennett (1998:462) dated from the lowest levels of Unit 11B. These samples are all from the red abalone layers that predate Stratum D. However, the dates for samples from these levels, with 2σ ranges extending between 5920 and 3810 cal BP, extend somewhat later than the dates that Glassow (1993, 2013; Glassow et al. 1988, 1994, 2008; also Raab 1992; Salls 1992) has associated with red abalone sites on Santa Cruz Island.

**House Depression 6**

The stratigraphy at House Depression 6 fits the pattern described in the previous section, with Stratum B subdivided into 3 substrata (Figure 3). We called the uppermost substratum Stratum B because it was most consistent with what Wilcoxon described in his notes and most similar to what we observed at other house depressions. This substratum is the darkest of the 3 and in the field seemed to contain the most whole shells of any stratum. California mussel was the most abundant species recovered during excavation. Below this, Stratum B/C is similar in composition to Stratum B, but lighter in color, suggesting a possible mixture with Stratum C. Finally, “Stratum B Fragmented” is similar in color to B/C, but with a lower shell density. Those shells that are present in this stratum seem to be more fragmented than in the other substrata of B. More sea urchin fragments seem to be present in this stratum than above, although mussel still appears to be the dominant species. This stratum is only present in the parts of the trench where Stratum C extends the deepest.

The surface depression at House 6 is deepest on the northern end of Trench 6, which was the component that was excavated by Wilcoxon. The 2010 excavations suggest that the end of Stratum C is within Wilcoxon’s trench and it extends southward rather than northward, the direction of the depression. Stratum C slopes generally downward to the south with its lowest point at the southern end of the newly excavated trench (Figure 3). The 3 substrata of Stratum B are most clearly defined where Stratum C extends the deepest. Within Wilcoxon’s original trench, “Stratum B Fragmented” does not exist and B and B/C could not be distinguished in the field. Furthermore, where Stratum C is not present, it is difficult to distinguish between Stratum B and Stratum D. The only qualitative distinction between Stratum B and D is that the shell in the latter is somewhat more fragmented than in the former and black abalone appear to make up a larger proportion of the assemblage.
In addition to collecting carbonized twigs during excavation, we collected samples of California mussel shells from the south wall of Trench 6C-LG. For this house depression, we have $^{14}$C dates from all of the strata except “B Fragmented,” where a suitable sample was not accessible in the profile. We submitted 2 samples from Stratum C, 1 charcoal and 1 California mussel (Table 2). To model the $^{14}$C dates from this profile, we used the “Sequence” and “Phase” commands in OxCal v 4.1 (Bronk Ramsey 2009; Culleton et al. 2012:1577). By modeling all of the dates as a sequence, we assign a priori information about their stratigraphic relationship to each other. For example, if we specify that the sample from Stratum A was deposited more recently than that from Stratum B, the program then constrains the 2σ range for each of the dates accordingly. Because the 2 samples from Stratum C could not be distinguished stratigraphically, we modeled them as a phase. Therefore, there is no assumed stratigraphic relationship between the 2 samples, but the phase as a whole is modeled as part of the sequence. Furthermore, the phase can be assigned boundaries, which models the initial and final deposition of material from the phase. These boundaries are better constrained in sequences that were deposited over relatively short periods of time. Boundaries for initial and final deposition are also generated for the sequence as a whole.

Table 2 Radiocarbon dates included in the model for Trench 6, including modeled 2σ ranges and boundaries. Dates are calibrated using OxCal v 4.1.3 (Bronk Ramsey 2009) and the Marine09 calibration curve (Reimer et al. 2009).

<table>
<thead>
<tr>
<th>UCIAMS #</th>
<th>Stratum</th>
<th>Provenience$^a$</th>
<th>Material</th>
<th>Conv. $^{14}$C age (BP)</th>
<th>Modeled 2σ cal BP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundary</td>
<td>A</td>
<td>Trench 6C, 21 cmbd</td>
<td>$M.\ californianus$</td>
<td>3000 ± 20</td>
<td>2590–2345</td>
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<tr>
<td>94051</td>
<td>B</td>
<td>Trench 6A, 29 cmbd</td>
<td>Carbonized twig</td>
<td>2485 ± 20</td>
<td>2710–2485</td>
</tr>
<tr>
<td>87891</td>
<td>B/C</td>
<td>Trench 6B, 49.5 cmbd</td>
<td>Carbonized twig</td>
<td>2540 ± 20</td>
<td>2745–2545</td>
</tr>
<tr>
<td>Boundary</td>
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<td>End of Stratum C</td>
<td></td>
<td></td>
<td>3205–3055</td>
</tr>
<tr>
<td>87892</td>
<td>C</td>
<td>Trench 6C, 61.5 cmbd</td>
<td>Carbonized twig</td>
<td>2970 ± 20</td>
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<td>C</td>
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<td>$M.\ californianus$</td>
<td>3555 ± 20</td>
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<tr>
<td>Boundary</td>
<td>D</td>
<td>Start of Stratum C</td>
<td></td>
<td></td>
<td>3300–3090</td>
</tr>
<tr>
<td>87890</td>
<td>D</td>
<td>Trench 6A, 78 cmbd</td>
<td>Carbonized twig</td>
<td>3080 ± 20</td>
<td>3365–3245</td>
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<tr>
<td>Boundary</td>
<td></td>
<td>Start of Stratum D</td>
<td></td>
<td></td>
<td>3945–3230</td>
</tr>
</tbody>
</table>

$^a$cmbd = centimeters below unit datum.
The sequence for House Depression 6 is well constrained overall within a model generated from the 
\(^{14}\text{C}\) dates collected as a part of this project (Table 2, Figure 4). The dates from carbonate and organic 
samples are consistent with each other when modeled with the appropriate calibration curves. 
Because the sample collected from Stratum D is from the top of the stratum, it better constrains the 
date for the beginning of Stratum C. On the other hand, the boundary for the start of the overall 
sequence is not particularly meaningful because it is not the base of the cultural deposits; excavation 
stopped before we were able to reach the base of Stratum D. The model places the start date of depo-
sition of Stratum C at 3300–3090 cal BP (2\(\sigma\)) and the date of the end of its deposition at 3205–3055 
cal BP (2\(\sigma\)). This terminal date could have been constrained more if a date for Stratum B Fragmented 
were available. However, the gap in dates between the samples from Stratum C and Stratum B/C are 
perhaps indicative of a delay in deposition of midden or a systematic removal of material while peo-
ple were living there (i.e. floor cleaning). Furthermore, the interpretation of B/C and B Fragmented 
as layers in which soils from above and below are mixed is consistent with the possibility that new 
midden was deposited on the loose, ashy Stratum C after it was fully formed. Alternatively, these 
may represent transitional strata with some characteristics of those above and below them.

The model places the end of occupation of this depression at 2600–1800 cal BP (2\(\sigma\)), which is a 
relatively long range, but this is because there is no later \(^{14}\text{C}\) date to constrain it. Additionally, Wil-
coxon (1993:148) obtained a date of 1530–1090 cal BP (2\(\sigma\)) from the 20–30 cm below the surface 
level of nearby Unit 6A. This suggests that the uppermost levels of the midden, above where we col-
clected the sample for Stratum A, may postdate our modeled date for the end of occupation. None-
theless, the sequence from Trench 6 has several convenient characteristics. First, upon calibration of 
the \(^{14}\text{C}\) dates with the appropriate calibration curves and \(\Delta R\) value, there are no reversals in the 
sequence, allowing us to incorporate all of the dates into the model. Second, the overall sequence is 
relatively well constrained, without long gaps between dates. And third, the dates from carbonate 
and charcoal samples are consistent with each other, suggesting that old-wood problems or fluctua-
tions in \(\Delta R\), at least for the samples that we tested, are negligible.
House Depression 32

The stratigraphy of Trench 32 fits the same pattern as Trench 6, with Stratum B subdivided into 3 substrata (Figure 5). Unfortunately, a profile is only available for the east wall of the 1 m of the trench that we excavated as a part of this project because Wilcoxon’s walls had slumped and become distorted after incomplete backfilling of the unit. He also excavated a 25 × 25 cm column sample into that wall. The uppermost of the 3 substrata, which we called Stratum B, is similar to the uppermost substratum of B in Trench 6. Strata A, C, and D are also similar to what we observed in Trench 6. The northern edge of the Stratum C is in the newly excavated trench, and it extends downward into Wilcoxon’s original trench. However, Stratum B1, which is stratigraphically below Stratum B, is different from anything that we observed in Trench 6. Unlike in Trench 6, where the lighter substrata of B only occur where Stratum C reaches its deepest points, at Trench 32, Stratum B1, which is lighter than and stratigraphically below Stratum B, occurs at and extends past the northern edge of Stratum C. Another stratum, the B-C Mixture, is south of Stratum B1 and overlies Stratum C. The soil there is somewhat anomalous in that it is darker than in the rest of Stratum B, so it may have a different origin than either of the mixed B strata in Trench 6.

The $^14$C sequence for Trench 32 is less well constrained overall than for Trench 6 (Table 3, Figure 6). There are several reasons for this. First, the overall range of $^14$C dates for this feature is longer than for Trench 6. To that end, the $^14$C dates themselves are more spread out chronologically. From this profile, we submitted 4 California mussel shells and 1 charcoal sample to be dated. One of each was from Stratum C. As in Trench 6, we modeled the dates as a sequence, with the 2 dates from Stratum C modeled as a phase. Because the dates were not as tightly patterned in Trench 32, the modeled boundaries are not as well constrained. The boundaries for the initial and final dates of the sequence extended beyond reasonable values. Therefore, we used the “before” and “after” commands in OxCal to better constrain these values. For the boundary of initial occupation, we forced the date range to be after 5300 yr ago, the traditional ending date for red abalone middens, which underlie the whole assemblage. This is conservative, since we have dates for the red abalone layers.
at SCRI-333 that may date as recently as 3800 yr ago (Table 1). For the date of final occupation of the site, we forced the date range to be before AD 1820, the date of historic depopulation of the islands.

The modeled dates for initial and final deposition of Stratum C are also not as well constrained in Trench 32 as in Trench 6. The initial date, modeled at 3270–2505 cal BP (2σ), has a relatively long range because of the gap in the dates between Stratum C and D. The boundary for the terminal date is even longer, modeled at 2475–795 cal BP (2σ). This is related to the lack of dates from any of the B strata in the model. We submitted a sample from Stratum B, but its calibrated range is 3125–2890 cal BP (2σ). This whole range predates the 2σ range for either of the samples from Stratum C. Therefore, because the sample that was deposited in the sequence has a more recent date and there is no overlap between the 2σ ranges, these dates cannot be reconciled in the model. This suggests that the sample from Stratum B is a reversal in the sequence, which is likely the product of redepotision of material from elsewhere in the assemblage. Since Stratum B and Stratum D appear similar
and the boundary between them is often unclear in the absence of Stratum C, this suggests that they were a continuous deposit. A possible explanation is that when a house was constructed, the inhabitants dug up existing midden and deposited it elsewhere, perhaps in an abandoned house depression. Therefore, in some cases, parts of Stratum B could be redeposition of materials from Stratum D that could have been moved during the construction of a new house feature. The date from Stratum A of 835–665 cal BP (2σ) is also interesting because it is the latest date that has been obtained from SCRI-333 and it significantly postdates all of the other dates from the site.

DISCUSSION

The El Montón site on the western end of Santa Cruz Island had a long occupation ranging at least from ~6000 yr ago until less than 1000 yr ago (835–665 cal BP). During that time, there were at least 2 distinct periods of intensive occupation and evidence of a later human presence that is less well understood. That this part of the island was an important focus of human activity is no surprise given the rich marine resources that were available adjacent to the site (Wilcoxon 1993; Glassow et al. 1994; Kennett 1998). The earliest evidence that is available is associated with the period of red abalone midden deposition on Santa Cruz Island. Dates associated with the red abalone layer have been obtained from units near house depressions 6 and 11 (Table 1; Wilcoxon 1993:148; Kennett 1998:462). These are the only units that Wilcoxon excavated deep enough to reach these levels, and it is likely that this layer underlies much of the site.

The earliest evidence that can be potentially associated with house construction is from the lower boundary of Stratum C at House Depression 6, for which we have a modeled date of 3300–3090 cal BP (2σ). The date we have obtained for the end of deposition of this stratum at 3205–3055 cal BP (2σ) places the occupation of this feature securely within the Middle Holocene. If this lens is associated with house construction and occupation, this places it among the earliest evidence for houses on the Channel Islands, particularly on the northern islands. On the southern islands, Salls et al. (1993; also Raab et al. 1994, 2009) describe Middle Holocene house features at Eel Point and the Nursery site (CA-SCLI-1215) on San Clemente Island. The Nursery site houses have been dated to as early as 3700 14C yr BP. Salls et al. (1993:177) argue that the adoption of substantial residential structures was related to maritime economic trends that influenced a large area at the same time.

The data show that Stratum C associated with House Depression 32 postdates the corresponding stratum at House Depression 6 by at least 285 yr. Unfortunately, the boundaries for Trench 32 are not as well defined as those for Trench 6 because the dates from strata D and C are much more distinct from each other in the former than in the latter. Additionally, the reversal for the Stratum B sample from Trench 32 prevents a precise terminal date range for the deposition of Stratum C. Therefore, to assess whether the 2 features were contemporaneous, it is necessary to model the likely range of occupation for each of the features. To do so, we used the “Interval” command in OxCal to determine the length of occupation to 2σ confidence. For example, the 2σ range of time of occupation of Stratum C of Trench 6 is 0–133 yr. This means that there is a 95.4% likelihood that the lens was occupied for <133 yr (and more than 0 yr). Because the dates for House Depression 32 are less tightly defined, its 2σ interval of occupation of Stratum C is 0–667 yr. For each feature, we took the midpoint between the median modeled initial date of deposition of Stratum C and median modeled terminal date of deposition of Stratum C. We placed the occupation intervals on the timeline, centered at these midpoints (Figure 7). This yields a 2σ range of time of occupation for the feature at Trench 6 of 3205–3075 cal BP, and a 2σ range of time of occupation for the feature at Trench 32 of 2790–2125 cal BP. Although these are estimates, they include the median values for initial and terminal occupation of Stratum C in their respective trenches and nearly the full 2σ ranges for direct
dates from samples. This is a further test that strongly suggests that Stratum C was not deposited contemporaneously in these 2 parts of the site. If this stratum is in fact a lens associated with house occupation, these 2 houses would not have been occupied simultaneously.

Although it is based on dates from only 2 house depressions and should be corroborated with a more extensive dating program, this distinction suggests that rather than a single large village occupied at one time, construction and occupation of the house depressions at SCRI-333 may have been staggered, with only a subset of them in use at once. This is supported by the reversal in the \(^{14}\)C record from Trench 32, in which the sample from Stratum B predates that from Stratum C. This may have been redeposited from a deeper stratum (Stratum D) when a later house was being constructed. Furthermore, it was apparent that not all of the depressions at the site corresponded with a Stratum C directly below them; there may be some depressions without this stratum, and this stratum may be present without or outside of depressions. In both Trench 6 and 32, Stratum C is not directly below the depression. In Trench 6, for example, the depression corresponds to the northernmost extent of the lens, which dips downward to the south. This could be interpreted in multiple ways: (1) The lens could have initially been below a surface depression, and strong winds, which are common on the west end of Santa Cruz Island, could have shifted the depression. (2) The lens could be the remains of a roof fall, which could have fallen to the south rather than straight down after the house was abandoned. This possibility is one of the reasons that even if Stratum C can be associated with house occupation, a more appropriate designation is a house lens rather than a house floor. It is also possible that Stratum C could represent a mixture of a floor or roof fall with the material deposited immediately after abandonment. Finally, (3) the surface depressions could be the remnants of the most recent houses, unknowingly constructed over earlier houses, like Stratum C at Trench 6.
14C dates from the uppermost strata of the midden at SCRI-333 suggest that the mound at least was visited later in time during the Late Holocene, although there is no evidence to tie these dates to any potential house lenses. A charcoal sample from the 20–30 cm level of Unit 6A dates to 1530–1090 cal BP, and the levels above it are likely more recent (Wilcoxon 1993:148). Additionally, several samples, both from Wilcoxon’s study and ours, date to the beginning of the Late Holocene. More significantly, a California mussel sample from Stratum A of Trench 32A/B-LG run as a part of this study dates to 835–665 cal BP, by far the most recent date obtained from the site. A more extensive study is necessary to assess the nature of the human presence at El Montón during that time.

CONCLUSION

In this paper, we refined the chronology for 2 house depressions at the El Montón site, a large residential site on the western end of Santa Cruz Island. We incorporated 16 existing 14C dates and 11 new AMS 14C dates from the shell midden component of the site that span a range of occupation from the Middle through the Late Holocene. During his initial excavations, Wilcoxon (1993) was not able to reach the base of the shell deposits. This suggests that occupation could have extended earlier in time, with the potential for the earliest occupation possibly predating the red abalone layer, the deepest level that he reached. Gamble’s 2010 excavations were focused on strata associated with 2 house depressions and did not reach the red abalone layers that underlie them.

We found that the 2 potential house lenses we investigated probably were not contemporaneous. Although we need to date more house depressions to test this hypothesis further, this suggests that house occupation occurred serially at SCRI-333 for at least several centuries. Another important contribution of this study is the use of 14C modeling software such as OxCal that incorporates Bayesian statistics to obtain a date for the construction and abandonment of house lenses. By taking 14C samples from below, within, and above the stratum in which we were interested, we were able to model dates for the boundaries between strata. This is a powerful tool that has been used in a variety of contexts to obtain dates for events that cannot be directly dated (e.g. Kennett et al. 2011, 2012; Culleton et al. 2012; Kennett and Culleton 2012). This has far-reaching implications for archaeology beyond just modeling house construction. By using a set of 14C dates to better understand the occupation history of an important site on the western end of Santa Cruz Island, we provide a better understanding of settlement patterns in an economically valuable area that was occupied throughout much of human habitation of the Channel Islands.

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