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Radiocarbon

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A Radiocarbon Chronology of Hunter-Gatherer Occupation from Bodega Bay, California, USA

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Introduction

The evolution of hunter-gatherer maritime adaptations in western North America has been a prominent topic of discussion among archaeologists in recent years (e.g. Arnold 1992; Erlandson and Colten 1991; Erlandson and Glassow 1997; Lightfoot 1993). Although vast coastal regions of the northeastern Pacific (for example, southern California) have been investigated in detail, our understanding of hunter-gatherer developments along the coast of northern California is limited. Previous research indicates that humans have exploited marine mammals, fish and shellfish along the northern California shoreline since the early Holocene (Schwaderer 1992). By the end of the late Holocene, some groups remained year-round on the coast subsisting primarily on marine resources (e.g. Gould 1975; Hildebrandt and Levulett 2002). However, a paucity of well-dated cultural deposits has hindered our understanding of these developments, particularly during the early and middle Holocene. The lack of a long and reliable chronological sequence has restricted our interpretations of behavioral change, including the adaptive strategies (such as foraging, mobility and settlement) used by human foragers to colonize and inhabit the coastal areas of this region. These shortcomings have also hindered comparative interpretations with other coastal and inland regions in western North America.

Here we present a Holocene radiocarbon chronology of hunter-gatherer occupation based on contemporaneous samples of charcoal and *Mytilus californianus* (California sea mussel) shell recovered from seven archaeological sites near Bodega Bay, California. A series of 127 ¹⁴C ages reveal a chronological sequence that spans from ca. 8940–1110 cal BP (1σ) (7890–160 ¹⁴C yr BP = charcoal; 8934–101 ¹⁴C yr BP = shell). As part of this sequence, we report new ¹⁴C dates from the stratified cave and open-air midden deposits at Duncan's Landing (CA-SON-348/H). In addition, we present ¹⁴C ages from three middle Holocene sites located in the Bodega Dunes, and from three late Holocene sites, including *Kili* (CA-SON-299), the oldest known village site in the region.

Bodega Bay (38°19'N, 123°03'W) is situated about 90 km north of San Francisco Bay, California (Figure 1). The Pacific, in conjunction with prominent geomorphological features, has given rise to a series of coastal habitats (e.g. semi-protected and protected shorelines) around Bodega Bay that are rather unique for the unprotected, surf swept rocky shores of northern California. This stretch of coastline also lies within a zone of particularly strong seasonal upwelling between Point Reyes Peninsula and Cape Mendocino; a region characterized by high Ekman transport (Huyer 1983), and high coastal

concentrations of the nutrients silica and phosphate (van Geen and Husby 1996). The interaction between land and sea results in a productive marine ecosystem that has attracted hunter-gatherers for much of the Holocene.

Methods

Sample Selection

Charcoal samples and sea mussel shells were selectively picked from ten discrete deposits (loci) at seven sites near Bodega Bay to assess contextual relationships between particular levels, strata, features, components, loci and sites. However, we were also interested in choosing charcoal and shell that suited the requirements of related stable isotope studies investigating seasonal foraging strategies and ocean conditions at Bodega Bay (Kennedy et al. 2004; Kennedy 2005). Thus, the number of samples selected from each context varies.

Charcoal was selected as the terrestrial material of choice since most of the loci have small faunal assemblages. Charred and burnt twigs and twig fragments were chosen to avert the interpretative problems associated with dating old wood (Schiffer 1986). However, at times only small, amorphous shaped charcoal pieces were available. *M. californianus* shells were chosen to represent the marine samples for two reasons. First, sea mussel shells are generally the most abundant faunal remains represented at northern California archaeological sites. Second, we wanted to select only one invertebrate species to eliminate the effect of inter-species variation in ^{14}C ages. Here we avoided species (e.g. *Macoma* spp.) from low energy habitats such as protected shorelines, which in addition to ocean carbon also incorporate carbon from terrestrial and atmospheric sources with different ^{14}C ages (e.g. Ingram and Southon 1996). In contrast, *M. californianus* is a filter-feeding species that lives in high-energy environments on the outer coast; thus it has a shell chemistry that serves as a better proxy for near-shore surface water conditions.

Radiocarbon Age Determinations

One hundred and fifteen radiocarbon determinations were submitted for analysis to the Center for Accelerator Mass Spectrometry at Lawrence Livermore National Laboratory. Shell samples were prepared for analysis by first physically removing the surface layers of the sample area with an electric dremel tool. Sub-samples of the newly exposed shell material were removed and chemically leached with hydrochloric acid. Approximately 10 mg of carbonate sample was evacuated in a 10 ml vacutainer and then reacted with 0.5 ml of phosphoric acid at 90°C to produce CO_2 . Charcoal samples (1–2 mg) were soaked sequentially in acid (1 N HCL) and base (1 N Na OH), and then given two acid rinses to remove CO_2 that may have been absorbed during the alkaline bath. This bath sequence removed adhering humic and fulvic acids, as well as secondary carbonates. The samples were then given 3 deionized water baths and dried. Samples were then loaded into quartz tubes with copper oxide (CuO_2) and silver (Ag) powder, sealed and combusted at 900°C.

Thereafter, both charcoal and shell CO_2 was reduced to graphite using an iron catalyst and H_2 gas (Vogel et al. 1987). The resulting graphite was pressed into individual aluminum target holders and measured for ^{14}C content by AMS (Davis et al. 1990). ^{14}C ages were calculated following Stuiver and Polach (1977) from fraction modern calculated from the measured $^{14}\text{C}/^{13}\text{C}$ ratios (Southon, unpublished data, see Guilderson et al. 2003) in a manner similar to that of Donahue et al. (1990). In addition, twelve radiocarbon samples

were submitted to Beta Analytic, Inc. Laboratory (Miami, FL, USA), for analysis and were subject to a similar pretreatment process. To produce the radiometric dates sample carbon was synthesized to benzene (92%) C, and measured for ^{14}C content in a scintillation spectrometer, and the radiocarbon age was calculated. All charcoal ^{14}C ages were calibrated with the atmospheric and marine calibration curves used in CALIB version 4.3 (Stuiver et al. 1998a; Stuiver 1998b). To account for the regional reservoir effect, the modern mean regional ΔR (267 ± 19 years) suggested for the northern California coast was subtracted from each shell ^{14}C age prior to calculation (Stuiver and Reimer 1993, CALIB version 4.3).

Archaeological Sites and Sampling

Here we describe the archaeological sites and sampling strategies. Contextual details of the samples chosen for dating are given in Figures 2 and 3 and Appendix 1. All sample depths are reported as below surface measurements (cm), unless noted otherwise.

Duncan's Landing (CA-SON-348/H)

Duncan's Landing ($38^{\circ}23'42''\text{N}$, $123^{\circ}5'40''\text{W}$) is a large multi-component midden site situated on a rocky point protruding from the shoreline about 6 km south of the Russian River (Figure 1). The ancient uplifted sea cave (Duncan's Point Cave) located on the site contains one of the most significant records of hunter-gatherer maritime adaptations along the California coast (Erlandson 1994). In 1989, the California State Department of Parks and Recreation excavated a 1.5 x 1.5 m test unit inside Duncan's Point Cave as part of a site protection project (Schwaderer 1992). The excavation revealed that the upper 60 cm of the deposit was heavily disturbed; yet the remaining deposit was remarkably well preserved up to a depth of nearly 3 meters. Five cultural/temporal components (discrete occupation periods) were identified and a series of seven ^{14}C assays indicated a chronological sequence dating from ca. 9000–3000 ^{14}C yr BP.

In 1997, the University of California (UC), Davis, Archaeological Field School identified two cultural strata (Components A and B1) in up to 1.5 m of heavy deposit at Locus B, the open-air midden area about 150 m northeast of the cave. Temporally sensitive artifacts (projectile points and a marine shell bead) recovered from the excavation units (1 x 1 m) suggested occupation between ca. 1500–250 BP.

Duncan's Landing, Duncan's Point Cave, Locus A

To better define the chronology of the deposits and components inside Duncan's Point Cave, we selected specimens from column sample levels excavated in 1989 from the southeast wall of the original test unit (Figure 2). Charcoal samples ($n=18$) and sea mussel shells ($n=25$) were hand picked from the archived matrix curated at the California State Archaeological Collections and Research Facility, Sacramento, CA, USA. We selected samples from levels that corresponded to Strata II–VIII and cultural Components 2–5 as reported by Schwaderer (1992). The small volume (1000 cm^3) of matrix within each 10 cm level gave us reasonable confidence that the shell and charcoal samples were closely associated despite the use of arbitrary excavation levels.

Duncan's Landing, Open-air Midden, Locus B

We obtained radiocarbon assays on charcoal (n=13) and sea mussel shells (n=13) selected from the water screened column sample matrix excavated along the east wall of Unit F, Strata II–V (Figure 3). Specimens were chosen from arbitrary 5 cm levels (4500 cm³) from the archived collection at the UC Davis Department of Anthropology Museum.

The Bodega Dune Sites

The Bodega Dune sites, Ocean Springs (CA-SON-2378), Two Seals (CA-SON-1735) and Salmon Creek Beach (CA-SON-284), are three shell-bearing sites situated along the lee side of the Salmon Creek Beach foredune (Figure 1). The sites are comprised of a series of small camps (loci) that were used for the purpose of processing seafood (mainly shellfish, fish and marine plants). The sites were only recently recorded, as they are isolated in the sand dunes and deflated. In 1999, the UC Davis Archaeological Field School conducted excavations at several loci and collected samples. Levels were excavated from 2 x 2 m units in arbitrary 10 cm (at Salmon Creek Beach) and 20 cm (at Ocean Springs and Two Seals) levels since the matrices consisted of unconsolidated, windblown dune sand mixed with fragments of shell. Few formal tools were encountered and the lack of time sensitive artifact types precluded temporal placement of the deposits.

Ocean Springs (CA-SON-2378), Locus SM1

Ocean Springs (38°19'19"N, 123°4'21"W) is located near a freshwater spring and a strip of rocky shoreline. Excavations were conducted at three loci (Loci SM1 and SM2). At Locus SM1, the deposit reached depths of over 60 cm. Here, a charcoal fragment (n=1) and a bulk sample of sea mussel shells (n=1) were chosen from a one liter matrix sub-sample excavated from the center of Unit A in the upper portions of Level 3 (41–45 cm).

Ocean Springs (CA-SON-2378), Locus SM2

At Ocean Springs, Locus SM2, we selected charcoal (n=3) and sea mussel shells (n=2) excavated from two cooking features in Unit A. Additionally, one shell sample (n=1) was chosen from an 1/8-inch field screen of Unit A, Level 1 (0–20 cm).

Two Seals (CA-SON-1735), Locus SM1

Two Seals (38°19'44"N, 123°4'10"W) is located midway along Salmon Creek Beach. Locus SM1 represents the densest deposit, and despite being heavily deflated, three cooking features were encountered during the excavations. Charcoal samples (n=4) and a sea mussel shell fragment (n=1) were picked from the flotation remains of the three cooking features. Two shell samples (n=2) were chosen from the 1/8-inch field screens of Units F and B, Level 2 (21–40 cm).

Salmon Creek Beach (CA-SON-284), Locus SM1

The Salmon Creek Beach site (38°20'24"N, 123°3'58"W) is situated around 1.5 km south of the present day mouth of Salmon Creek. More than 50 cm of deposits were revealed at Loci SM1 and SM2. At Locus SM1, charcoal samples (n=2) were selected from one-liter matrix sub-samples from the center of Unit B, the upper portion of Level 2 (11–15 cm), and from the center of Unit C, upper portion of Level 5 (41–45 cm). Sea mussel shells (n=2) were chosen from the 1/8-inch field screens of Unit B, Level 2 (11–20 cm), and Unit C, Level 11 (101–110 cm).

Salmon Creek Beach (CA-SON-284), Locus SM2

At Salmon Creek Beach, Locus SM2, a charcoal sample (n=1) was chosen from a matrix sub-sample removed from the center of Unit A, upper portions of Level 2 (11–15 cm). Two sea mussel shells (n=2) were selected from the 1/8-inch field screens of Unit A, Level 2 (11–20 cm) and Level 10 (91–95 cm).

Mussel Point (CA-SON-327)

The Mussel Point site (38°19'23"N, 123°4'40"W) is an eroding camp perched along the cliffs on the northern most tip of the Bodega Headland (Figure 1). Wind and wave action have destroyed the majority of the site. However, enough deposit remained to permit excavation of a 1 x 1 m test unit and column sample by the UC Davis Archaeological Field School in 1999. Since the matrix consisted of unconsolidated dune sand intermixed with shell fragments and other cultural material, excavation was conducted in arbitrary 5 cm (column sample) and 10 cm (Unit A) levels. The limited depth of the deposit (about 40 cm) suggests short-term occupation. Temporal placement was not known as temporally diagnostic artifacts were not encountered.

Mussel Point, Locus SM1

We collected charcoal (n=2) and sea mussel shells (n=3) from the flotation remains of a 30 x 30 cm column sample taken along the eroded face of the deposit. Samples were chosen from Levels 5 (71–75 cm), 6 (76–80 cm) and 7 (81–85 cm). One charcoal sample (n=1) was selected from a one liter matrix sub-sample removed from the center of Unit A, upper portions of Level 3 (21–25 cm). One sea mussel sample (n=1) was chosen from an 1/8-inch field screen of Unit A, Level 3 (21–30 cm).

Kili (CA-SON-299)

CA-SON-299 (38°19'21"N, 123°3'26"W) was a large, dense shell midden situated along the protected shores of Bodega Lagoon (Figure 1). The UC Archaeological Survey excavated the site in 1949 and 1950 as part of a salvage project prior to its destruction by the landowner (Fenenga 1948; Greengo 1951; Riddell 1948). The excavations revealed that the deposit was up to 4 meters deep and contained a highly varied artifact assemblage as well as human interments. Speculation on the age of CA-SON-299 has been largely based on cross dating with Middle Horizon (ca. 4000–1500 BP) sites from the North Coast Range and San Francisco Bay region (Beardsley 1954; Fredrickson 1973; Greengo 1951; Meighan 1955). Based on artifact (e.g. shell beads) and other cultural similarities (such as

human interment practices) with these sites, Davis and Treganza (1959) propose that the uppermost levels of *Kili* date between 3000–2500 B.P., and suggest the lowermost levels are possibly older. Ethnographic documents and site records indicate CA-SON-299 was also the Native American settlement *Kili* (Collier and Thalman 1996; Fenenga 1948; Riddell 1948).

Sea mussel shells were chosen from the archived remains curated at the Phoebe A. Hearst Museum of Anthropology, UC Berkeley. Charcoal excavated from *Kili* was discarded from the museum collection in 1955, therefore was not available for dating.

Kili, Trench F

There were only seven sea mussel shells (n=7) with provenience information available for radiocarbon dating and the stable isotope studies. The UC Archaeological Survey collected the specimens from Trench F in 1949. The shells are from 12 inch levels excavated from 60 x 60 inch units or pits within the trench (Fenenga 1951; Greengo 1950, 1951). Six sea mussel shells are from Pit F-2. One shell is from Pit F-5.

Kili, Unknown Provenience

Since only a limited number of sea mussel shells with provenience information were suitable for ¹⁴C dating and the stable isotope analyses, we selected ten sea mussel shells (n=10) from unknown contexts. The UC Archaeological Survey most likely recovered the specimens in 1949 or 1950. Method of field collection is unknown.

Bodega Lagoon (CA-SON-322)

The Bodega Lagoon site (38° 18' 58" N, 123° 3' 30" W) is a food processing location associated with the nearby ethnographic and prehistoric settlement *Tokau* (CA-SON-321) (Figure 1). Auger testing by the UC Davis Archaeological Field School (1998) revealed up to 2–3 meters of dense deposit was buried beneath more recent dune sand, however test unit excavations mainly tested the upper portions of the midden. Units (1 x 1 m) were excavated in arbitrary 10 cm levels. Temporally sensitive marine shell beads and a projectile point suggested an occupation between ca. 500–100 BP for the upper portions of the deposit.

Bodega Lagoon, Locus SM1

Charcoal specimens (n=5) and sea mussel shells (n=4) were chosen from the 1/8-inch field screens of Unit E, Level 12 (141–150 cm). One twig fragment (n=1) and a sea mussel shell fragment (n=1) were selected from the flotation remains of a one liter matrix sub-sample excavated from the northwest corner of Unit D, Level 12 (111–115 cm). One burnt twig (n=1) was chosen from a one liter matrix sub-sample removed from the center of Unit B, Level 12 (111–115 cm).

Results and Discussion

The Duncan's Point Cave (Locus A) sequence shows a very strong correlation between depth and ^{14}C age as both charcoal ($r^2 = .83$; $p < .0001$) and sea mussel shell ($r^2 = .88$; $p < .0001$) dates become progressively older with depth (Figure 4). The sequence shows remarkable consistency and suggests that the basic integrity of the deposit is intact. The calibrated charcoal and shell ages indicate an occupation period between 8930–2870 cal BP (1σ) and 8980–3110 cal BP (1σ), respectively; in general agreement with the original ^{14}C dates reported by Schwaderer (1992). The ^{14}C ages from the Open-air Midden (Locus B) at Duncan's Landing also reveal strong correlations as both charcoal ($r^2 = .75$; $p < .0001$) and sea mussel shell ($r^2 = .35$; $p < .05$) ^{14}C ages become older with depth (Figure 5). The calibrated charcoal ages indicate Locus B was occupied between 1180–350 cal BP (1σ) while the calibrated shell ages indicate occupation from 820–110 cal BP (1σ).

The Bodega Dune sites reveal a discrete suite of charcoal and sea mussel shell ^{14}C ages related to a series of middle Holocene processing camps used for short periods of time (i.e. up to a few centuries). The calibrated charcoal ^{14}C ages at Ocean Springs, Locus SM2, range from 5310–4880 cal BP (1σ) while the calibrated shell ^{14}C ages range from 5230–4810 cal BP (1σ). At Ocean Springs, Locus SM1, the calibrated charcoal ^{14}C age ranges from 4510–4410 cal BP (1σ) and the calibrated shell ^{14}C age ranges from 4610–4430 cal BP (1σ). The grouping of shell and charcoal ^{14}C ages from Two Seals (Locus SM1) is also extremely consistent. The calibrated charcoal ^{14}C ages range from 4570–4100 cal BP (1σ) and calibrated shell ^{14}C ages range from 4590–4420 cal BP (1σ), and are contemporaneous with the ages obtained from Ocean Springs, Locus SM1. Likewise, the ^{14}C ages from the Salmon Creek Beach site also indicate great consistency. The charcoal and shell ^{14}C ages range from Loci SM1 and SM2 indicate occupation between 4420–4090 cal BP (1σ) and 4420–4070 cal BP (1σ), respectively; coeval with Ocean Springs, Locus SM1 and Two Seals, Locus SM1.

Similarly, the charcoal and sea mussel shell ^{14}C ages from Mussel Point, *Kili* and Bodega Lagoon reveal three discrete late Holocene occupations. At Mussel Point (Locus SM1), the calibrated charcoal ages range from 2350–2160 cal BP (1σ) while the calibrated shell ages range from 2180–1830 cal BP (1σ). At the village site *Kili*, we observe a tight sequence of shell ^{14}C ages despite the use of specimens without contextual information. The calibrated ages range from 1990–1490 cal BP (1σ). The Bodega Lagoon (Locus SM1) site also exhibits a series of ^{14}C ages from a discrete deposit. The calibrated charcoal ^{14}C ages range from 480–0* cal BP (1σ) and the calibrated shell ages range between 430–140 cal BP (1σ).

Conclusions

In sum, the suite of radiocarbon dates reveal that the sampled loci are relatively well preserved and contain a major proportion of their original integrity, although some mixing is apparent within a few of the deposits. This sequence serves as a foundation from which diachronic comparisons between components and their constituents can be used to develop a local cultural sequence. In addition, since the radiocarbon dates were conducted on groupings of closely associated charcoal and sea mussel shell, they also provide important paleoceanographic information about the past by promoting the development of marine reservoir corrections. These estimates will aid in the calibration of regional ^{14}C ages from

ancient marine remains and facilitate the investigation of trends in ocean conditions at the time of occupation (e.g. Ingram 1998; Kennett et al. 1997). These data will permit us to explore major dimensions of temporal change in Holocene marine conditions and their potential affect on the resources that were available to hunter-gatherers.

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Appendix 1: Archaeological ¹⁴C Results

The charcoal and *M. californianus* shell ¹⁴C ages for each of the ten Bodega Bay loci are listed below. Radiocarbon assays are reported from oldest to youngest by site and locus. Charcoal ¹⁴C ages are reported first, followed by the shell ages. For each date we present a brief contextual description. For a number of samples, we provide an archaeological and stratigraphic assessment. Charcoal and shell ¹⁴C ages are accompanied by calibrated spreads (1σ) and intercepts in the comment section.

Duncan's Landing (CA-SON-348/H), Locus A (Duncan's Point Cave)

7890 ± 35

CAMS-86877. Sample ID No. SON 348 114-7-1 $\delta^{13}\text{C} = -26.1\text{‰}$
Small charcoal fragment, column sample, interface of Strata VII and VIII, Level 22, 230–240 cm, crushed shell with very little midden (VII) mixed with sandy loam/midden with shell (VIII).

Comment: 8925 (8641) 8602 cal BP (1σ). The calibrated spread of this sample sets initial marine resource use at the cave to at least 8900 cal BP. A charcoal ¹⁴C age (Schwaderer 1992; 8620 ± 420 BP, Beta-35229) collected in 1989 from the test unit's south corner (222 cm) suggested greater possible antiquity, however, it was accompanied by a large error estimate.

7875 ± 45

CAMS-86880. Sample ID No. SON 348 114-8-1 $\delta^{13}\text{C} = -25.8\text{‰}$
Small burned twig, column sample, upper portion of Stratum VIII, Level 23, 240–250 cm, sandy loam/midden mixed with shell.

Comment: 8748 (8634) 8595 cal BP (1σ). This ¹⁴C age overlaps at 1σ and corroborates the ages of CAMS-86877 (above) and CAMS-86878 (below).

7835 ± 35

CAMS-86878. Sample ID No. SON 348 114-7-2 $\delta^{13}\text{C} = -26.1\text{‰}$
Small charcoal fragment, see CAMS-86877 (above) for 230–240 cm level description.

Comment: 8635 (8597) 8589 cal BP (1σ). The $\delta^{13}\text{C}$ value of this sample was estimated from CAMS-86877, above.

7775 ± 35

CAMS-86876. Sample ID No. SON 348 114-5-1 $\delta^{13}\text{C} = -24.0\text{‰}$
Small burned twig fragment, column sample, lowest portion of Stratum VI, Level 19, 200–210 cm, dark midden mixed with crushed shell.

Comment: 8592 (8585, 8574, 8542) 8460 cal BP (1σ).

7690 ± 35
 $\delta^{13}\text{C} = -24.3\text{‰}$

CAMS-96630. Sample ID No. SON 348 114-13-1
Small charcoal fragment, column sample, lower portion of Stratum VI, Level 18, 190–200 cm, dark midden mixed with crushed shell.

Comment: 8535 (8444, 8443, 8426) 8411 cal BP (1 σ). This date, when compared with our other charcoal dates from between 190–260 cm, suggests that the upper portions of Component 2 extend to the middle of Stratum VI (about 190 cm).

7575 ± 35
 $\delta^{13}\text{C} = -26.1\text{‰}$

CAMS-86879. Sample ID No. SON 348 114-7-3
Small charcoal fragment, see CAMS-86877 (above) for 230–240 cm level description.

Comment: 8393 (8385) 8365 cal BP (1 σ). $\delta^{13}\text{C}$ was estimated from CAMS-86877, above.

7550 ± 35
 $\delta^{13}\text{C} = -23.6\text{‰}$

CAMS-96629. Sample ID No. SON 348 114-12-1
Small charcoal fragment, column sample, upper portion of Stratum VI, Level 16, 170–180 cm, dark midden mixed with crushed shell.

Comment: 8388 (8370) 8347 cal BP (1 σ). This calibrated spread overlaps at 1 σ with a charcoal sample from 230–240 cm (CAMS-86879, above); however, a shell sample (CAMS-96617, below) from the same 170–180 cm level dates to the middle Holocene.

4565 ± 35
 $\delta^{13}\text{C} = -26.4\text{‰}$

CAMS-86873. Sample ID No. SON 348 114-4-1
Small burned twig fragment, column sample, uppermost portion of Stratum VI, Level 15, 160–170 cm, dark midden mixed with crushed shell.

Comment: 5313 (5302) 5089 cal BP (1 σ). This ^{14}C age, along with our other charcoal dates from between 140–170 cm (see below), post-date the Component 3 charcoal ^{14}C age (Schwaderer 1992; 6260 ± 120 BP, Beta-35528; see also Schwaderer 1989–1992) obtained at a depth of 160 cm from an occupation floor/hearth (Feature 1) in the north corner of the test unit.

4490 ± 40
 $\delta^{13}\text{C} = -25.7\text{‰}$

CAMS-86871. Sample ID No. SON 348 114-3-2
Small charcoal fragment, column sample, middle portion of Stratum IV, Level 10, 110–120 cm, interbedded layers of shell and dark midden.

Comment: 5290 (5260, 5185, 5119, 51110, 5065, 5063, 5052) 5044 cal BP (1 σ). The 110–120 cm level corresponds to Component 4 as described by Schwaderer (1992).

4485 ± 30
 $\delta^{13}\text{C} = -27.6\text{‰}$

CAMS-96628. Sample ID No. SON 348 114-11-1
Small charcoal fragment, column sample, mainly Stratum V, Level 14, 150–160 cm, a dark sandy loam.

Comment: 5295 (5278, 5167, 5129, 5106, 5070) 5048 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with CAMS-86871, above. See CAMS-86873 (above) for comment.

4415 ± 30
 $\delta^{13}\text{C} = -25.4\text{‰}$

CAMS-96627. Sample ID No. SON 348 114-10-1
Small charcoal fragment, column sample, lowest portions of Stratum IV, Level 13, 140–150 cm, interbedded layers of shell and dark midden.

Comment: 5044 (5028, 5019, 4976) 4876 cal BP (1 σ).

4370 ± 35
 $\delta^{13}\text{C} = -26.4\text{‰}$

CAMS-86875. Sample ID No. SON 348 114-4-3
Small charcoal fragment, see CAMS-86873 (above) for 160–170 cm level description.

Comment: 5026 (4954, 4951, 4872) 4865 cal BP (1 σ). $\delta^{13}\text{C}$ was estimated from CAMS-86873, above.

4130 ± 35
 $\delta^{13}\text{C} = -26.4\text{‰}$

CAMS-86874. Sample ID No. SON 348 114-4-2
Small burned twig fragment, see CAMS-86873 (above) for 160–170 cm level description.

Comment: 4811 (4789, 4766, 4616, 4595, 4592) 4549 cal BP (1 σ). This ^{14}C age is the same age as a charcoal sample (CAMS-86870, below) from the 110–120 cm level. $\delta^{13}\text{C}$ was estimated from CAMS-86873, above.

4130 ± 60
 $\delta^{13}\text{C} = -25.7\text{‰}$

CAMS-86870. Sample ID No. SON 348 114-3-1
Small burned twig fragment, see CAMS-86871 (above) for 110–120 cm level description.

Comment: 4823 (4789, 4766, 4616, 4595, 4592) 4530 cal BP (1 σ). $\delta^{13}\text{C}$ was estimated from CAMS-86871, above.

4095 ± 30
 $\delta^{13}\text{C} = -25.7\text{‰}$

CAMS-86872. Sample ID No. SON 348 114-3-3
Small charcoal fragment, see CAMS-86871 (above) for 110–120 cm level description.

Comment: 4809 (4570, 4557, 4550) 4448 cal BP (1 σ). $\delta^{13}\text{C}$ was estimated from CAMS-86871, above.

3140 ± 35
 $\delta^{13}\text{C} = -24.5\text{‰}$

CAMS-86868. Sample ID No. SON 348 114-2-1
Small burned twig fragment, column sample, upper portion of Stratum IV, Level 8, 90–100 cm, interbedded layers of shell and dark midden.

Comment: 3383 (3361) 3273 cal BP (1 σ). This sample is from the lower levels of Component 5, and is compatible with a charcoal date (Schwaderer 1992; 3400 ± 120 BP, Beta-35226) obtained at a depth of 90–92 cm from the southwest wall of the test unit.

2940 ± 35
 $\delta^{13}\text{C} = -24.5\text{‰}$

CAMS-86869. Sample ID No. SON 348 114-2-2
Small burned twig fragment, see CAMS-86868 (above) for 90–100 cm level description.

Comment: 3205 (3121) 3000 cal BP (1 σ). $\delta^{13}\text{C}$ was estimated from CAMS-86868, above.

2820 ± 25
 $\delta^{13}\text{C} = -23.5\text{‰}$

CAMS-86867. Sample ID No. SON 348 114-1-1
Small charcoal fragment, column sample, largely Stratum II, Level 5, 60–70 cm, whole and large fragments of shell in loose midden.

Comment: 2951 (2922, 2905, 2890) 2870 cal BP (1 σ). This is the youngest charcoal date from the undisturbed portion of Component 5.

8715 ± 35
 $\delta^{13}\text{C} = -0.1\text{‰}$

CAMS-82844. Sample ID No. SON 348/H 114-9-C
M. californianus shell fragment, column sample, lower portion of Stratum VIII, Level 24, 250–260 cm, sandy loam/midden mixed with shell.

Comment: 8978 (8934) 8884 cal BP (1 σ). This sample came from the basal level of Component 2 and is the oldest marine shell ^{14}C age from the cave.

8570 ± 40
 $\delta^{13}\text{C} = 0.5\text{‰}$

CAMS-82841. Sample ID No. SON 348/H 114-5-A
Nearly complete *M. californianus* shell, see CAMS-86876 (above) for 200–210 cm level description.

Comment: 8903 (8844) 8769 cal BP (1 σ). This ^{14}C age is commensurate with our other shell ages from this level, and a *Mytilus* shell age (Schwaderer 1992, 1989-1992; 8610 ± 110 BP, BETA-34844) collected in 1989 from the southeast wall of the test unit at a depth of 238–240 cm.

8565 ± 30
 $\delta^{13}\text{C} = 0.2\text{‰}$

CAMS-96618. Sample ID No. SON 348 114-13-B
M. californianus shell fragment, see CAMS-96630 (above) for 190–200 cm level description.

Comment: 8898 (8839) 8771 cal BP (1 σ). See CAMS-96630 (above) for comment.

8550 ± 35
 $\delta^{13}\text{C} = 0.5\text{‰}$

CAMS-82842. Sample ID No. SON 348/H 114-5-D
M. californianus shell fragment, see CAMS-86876 (above) for 200–210 cm level description.

Comment: 8890 (8825) 8749 cal BP (1 σ).

8520 ± 35
 $\delta^{13}\text{C} = 0.1\text{‰}$

CAMS-80457. Sample ID No. 114-7-H
M. californianus shell fragment, see CAMS-86877 (above) for 230–240 cm level description.

Comment: 8871 (8775) 8690 cal BP (1 σ).

8495 ± 35
 $\delta^{13}\text{C} = 0.1\text{‰}$

CAMS-80458. Sample ID No. 114-7-F
M. californianus shell fragment, see CAMS-86877 (above) for 230–240 cm level description.

Comment: 8854 (8744) 8637 cal BP (1 σ).

8470 ± 35
 $\delta^{13}\text{C} = 0.1\text{‰}$

CAMS-82843. Sample ID No. SON 348/H 114-9-A
M. californianus shell fragment, see CAMS-82844 (above) for 250–260 cm level description.

Comment: 8833 (8691) 8605 cal BP (1 σ).

8430 ± 35
 $\delta^{13}\text{C} = 0.2\text{‰}$

CAMS-80459. Sample ID No. 114-8-B
Nearly complete *M. californianus* shell, see CAMS-86880 (above) for 240–250 cm level description.

Comment: 8711 (8620) 8575 cal BP (1 σ).

8300 ± 30
 $\delta^{13}\text{C} = 0.2\text{‰}$

CAMS-80460. Sample ID No. 114-8-C
Nearly complete *M. californianus* shell, see CAMS-86880 (above) for 240–250 cm level description.

Comment: 8537 (8460) 8415 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with a shell age (CAMS-80456, below) from the 230–240 cm level.

8285 ± 45
 $\delta^{13}\text{C} = -0.1\text{‰}$

CAMS-80456. Sample ID No. 114-7-A
Nearly complete *M. californianus* shell, see CAMS-86877 (above) for 230–240 cm level description.

Comment: 8534 (8443) 8397 cal BP (1 σ). This date is consistent with the ^{14}C age (Schwaderer 1992, 1989-1992; 8270 ± 110 BP, BETA-37473) of a *Mytilus* shell collected in 1989 at a depth of 200–205 cm from the column sample location along the southeast wall.

5340 ± 35
 $\delta^{13}\text{C} = 0.1\text{‰}$

CAMS-82839. Sample ID No. SON 348/H 114-4-C
Nearly complete *M. californianus* shell, see CAMS-86873 (above) for 160–170 cm level description.

Comment: 5469 (5444) 5354 cal BP (1 σ). See CAMS-86873 (above) for comment.

5320 ± 35
 $\delta^{13}\text{C} = 0.2\text{‰}$

CAMS-82840. Sample ID No. SON 348/H 114-4-G
Nearly complete *M. californianus* shell, see CAMS-86873 (above) for 160–170 cm level description.

Comment: 5457 (5433) 5320 cal BP (1 σ).

5290 ± 35
 $\delta^{13}\text{C} = -0.1\text{‰}$

CAMS-82838. Sample ID No. SON 348/H 114-4-A
Nearly complete *M. californianus* shell, see CAMS-86873 (above) for 160–170 cm level description.

Comment: 5440 (5327) 5305 cal BP (1 σ).

5245 ± 30
 $\delta^{13}\text{C} = 1.2\text{‰}$

CAMS-96615. Sample ID No. SON 348 114-10-A
M. californianus shell fragment, see CAMS-96627 (above) for 140–150 cm level description.

Comment: 5324 (5304) 5285 cal BP (1 σ).

5215 ± 35
 $\delta^{13}\text{C} = 0.6\text{‰}$

CAMS-83039. Sample ID No. SON 348/H 114-3-H
M. californianus shell fragment, see CAMS-86871 (above) for 110–120 cm level description.

Comment: 5310 (5289) 5264 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with a shell age (CAMS-96615, above) obtained from the 140–150 cm level, but is older than a shell age (CAMS-83038, below) from the same level.

5130 ± 30

CAMS-96617. Sample ID No. SON 348 114-12-B $\delta^{13}\text{C} = -0.1\text{‰}$
Complete *M. californianus* shell, see CAMS-96629 (above) for 170–180 cm level description.

Comment: 5260 (5217) 5071 cal BP (1 σ). See CAMS-96629 (above) for comment.

5115 ± 25

CAMS-96616. Sample ID No. SON 348 114-11-G $\delta^{13}\text{C} = -0.2\text{‰}$
M. californianus shell fragment, see CAMS-96628 (above) for 150–160 cm level description.

Comment: 5243 (5200) 5054 cal BP (1 σ). This date is in accord with a *Mytilus* shell ^{14}C age (Schwaderer 1992, 1989-1992; 5050 ± 90 BP, Beta-37472) obtained from the column sample location at a depth of 110–120 cm.

4560 ± 35

CAMS-83038. Sample ID No. SON 348/H 114-3-G $\delta^{13}\text{C} = 0.4\text{‰}$
M. californianus shell fragment, see CAMS-86871 (above) for 110–120 cm level description.

Comment: 4438 (4407) 4371 cal BP (1 σ). This ^{14}C age post-dates the shell ages from lower levels (see above), and a shell age (CAMS-83039, above) from the same 110–120 cm level.

4490 ± 25

CAMS-83037. Sample ID No. SON 348/H 114-3-D $\delta^{13}\text{C} = 0.0\text{‰}$
Nearly complete *M. californianus* shell, see CAMS-86871 (above) for 110–120 cm level description.

Comment: 4375 (4333) 4262 cal BP (1 σ). See CAMS-83038 (above) for comment.

3890 ± 35

CAMS-80453. Sample ID No. 114-1-D $\delta^{13}\text{C} = 0.3\text{‰}$
M. californianus shell fragment, see CAMS-86867 (above) for 60–70 cm level description.

Comment: 3566 (3517) 3459 cal BP (1 σ). This ^{14}C age post-dates all the shell ages from levels above 110 cm and is the earliest shell date from Component 5.

3740 ± 35

CAMS-82836. Sample ID No. SON 348/H 114-1-C $\delta^{13}\text{C} = -0.1\text{‰}$
Nearly complete *M. californianus* shell, see CAMS-86867 (above) for 60–70 cm level description.

Comment: 3383 (3350) 3318 cal BP (1 σ). This ^{14}C age is commensurate with a shell age (CAMS-80453, above) from the same level.

3660 ± 35
 $\delta^{13}\text{C} = 1.0\text{‰}$

CAMS-82837. Sample ID No. SON 348/H 114-2-N
M. californianus shell fragment, see CAMS-86868 (above) for 90–100 cm level description.

Comment: 3328 (3261) 3203 cal BP (1 σ).

3635 ± 35
 $\delta^{13}\text{C} = 0.2\text{‰}$

CAMS-80452. Sample ID No. 114-1-A
Nearly complete *M. californianus* shell, see CAMS-86867 (above) for 60–70 cm level description.

Comment: 3298 (3235) 3190 cal BP (1 σ).

3620 ± 30
 $\delta^{13}\text{C} = 0.3\text{‰}$

CAMS-80455. Sample ID No. 114-2-M
M. californianus shell fragment, see CAMS-86868 (above) for 90–100 cm level description.

Comment: 3260 (3210) 3164 cal BP (1 σ). This is the same ^{14}C age (Schwaderer 1992; 3620 ± 100 BP, Beta-34837) obtained in 1989 from a *Saxidomus* shell at a depth of 62 cm near the column sample location

3585 ± 35
 $\delta^{13}\text{C} = 0.4\text{‰}$

CAMS-80454. Sample ID No. 114-2-A
Nearly complete *M. californianus* shell, see CAMS-86868 (above) for 90–100 cm level description.

Comment: 3222 (3166) 3107 cal BP (1 σ).

Duncan's Landing (CA-SON-348/H), Locus B (Open-air Midden)

1805 ± 30
 $\delta^{13}\text{C} = -25.4\text{‰}$

CAMS-91667. Sample ID No. SON 348 CS-L34-1
Small charcoal fragment, Unit F, column sample, upper portion of Stratum V, Level 34, 166–170 cm, compact sandy loam.

Comment: 1815 (1713) 1635 cal BP (1 σ). This sample is from the lower levels of Component A. It is a non-twig sample and may represent old wood brought to the site and used by the occupants.

1210 ± 30
 $\delta^{13}\text{C} = -23.9\text{‰}$

CAMS-90387. Sample ID No. SON 348 CS-L25-1
Small charcoal fragment, Unit F, column sample, middle portion of Stratum IV, Level 25, 121–125 cm, compact shell lens of silty loam mixed with moderate midden.

Comment: 1174 (1169, 1157, 1148) 1064 cal BP (1 σ). This date marks the initial date of occupation for Component A.

1085 ± 30
 $\delta^{13}\text{C} = -26.3\text{‰}$

CAMS-90386. Sample ID No. SON 348 CS-L24-1
Small charcoal fragment, Unit F, column sample, upper portions of Stratum IV, Level 24, 116–120 cm, see CAMS-90387 (above) for description.

Comment: 1050 (970) 954 cal BP (1 σ). This ^{14}C age overlaps at 2 σ with a charcoal sample (CAMS-91653, below) from the 96–100 cm level.

1025 ± 30
 $\delta^{13}\text{C} = -23.9\text{‰}$

CAMS-91653. Sample ID No. SON 348 CS-L20-
Burnt twig fragment, Unit F, column sample, Stratum III, Level 20, 96–100 cm, shell lens of silty loam mixed with heavy midden and shell fragments.

Comment: 956 (933) 927 cal BP (1 σ). The sample is from the mixed levels at the interface (85–100 cm) of Components A and B1, and is commensurate with the other charcoal ^{14}C ages from below 100 cm.

960 ± 30
 $\delta^{13}\text{C} = -24.8\text{‰}$

CAMS-90388. Sample ID No. SON 348 CS-L26
Small charcoal fragment, Unit F, column sample, middle portion of Stratum IV, Level 26, 126–130 cm, see CAMS-90387 (above) for description.

Comment: 928 (916) 795 cal BP (1 σ).

830 ± 50
 $\delta^{13}\text{C} = -26.3\text{‰}$

Beta-140865. Sample ID No. SON 348/H #3
Several burnt twig fragments, see CAMS-90388 (above) for the 126–130 cm level description.

Comment: 787 (732) 687 cal BP (1 σ).

635 ± 35
 $\delta^{13}\text{C} = -24.4\text{‰}$

CAMS-90385. Sample ID No. SON 348 CS-L8-3
Small charcoal fragment, Unit F, column sample, upper portions of Stratum II, Level 8, 36–40 cm, shell lens of silty loam mixed with heavy midden, fire altered rock and charcoal.

Comment: 653 (647, 582, 567) 557 cal BP (1 σ). This ^{14}C age establishes the initial occupation of Component B1 and overlaps at 1 σ with charcoal ^{14}C ages from the same level (Beta-140863, below), and from the 56–60 level (CAMS-91650, below).

630 ± 30
 $\delta^{13}\text{C} = -25.7\text{‰}$

CAMS-91650. Sample ID No. SON 348 CS-L12-1
Charcoal fragment, Unit F, column sample, lower portions of Stratum II, Level 12, 56–60 cm, see CAMS-90385 (above) for description.

Comment: 651 (646, 583, 565) 557 cal BP (1 σ).

600 ± 50
 $\delta^{13}\text{C} = -22.7\text{‰}$

Beta-140863. Sample ID No. SON 348/H #1
Several charcoal pieces and burnt twig fragments, see CAMS-90385 (above) for the 36–40 cm level description.

Comment: 650 (623, 604, 557) 544 cal BP (1 σ).

525 ± 30
 $\delta^{13}\text{C} = -27.7\text{‰}$

CAMS-91652. Sample ID No. SON 348 CS-L18-1
Burnt twig fragment, Unit F, column sample upper portions of Stratum III, Level 18, 86–90 cm, see CAMS-91653 (above) for description.

Comment: 547 (536) 521 cal BP (1 σ). The sample is from the interface mixing zone between Components A and B1 and is compatible with the charcoal ^{14}C ages from higher levels.

465 ± 30
 $\delta^{13}\text{C} = -23.6\text{‰}$

CAMS-91651. Sample ID No. SON 348 CS-L14-1
Charcoal fragment, Unit F, column sample, lower portions of Stratum II, Level 14, 66–70 cm, see CAMS-90385 (above) for description.

Comment: 524 (512) 506 cal BP (1 σ).

460 ± 30
 $\delta^{13}\text{C} = -24.4\text{‰}$

CAMS-90384. Sample ID No. SON 348 CS-L8-2
Charcoal fragment, see CAMS-90385 (above) for the 36–40 cm level description.

Comment: 522 (511) 505 cal BP (1 σ).

390 ± 30
 $\delta^{13}\text{C} = -24.5\text{‰}$

CAMS-90383. Sample ID No. SON 348 CS-L8-1
Charcoal fragment, see CAMS-90385 (above) for the 36–40 cm level description.

Comment: 503 (474) 341 cal BP (1 σ). This is the youngest charcoal ^{14}C age from Component B1.

1500 ± 35
 $\delta^{13}\text{C} = -0.5\text{‰}$

CAMS-90254. Sample ID No. SON 348 CS-L26-A
M. californianus shell fragment, see CAMS-90388 (above) for the 126–130 cm level description.

Comment: 759 (723) 683 cal BP (1 σ). This is the oldest shell ^{14}C age from Component A.

1460 ± 30
 $\delta^{13}\text{C} = 0.1\text{‰}$

CAMS-90253. Sample ID No. SON 348 CS-L25-A
M. californianus shell fragment, see CAMS-90387 (above) for the 121–125 cm level description.

Comment: 815 (762) 801 cal BP (1 σ).

1435 ± 30
 $\delta^{13}\text{C} = 0.4\text{‰}$

CAMS-90252. Sample ID No. SON 348 CS-L24-A
M. californianus shell fragment, see CAMS-90386 (above) for the 116–120 cm level description.

Comment: 732 (697) 667 cal BP (1 σ).

1385 ± 30
 $\delta^{13}\text{C} = 0.3\text{‰}$

CAMS-91666. Sample ID No. SON 348 CS-L34-A
M. californianus shell fragment, see CAMS-91667 (above) for the 166–170 cm level description.

Comment: 688 (661) 645 cal BP (1 σ). This ^{14}C age suggests that remains from Component A reach a depth of 170 cm.

1280 ± 30
 $\delta^{13}\text{C} = -0.1\text{‰}$

CAMS-90250. Sample ID No. SON 348 CS-L14-A
Nearly complete *M. californianus* shell, see CAMS-91651 (above) for the 66–70 cm level description.

Comment: 630 (609) 548 cal BP (1 σ). This is the oldest shell ^{14}C age from Component B1.

1275 ± 35
 $\delta^{13}\text{C} = 0.3\text{‰}$

CAMS-91649. Sample ID No. SON 348 CS-L12-A
M. californianus shell fragment, see CAMS-91650 (above) for the 56–60 cm level description.

Comment: 630 (601) 544 cal BP (1 σ).

1260 ± 60
 $\delta^{13}\text{C} = 0.5\text{‰}$

Beta-140866. Sample ID No. SON 348/H #4
Eight sea mussel shell fragments (44.1 g), see CAMS-90388 (above) for the 126–130 cm level description.

Comment: 634 (559) 523 cal BP (1σ). This ^{14}C age overlaps at 1σ with shell ages (CAMS-90250 and CAMS-91649, above) from Component B1.

1165 ± 30
 $\delta^{13}\text{C} = -0.9\text{‰}$

CAMS-90251. Sample ID No. SON 348 CS-L18-A
M. californianus shell fragment, see CAMS-91652 (above) for the 86–90 cm level description.

Comment: 527 (508) 491 cal BP (1σ). The sample is from the interface mixing zone and is consistent with shell ^{14}C ages from Component B1.

1140 ± 30
 $\delta^{13}\text{C} = 0.2\text{‰}$

CAMS-90247. Sample ID No. SON 348 CS-L8-A
M. californianus shell fragment, see CAMS-90385 (above) for the 36–40 cm level description.

Comment: 514 (497) 474 cal BP (1σ).

1130 ± 30
 $\delta^{13}\text{C} = -0.2\text{‰}$

CAMS-90248. Sample ID No. SON 348 CS-L8-B
M. californianus shell fragment, see CAMS-90385 (above) for the 36–40 cm level description.

Comment: 509 (492) 467 cal BP (1σ).

1000 ± 60
 $\delta^{13}\text{C} = 0.5\text{‰}$

Beta-140864. Sample ID No. SON 348/H #2
Nine sea mussel shell fragments (45.3 g), see CAMS-90385 (above) for the 36–40 cm level description.

Comment: 448 (394) 297 cal BP (1σ).

990 ± 40
 $\delta^{13}\text{C} = -0.4\text{‰}$

CAMS-90249. Sample ID No. SON 348 CS-L8-C
M. californianus shell fragment, see CAMS-90385 (above) for the 36–40 cm level description.

Comment: 425 (371) 302 cal BP (1σ).

790 ± 30
 $\delta^{13}\text{C} = -0.1\text{‰}$

CAMS-91654. Sample ID No. SON 348 CS-L20-A
M. californianus shell fragment, see CAMS-91653 (above) for the 96–100 cm level description.

Comment: 241 (139) 101 cal BP (1 σ). The sample is from the interface mixing zone. This ^{14}C age is in accord with the shell ages from the upper levels (Component B1).

Ocean Springs (CA-SON-2378H), Locus SM2

4530 ± 30
 $\delta^{13}\text{C} = -22.7\text{‰}$

CAMS-91672. Sample ID No. BML SM2-F1-L1-1
Small charcoal fragment, Unit A, Feature 1, Level 1, 7–20 cm, sand with oxidized patches mixed with burnt and unburnt shell, charcoal, bone and fire altered rock.

Comment: 5301 (5156) 5053 cal BP (1 σ). This calibrated spread is commensurate with other charcoal ages from Feature 1 (Beta-140870, below) and Feature 2 (CAMS-91673, below).

4505 ± 30
 $\delta^{13}\text{C} = -26.1\text{‰}$

CAMS-91673. Sample ID No. BML SM2-F2-L3-1
Small, sandy charcoal fragment, Unit A, Feature 2, Level 3, 44–57 cm, sand mixed with shell fragments, charcoal, ash and cooking stones.

Comment: 5292 (5289, 5155, 5150, 5097, 5091) 5049 cal BP (1 σ).

4420 ± 60
 $\delta^{13}\text{C} = -22.6\text{‰}$

Beta-140870. Sample ID No. BML SM2 #1
Several charcoal pieces and small burned twig fragments, Unit A, Feature 1, see CAMS-91672 (above) for description.

Comment: 5213 (5030, 5017, 4978) 4871 cal BP (1 σ).

5095 ± 40
 $\delta^{13}\text{C} = 0.2\text{‰}$

CAMS-86883. Sample ID No. BML SM2-A-L3
Complete *M. californianus* shell, Unit A, Feature 2, see CAMS-91673 (above) for description.

Comment: 5233 (5113, 5101, 5079) 5029 cal BP (1 σ). This ^{14}C age is compatible with the shell ages from Feature 2 (Beta-140871, below) and from the Unit A, Level 1 matrix (CAMS-86884, below).

5030 ± 35
 $\delta^{13}\text{C} = 0.8\text{‰}$

CAMS-86884. Sample ID No. BML SM2-A-L1
M. californianus shell fragment, Unit A, unit matrix, Level 1, 0–20 cm, sand mixed with fragmented shell.

Comment: 5046 (4993) 4948 cal BP (1 σ).

4930 ± 80
 $\delta^{13}\text{C} = 0.8\text{‰}$

Beta-140871. Sample ID No. BML SM2 #2
Eight shell fragments (48.5 g), Unit A, Feature 1, see CAMS-91672 (above) for description.

Comment: 4970 (4852) 4809 cal BP (1 σ).

Ocean Springs (CA-SON-2378H), Locus SM1

3970 ± 40
 $\delta^{13}\text{C} = -24.9\text{‰}$

Beta-153356. Sample ID No. BML SM1 #1-A
Charcoal fragment, Unit A (center), matrix sub-sample, upper portions of Level 3, 41–45 cm, sand mixed with sporadic fragmented shell.

Comment: 4507 (4419) 4410 cal BP (1 σ). This ^{14}C age post-dates the charcoal ages from Ocean Springs, Locus SM2.

4650 ± 60
 $\delta^{13}\text{C} = 0.1\text{‰}$

Beta-153357. Sample ID No. BML SM1 #2-A
Eleven shell fragments (15.4 g). See BETA-153356 (above) for 41–45 cm description.

Comment: 4604 (4515) 4423 cal BP (1 σ). This ^{14}C age post-dates the shell ages from Locus SM2. This sample required extended counting time for ^{14}C content.

Two Seals (CA-SON-1735), Locus SM1

4060 ± 30
 $\delta^{13}\text{C} = -27.6\text{‰}$

CAMS-91664. Sample ID No. SON 1735 E-F3-L2-1
Small burned twig fragment, Units E and F, Feature 3, Level 2, 21–40 cm, sand mixed with charcoal, burnt wood, ash, weathered shell and fire altered rock.

Comment: 4569 (4564, 4564, 4527) 4448 cal BP (1 σ). The sample is from the lower portion of the feature and predates a bulk charcoal sample (Beta-140869, below) from the entire feature.

4005 ± 30
 $\delta^{13}\text{C} = -24.7\text{‰}$

CAMS-91663. Sample ID No. SON 1735 C-F2-L2-1
Small burned twig fragment, Unit C, Feature 2 (south area), Level 2, 26–40 cm, sand mixed charcoal, ash, weathered shell and fire altered rock.

Comment: 4520 (4503, 4488, 4422) 4419 cal BP (1 σ). This ^{14}C age overlaps at 2 σ with a charcoal age from Feature 3 (CAMS-91664, above).

3840 ± 80
 $\delta^{13}\text{C} = -25.8\text{‰}$

Beta-140869. Sample ID No. SON 1735 #1
Bulk sample of charcoal pieces (15 g), Unit F, Feature 3, Levels 1 and 2, 6–40 cm, see CAMS-91664 (above) for description.

Comment: 4410 (4240) 4094 cal BP (1 σ).

3800 ± 30
 $\delta^{13}\text{C} = -25.6\text{‰}$

CAMS-91662. Sample ID No. SON 1735 B-F1-L1-1
Small charcoal fragment, Unit B, Feature 1, Level 1, 5–20 cm, sand mixed with charcoal, weathered shell and fire-altered rock.

Comment: 4237 (4219, 4207, 4174, 4174, 4152) 4097 cal BP (1 σ). This ^{14}C age overlaps at 2 σ with a charcoal age (Beta-140869, above) from Feature 3.

4670 ± 30
 $\delta^{13}\text{C} = 0.3\text{‰}$

CAMS-91671. Sample ID No. SON 1735 F-L2-A
M. californianus shell fragment, Unit F, unit matrix, Level 2, 21–40 cm, sand mixed with sporadic shell fragments.

Comment: 4581 (4529) 4502 cal BP (1 σ). This ^{14}C age is the same age as a shell (CAMS-91669, below) from the Unit B matrix.

4670 ± 35
 $\delta^{13}\text{C} = -0.1\text{‰}$

CAMS-91669. Sample ID No. SON 1735 B-L2-A
M. californianus shell fragment, Unit B, unit matrix, Level 2, 21–40 cm, sand mixed with sporadic shell fragments.

Comment: 4600 (4529) 4499 cal BP (1 σ).

4620 ± 30
 $\delta^{13}\text{C} = 1.1\text{‰}$

CAMS-91670. Sample ID No. SON 1735 C-F2-SA-L2-A
M. californianus shell fragment, Unit C, Feature 2 (south area), see CAMS-91663 for 26–40 cm level description.

Comment: 4519 (4490) 4419 cal BP (1 σ).

Salmon Creek Beach (CA-SON-284), Locus SM1

CAMS-91658. Sample ID No. SON 284 SM1-B-L2-1 **3935 ± 30**
 $\delta^{13}\text{C} = -25.5\text{‰}$
Small charcoal fragment, Unit B (center), matrix sub-sample, upper portions of Level 2, 11–15 cm, sand and slightly silty/midden mixed with whole and fragmented shells.

Comment: 4418 (4412) 4303 cal BP (1 σ). This ^{14}C age marks the initial occupation of Locus SM1 and overlaps with CAMS-91668 (below) at 1 σ .

CAMS-91668. Sample ID No. SON 284 SM1-C-L5-1 **3925 ± 45**
 $\delta^{13}\text{C} = -23.2\text{‰}$
Small charcoal fragment, Unit C (center), matrix sub-sample, upper portions of Level 5, 41–45 cm sand and slightly silty/midden mixed with fragmented shells.

Comment: 4419 (4410) 4295 cal BP (1 σ).

CAMS-86881. Sample ID No. SON 284 SM1-B-L2 **4465 ± 35**
 $\delta^{13}\text{C} = 0.1\text{‰}$
M. californianus shell fragment, Unit B, unit matrix, see CAMS-91658 (above) for the 11–20 cm level description.

Comment: 4350 (4280) 4225 cal BP (1 σ).

CAMS-86882. Sample ID No. SON 284 SM1-C-L11 **4345 ± 35**
 $\delta^{13}\text{C} = -0.6\text{‰}$
M. californianus shell fragment, Unit C, unit matrix, Level 11, 101–110 cm, sand.

Comment: 4153 (4098) 4065 cal BP (1 σ).

Salmon Creek Beach (CA-SON-284), Locus SM2

CAMS-91660. Sample ID No. SON 284 SM2-A-L2-1 **3780 ± 45**
 $\delta^{13}\text{C} = -23.2\text{‰}$
Small burned twig fragment, Unit A (center), matrix sub-sample, upper portions of Level 2, 11–15 cm, slightly silty sand mixed with fragmented shells.

Comment: 4235 (4149) 4088 cal BP (1 σ).

CAMS-91661. Sample ID No. SON 284 SM2-A-L10-A **4530 ± 30**
 $\delta^{13}\text{C} = -0.1\text{‰}$
M. californianus shell fragment, Unit A, unit matrix, Level 10, 91–95 cm, sand.

Comment: 4411 (4385) 4337 cal BP (1 σ).

4415 ± 30
 $\delta^{13}\text{C} = 0.1\text{‰}$

CAMS-91659. Sample ID No. SON 284 SM2-A-L2-A
M. californianus shell fragment, Unit A, unit matrix, see CAMS-91660 (above) for the 11–20 cm level description.

Comment: 4257 (4218) 4146 cal BP (1 σ). This ^{14}C age is consistent with the shell ages from Locus SM1, above.

Mussel Point (CA-SON-327), Locus SM1

2285 ± 30
 $\delta^{13}\text{C} = -23.6\text{‰}$

CAMS-91656. Sample ID No. SON 327 CS-L5-1
Small charcoal fragment, column sample, Level 5, 71–75 cm, sand mixed with moderate midden, ash, charcoal and fragmented shell.

Comment: 2344 (2334) 2211 cal BP (1 σ). This ^{14}C age overlaps at 2 σ with a shell age (CAMS-91657, below) from the 76–80 cm level.

2235 ± 35
 $\delta^{13}\text{C} = -23.8\text{‰}$

CAMS-91657. Sample ID No. SON 327 CS-L6-1
Small charcoal fragment, column sample, Level 6, 76–80 cm, see CAMS-91656 (above) for description.

Comment: 2330 (2307, 2223, 2208, 2186, 2184) 2155 cal BP (1 σ).

225 ± 30
 $\delta^{13}\text{C} = -25.0\text{‰}$

CAMS-91655. Sample ID No. SON 327 A-L3-1
Burned twig fragment, Unit A, matrix sub-sample, upper portions of Level 3, 21–25 cm, silty sand mixed with fragmented shell.

Comment: 302 (287, 164, 164, 157, 156) 0* cal BP (1 σ). This sample can be rejected by criterion of Chauvenet (see Long and Rippeteau 1974). It represents modern charcoal introduced into the upper levels of Unit A.

2755 ± 35
 $\delta^{13}\text{C} = 0.7\text{‰}$

CAMS-90256. Sample ID No. SON 327 CS-L5-A
M. californianus shell fragment, column sample, Level 5, 71–75 cm, see CAMS-91656 (above) for description.

Comment: 2175 (2129) 2093 cal BP (1 σ). This shell ^{14}C age overlaps at 1 σ with shell ages from the 76–80 cm level (CAMS-90257, below) and the 81–85 cm level (Beta-153358, below).

2735 ± 40
 $\delta^{13}\text{C} = 1.0\text{‰}$

CAMS-90257. Sample ID No. SON 327 CS-L6-A
M. californianus shell fragment, column sample, Level 6, 76–80 cm, see CAMS-91656 (above) for description.

Comment: 2152 (2112) 2052 cal BP (1 σ).

2730 ± 40
 $\delta^{13}\text{C} = -0.3\text{‰}$

Beta-153358. Sample ID No. SON 327 #1-A
Eight *M. californianus* shell fragments (2.7 g), column sample, Level 7, 81–85 cm, sand mixed with fragments of shell.

Comment: 2148 (2108) 2045 cal BP (1 σ).

2530 ± 25
 $\delta^{13}\text{C} = 0.3\text{‰}$

CAMS-90255. Sample ID No. SON 327 Unit A-L3-A
M. californianus shell fragment, Unit A, unit matrix, Level 3, 21–30 cm, see CAMS-91655 (above) for description.

Comment: 1896 (1866) 1826 cal BP (1 σ).

Kili (CA-SON-299), Unknown Provenience

2610 ± 25
 $\delta^{13}\text{C} = -0.5\text{‰}$

CAMS-100074. Sample ID No. SON 299 1-200631-5-E
M. californianus shell fragment.

Comment: 1988 (1949) 1917 cal BP (1 σ). This is the oldest shell age from *Kili*.

2525 ± 35
 $\delta^{13}\text{C} = 0.9\text{‰}$

CAMS-100075. Sample ID No. SON 299 1-200631-7-G
Nearly complete *M. californianus* shell.

Comment: 1899 (1863) 1817 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with CAMS-96624 and CAMS-96622, below.

2520 ± 30
 $\delta^{13}\text{C} = 0.0\text{‰}$

CAMS-96624. Sample ID No. SON 299 1-200631-6-F
Nearly complete *M. californianus* shell.

Comment: 1890 (1859) 1816 cal BP (1 σ).

CAMS-96622. Sample ID No. SON 299 1-200631-1-A 2490 ± 30
Complete *M. californianus* shell. $\delta^{13}\text{C} = 0.0\text{‰}$

Comment: 1864 (1820) 1788 cal BP (1 σ).

CAMS-100078. Sample ID No. SON 299 1-200631-10-J 2450 ± 30
M. californianus shell fragment. $\delta^{13}\text{C} = 0.4\text{‰}$

Comment: 1818 (1785) 1721 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with CAMS-100072 and CAMS-96623, below.

CAMS-100072. Sample ID No. SON 299 1-200631-2-B 2440 ± 35
Nearly complete *M. californianus* shell. $\delta^{13}\text{C} = 0.6\text{‰}$

Comment: 1815 (1770) 1708 cal BP (1 σ).

CAMS-96623. Sample ID No. SON 299 1-200631-4-D 2420 ± 30
Nearly complete *M. californianus* shell. $\delta^{13}\text{C} = -0.6\text{‰}$

Comment: 1797 (1730) 1696 cal BP (1 σ).

CAMS-100077. Sample ID No. SON 299 1-200631-9-I 2395 ± 30
Nearly complete *M. californianus* shell. $\delta^{13}\text{C} = -0.6\text{‰}$

Comment: 1758 (1705) 1681 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with CAMS-96623 (above) and CAMS-100073 (below), and is compatible with the shell ages from Trench F (below).

CAMS-100073. Sample ID No. SON 299 1-200631-3-C 2390 ± 35
Nearly complete *M. californianus* shell. $\delta^{13}\text{C} = 0.5\text{‰}$

Comment: 1755 (1701) 1670 cal BP (1 σ).

CAMS-100076. Sample ID No. SON 299 1-200631-8-H 2265 ± 30
Nearly complete *M. californianus* shell. $\delta^{13}\text{C} = 1.1\text{‰}$

Comment: 1594 (1543) 1515 cal BP (1 σ).

Kili (CA-SON-299), Trench F

2380 ± 35

CAMS-100071. SON 299 1-107342-1-A

$\delta^{13}\text{C} = 1.1\text{‰}$

M. californianus shell fragment, Pit F-5, 48–60 inches.

Comment: 1733 (1694) 1629 cal BP (1 σ). This is the oldest shell ^{14}C age from Trench F.

2375 ± 35

CAMS-96621. SON 299 1-107336-1-A

$\delta^{13}\text{C} = 0.5\text{‰}$

Nearly complete *M. californianus* shell, Pit F-2, 48–60 inches.

Comment: 1726 (1690) 1624 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with a shell age from the same depth (CAMS-100071, above) at Pit F-5, and with a shell age from the 36–48 inch level (CAMS-100070, below) in the same pit (Pit F-2).

2360 ± 35

CAMS-100070. SON 299 1-107324-2-B

$\delta^{13}\text{C} = 0.8\text{‰}$

Nearly complete *M. californianus* shell, Pit F-2, 36–48 inches.

Comment: 1709 (1682) 1608 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with shell ages from the 48–60 inch level (CAMS-96621, above) and from the 12–24 inch level (CAMS-96619 and CAMS-100068, below).

2335 ± 25

CAMS-96619. Sample ID No. SON 299 1-107303-1-A

$\delta^{13}\text{C} = 0.5\text{‰}$

Nearly complete *M. californianus* shell, Pit F-2, 12–24 inches.

Comment: 1686 (1626) 1592 cal BP (1 σ). This is the same ^{14}C age produced by another shell (CAMS-100068, below) from the same level.

2335 ± 35

CAMS-100068. Sample ID No. SON 299 1-107303-2-B

$\delta^{13}\text{C} = 0.2\text{‰}$

Nearly complete *M. californianus* shell, Pit F-2, 12–24 inches.

Comment: 1691 (1626) 1582 cal BP (1 σ).

2235 ± 35

CAMS-100069. Sample ID No. SON 299 1-107312-1-A

$\delta^{13}\text{C} = 0.4\text{‰}$

M. californianus shell fragment, Pit F-2, 24–36 inches.

Comment: 1555 (1519) 1484 cal BP (1 σ). This ^{14}C age overlaps at 1 σ with a shell sample (CAMS-96620, below) from the 36–48 inch level.

2230 ± 30
 $\delta^{13}\text{C} = 0.7\text{‰}$

CAMS-96620. Sample ID No. SON 299 1-107324-1-A
Complete *M. californianus* shell, Pit F-2, 36–48 inches.

Comment: 1546 (1517) 1483 cal BP (1 σ). This is the youngest shell age from *Kili*.

Bodega Lagoon (CA-SON-322), Locus SMI

665 ± 35
 $\delta^{13}\text{C} = -26.6\text{‰}$

CAMS-83043. Sample ID No. SON 322 676/001 #1
Small burnt twig fragment, Unit D (northwest corner), matrix sub-sample, Level 12, 111–115 cm, silty sand mixed with dark midden and densely packed shell fragments.

Comment: 661 (652) 565 cal BP (1 σ). This non-twig sample can be rejected by criterion of Chauvenet (see Long and Rippeteau 1974). It may represent old wood, possibly from a charred log located along the south wall of excavation Unit A, or may be intrusive from deeper deposits.

365 ± 30
 $\delta^{13}\text{C} = -23.7\text{‰}$

CAMS-90389. Sample ID No. SON 322 675/001-L12-2
Very small burnt twig fragment, Unit B (center), matrix sub-sample, Level 12, 111–115 cm, silty sand mixed with dark midden and densely packed shell fragments.

Comment: 480 (462, 345, 345) 325 cal BP (1 σ). This is the oldest accepted ^{14}C age for the upper levels of the deposit.

225 ± 35
 $\delta^{13}\text{C} = -27.1\text{‰}$

CAMS-83042. Sample ID No. SON 322 775/995 #3
Burnt twig fragment, Unit E, unit matrix, Level 12, 141–150 cm, sand mixed with moderate midden and loose shell.

Comment: 303 (287, 164, 164, 157, 156) 0* cal BP (1 σ). This ^{14}C age overlaps at 1 σ with a charcoal age from the same provenience (CAMS-86866, below). $\delta^{13}\text{C}$ was estimated from CAMS-83040, below.

190 ± 35
 $\delta^{13}\text{C} = -27.1\text{‰}$

CAMS-86866. Sample ID No. SON 322 775/995-L12
Charcoal fragment, Unit E, unit matrix, see CAMS-83042 (above) for 141–150 cm level description.

Comment: 288 (282, 169, 153, 5, 0*, 0*) 0* cal BP (1 σ). $\delta^{13}\text{C}$ was estimated from CAMS-83040, below.

175 ± 35
 $\delta^{13}\text{C} = -27.1\text{‰}$

CAMS-83040. Sample ID No. SON 322 775/995 #1
Burnt twig fragment, Unit E, unit matrix, see CAMS-83042 (above) for 141–150 cm level description.

Comment: 284 (281, 275, 270, 183, 180, 171, 151, 10, 0*) 0* cal BP (1 σ). This ^{14}C age overlaps a 1 σ with CAMS-86866 (above) and CAMS-83041 (below).

160 ± 35
 $\delta^{13}\text{C} = -27.1\text{‰}$

CAMS-83041. Sample ID No. SON 322 775/995 #2
Burnt twig fragment, Unit E, unit matrix, see CAMS-83042 (above) for 141–150 cm level description.

Comment: 283 (267, 211, 206, 187, 175, 174, 174, 173, 145, 144, 144, 20, 18, 18, 16, 11, 0*) 0* cal BP (1 σ). $\delta^{13}\text{C}$ was estimated from CAMS-83040, above.

90 ± 50
 $\delta^{13}\text{C} = -25.2\text{‰}$

Beta-140867. Sample ID No. SON 322 #1
Several burnt twig fragments (18.4 g), Unit E, unit matrix, see CAMS-83042 (above) for 141–150 cm level description.

Comment: 266 (122, 122, 69, 67, 59, 43, 0*) 0* cal BP (1 σ). The calibrated spread of this bulk sample date corresponds with other charcoal samples from the site, but may represent modern/historic charcoal (mean calibrated intercept = 69 cal BP).

1000 ± 35
 $\delta^{13}\text{C} = 0.6\text{‰}$

CAMS-80450. Sample ID No. 775/995-L12 #1
M. californianus shell fragment, Unit E, unit matrix, see CAMS-83042 (above) for 141–150 cm level description.

Comment: 429 (394) 311 cal BP (1 σ). This is the oldest shell age from the upper levels of the deposit.

895 ± 35
 $\delta^{13}\text{C} = 1.2\text{‰}$

CAMS-82846. Sample ID No. SON 322 676/001 #1
M. californianus shell fragment, Unit D (northwest corner), matrix sub-sample, see CAMS-83043 (above) for 111–115 cm level description.

Comment: 296 (276) 258 cal BP (1 σ). This shell ^{14}C age overlaps at 1 σ with other shell ages from 141–150 cm at Unit E (CAMS-80451 and CAMS-82845, below).

865 ± 40
 $\delta^{13}\text{C} = 0.2\text{‰}$

CAMS-80451. Sample ID No. 775/995-L12 #2
M. californianus shell fragment, Unit E, unit matrix, see CAMS-83042 (above) for 141–150 cm level description.

Comment: 283 (262) 237 cal BP (1 σ). This is the same ^{14}C age as another shell (CAMS-82845, below) from this level.

865 ± 35
 $\delta^{13}\text{C} = 0.5\text{‰}$

CAMS-82845. Sample ID No. SON 322 775/995 #5
Complete *M. californianus* shell, Unit E, unit matrix, see CAMS-83042 (above) for 141–150 cm level description.

Comment: 281 (262) 241 cal BP (1 σ).

850 ± 70
 $\delta^{13}\text{C} = 0.7\text{‰}$

Beta-140868. Sample ID No. SON 322 #2
Five *M. californianus* shell fragments (59.2 g), Unit E, unit matrix, see CAMS-83042 (above) for 141–150 cm level description.

Comment: 289 (255) 131 cal BP (1 σ).

Notes

* - represents a negative radiocarbon age BP as reported by CALIB v. 4.3 (Stuiver and Reimer 1993).

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Figure 1. Location Map. (1) Duncan's Landing (CA-SON-348/H); (2) Salmon Creek Beach (CA-SON-284); (3) Ocean Springs (CA-SON-2378), Two Seals (CA-SON-1735) and Mussel Point (CA-SON-327); (4) *Kili* (CA-SON-299), Bodega Lagoon (CA-SON-322) and *Tokau* (CA-SON-321).

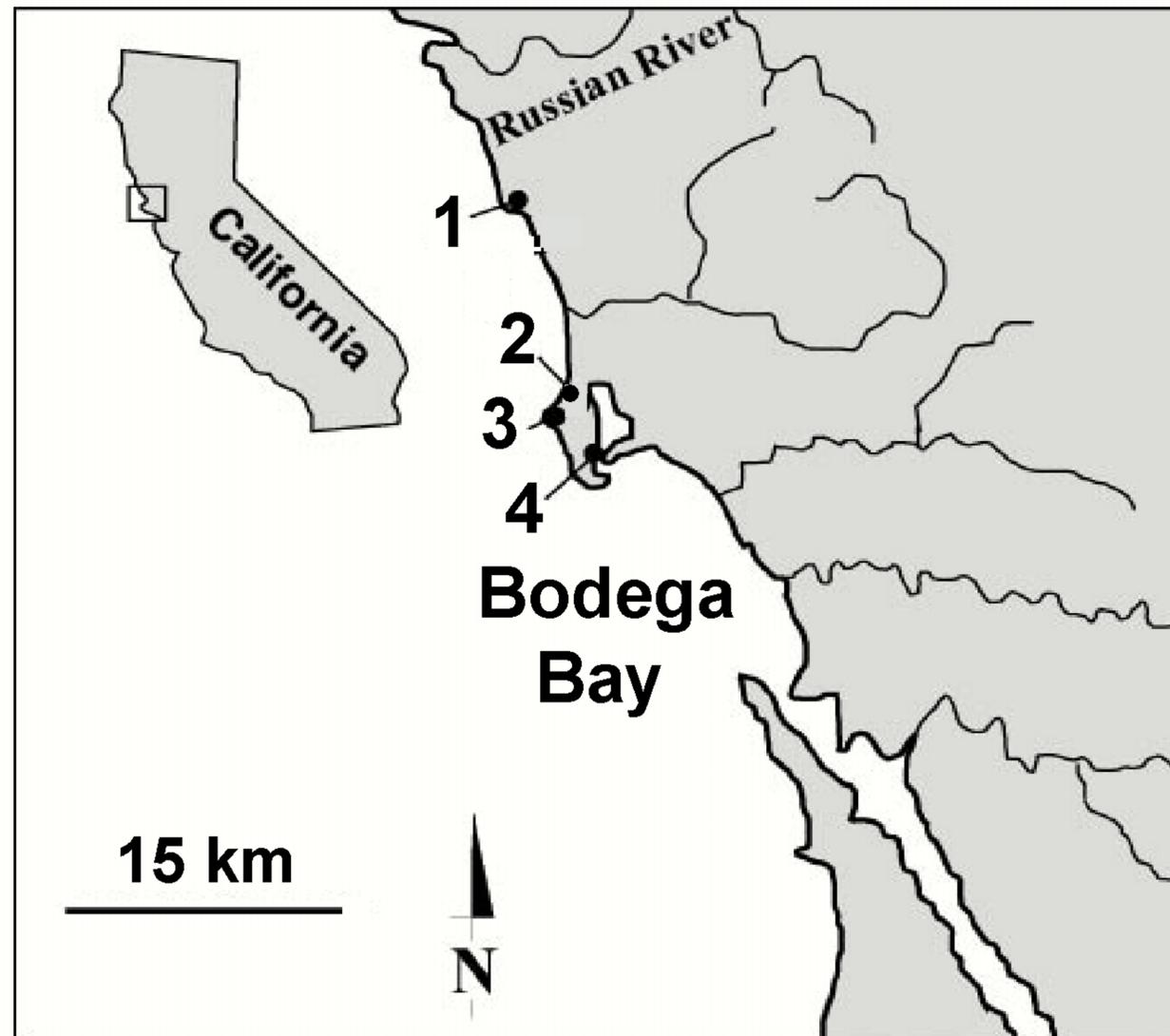


Figure 2. Stratigraphic profile of Duncan's Landing (CA-SON-348/H), Duncan's Point Cave (Locus A), Test Unit, Southeast Wall (after Schwaderer 1992:Figure 3.1).

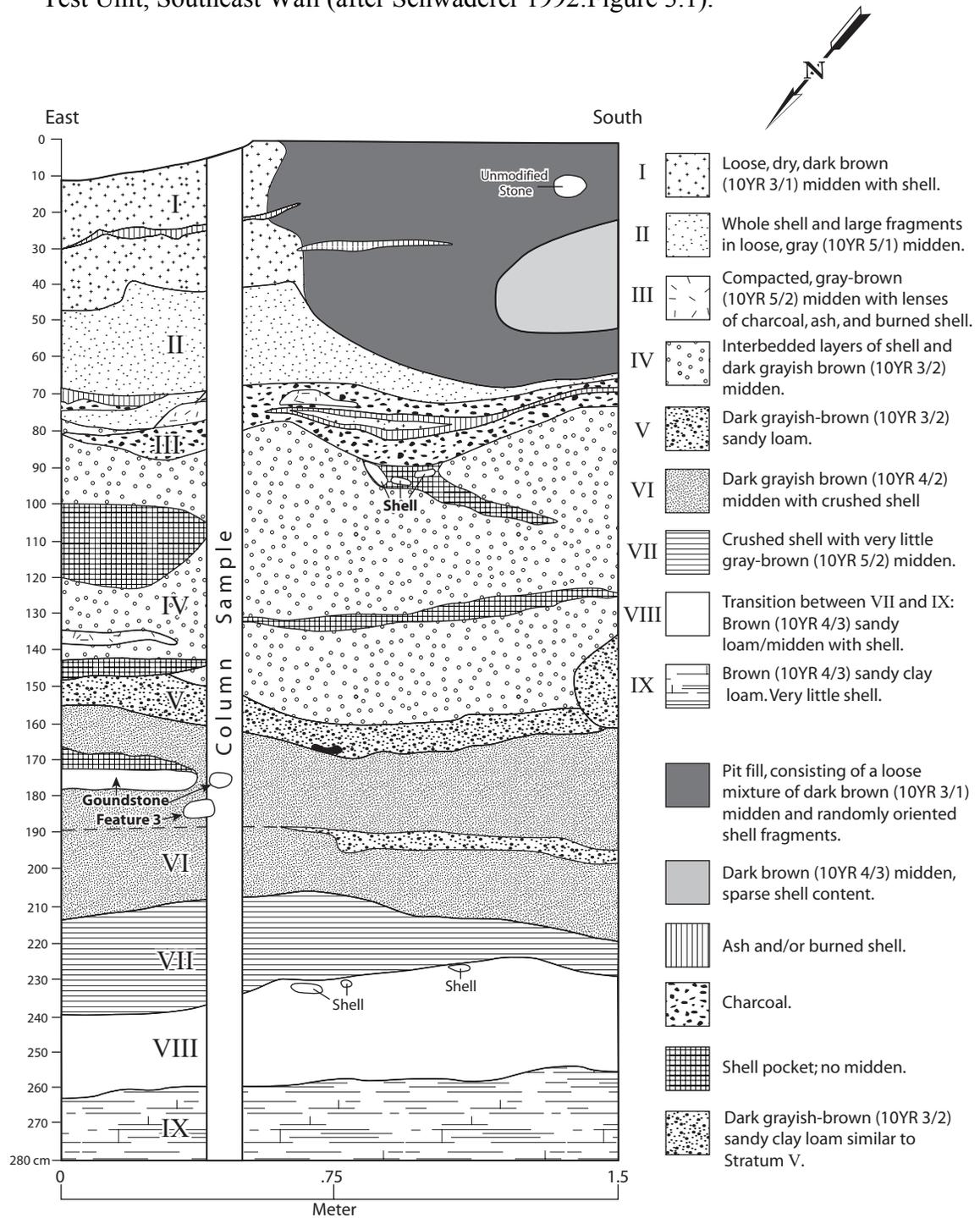
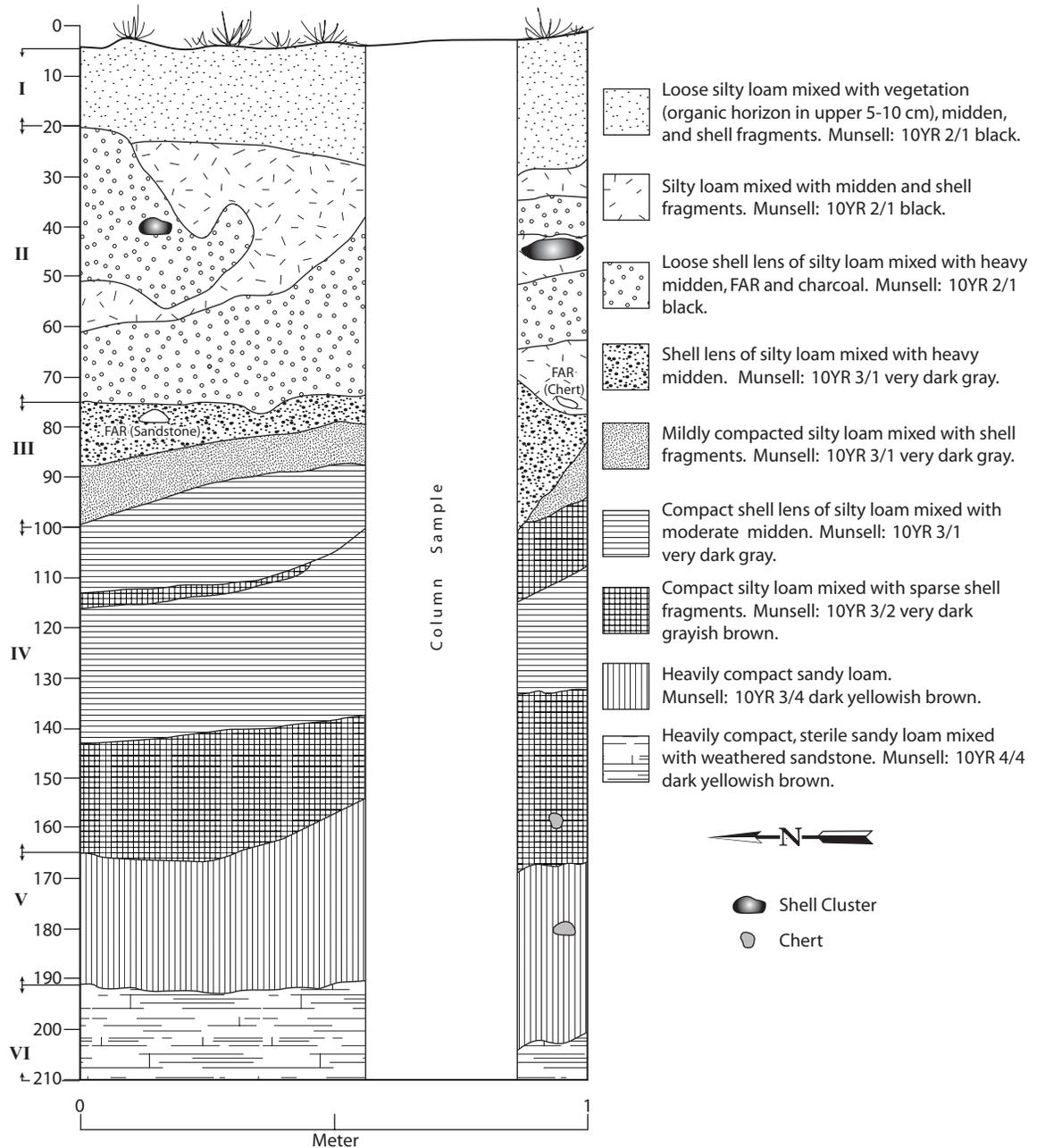


Figure 3. Stratigraphic profile of Duncan's Landing (CA-SON-348/H), Open-air Midden (Locus B), Unit F, East Wall.



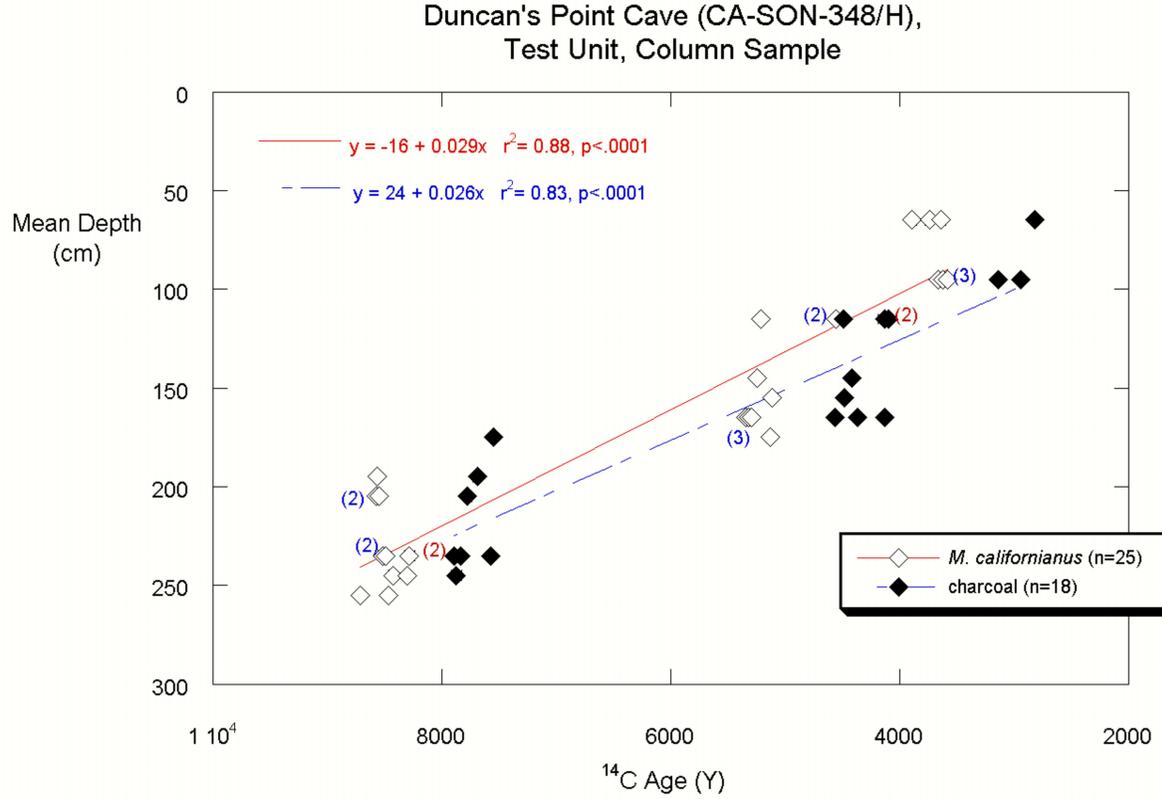


Figure 4. Charcoal and *Mytilus californianus* shell ^{14}C ages (1σ) and depth (cm) of recovery from Duncan's Landing (CA-SON-348/H), Duncan's Point Cave (Locus A), Test Unit, Column Sample.
 Note: Standard deviations are smaller (1σ) than symbol widths.

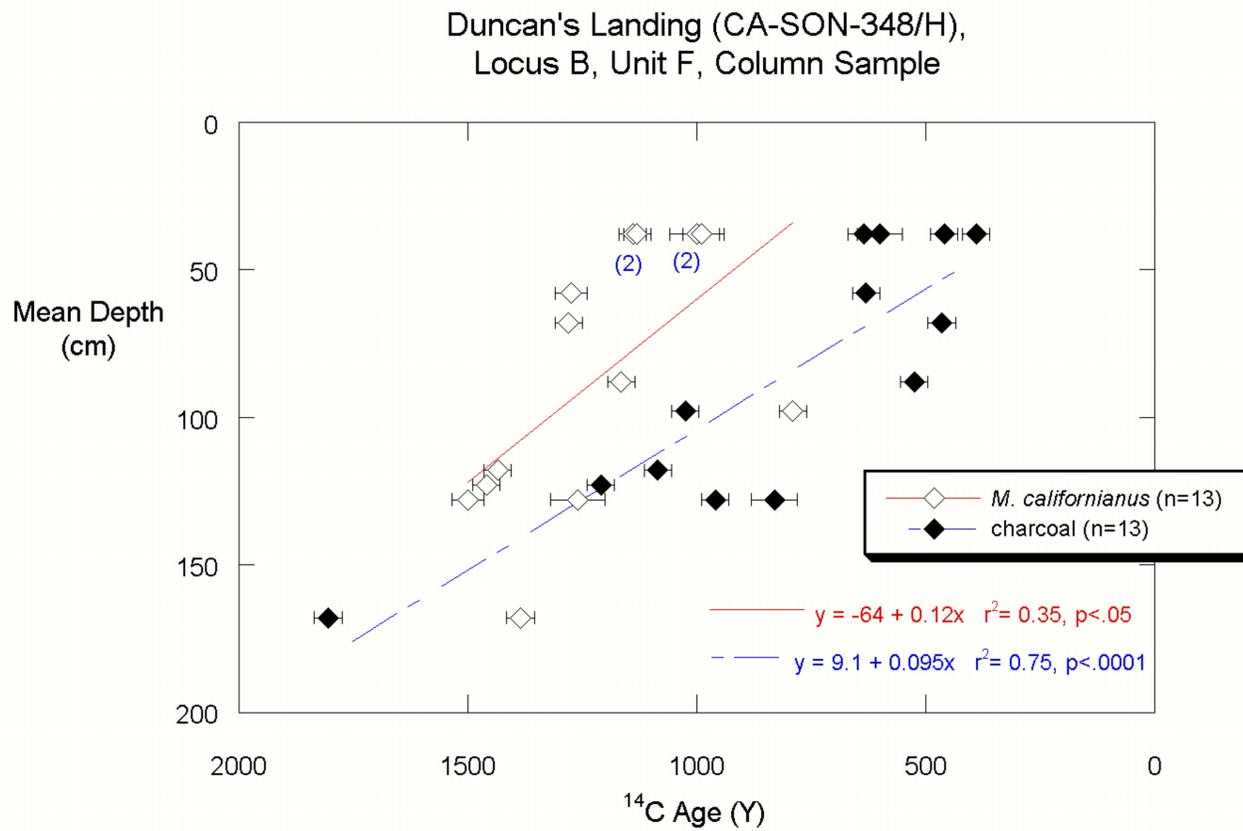


Figure 5. Charcoal and *Mytilus californianus* shell ^{14}C ages (1σ) and depth (cm) of recovery from Duncan's Landing (CA-SON-348/H), Locus B (Open-air Midden), Unit F, Column Sample.