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Pismo Clam (*Tivela stultorum*) Harvesting on Middle Holocene Santa Rosa Island, California

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*Pismo clams (*Tivela stultorum*) are relatively common in California's surf-swept, sandy beaches, and archaeological specimens have been used as proxies for sand beach accretion and El Niño (ENSO) periodicity during the last 10,000 years. Native Americans in coastal southern California harvested Pismo clams throughout the Holocene, but these clams are generally rare in Channel Island archaeological sites. Here we report on human harvesting of Pismo clams at CA-SRI-209, located near Southeast Anchorage on Santa Rosa Island. Excavation of three discrete shell midden deposits produced evidence for intensive harvesting of California mussels (*Mytilus californianus*) between 5,030 and 4,820 cal B.P., and Pismo clams from about 4,770 to 4,310 cal B.P. Ancient Pismo clam sizes and population data from eastern Santa Rosa Island suggest that people harvested Pismo clams infrequently during the Holocene, with the CA-SRI-209 sample representing a population of similar sized (~83 mm. in height) individuals that fall within the size range of modern Pismo clams measured from the same area today. The timing of intensive Pismo clam harvests on Santa Rosa and adjacent Santa Cruz Island differs from that of the western Santa Barbara coast and hypothesized decreases in Middle and Late Holocene ENSO frequencies. Pismo clams are common prey of sea otters (*Enhydra lutris*), and it is possible that the abundance of Pismo clams in island archaeological assemblages may reflect a dearth of otters in local catchments.*

Shellfish were an important component of Native American diets on California's Channel Islands for some 13,000 years. People harvested rocky intertidal, estuarine, and sandy beach shellfish by the millions (or more) and also used the shells for making beads and ornaments, adzes, fishhooks, and other tools (Arnold and Graesch 2001; Braje et al. 2012). During the Middle Holocene, a number of important environmental changes, including dramatic reductions in sea level rise, a possibly reduced El Niño (ENSO), and other variables, likely influenced the productivity and availability of a variety of shellfish, as well as the human exploitation of those resources (Braje et al. 2009; Glassow 1993; Glassow et al. 1994, 2009; Kennett et al. 2007; Rick et al. 2005). On the northern Channel Islands, the use of red abalone (*Haliotis cracherodii*) and the more localized harvesting of a variety of species of estuarine shellfish (*Chione undatella*, *Saxidomus nuttalli*, etc.) have been a focus of research and have helped to document local environmental changes, human responses to such environmental developments, and human impacts on shellfish populations (Braje et al. 2009; Erlandson et al. 2008; Glassow et al. 2009; Rick 2009; Rick et al. 2005; Vellanoweth et al. 2002). Although the widespread use of rocky shore shellfish and the localized harvesting of estuarine shellfish have been documented, sandy beach shellfish like Pismo clams (*Tivela stultorum*) appear to have been of minor importance on the Channel Islands.

In this paper, we present the results of our excavation and analysis of CA-SRI-209, a Middle Holocene site on eastern Santa Rosa Island (Fig. 1). During survey in 2006, we visited CA-SRI-209 and were impressed by the large amounts of Pismo clams located on the site surface. Not having encountered deposits like this on the island before, and because the site was badly eroding, we conducted a salvage excavation designed to evaluate the chronology, function, and range of human activities performed by people who lived at the site. Pismo clams are important commercial and recreational shellfish found burrowed (<15 cm.) in sandy, surf-swept beaches in the intertidal to subtidal depths of 25 m. from Monterey Bay (Half Moon Bay, historically) to Socorro Island, Baja California (Pattison 2001; Shaw and Hassler 1989). Pismo clams, which were occasionally a focus of human subsistence on the mainland (see Erlandson 1988; Masters 2006; Vellanoweth and Erlandson 2006), are generally rare in Channel Island sites (see Braje et al. 2012). However, Thakar (2011, 2012) recently reported

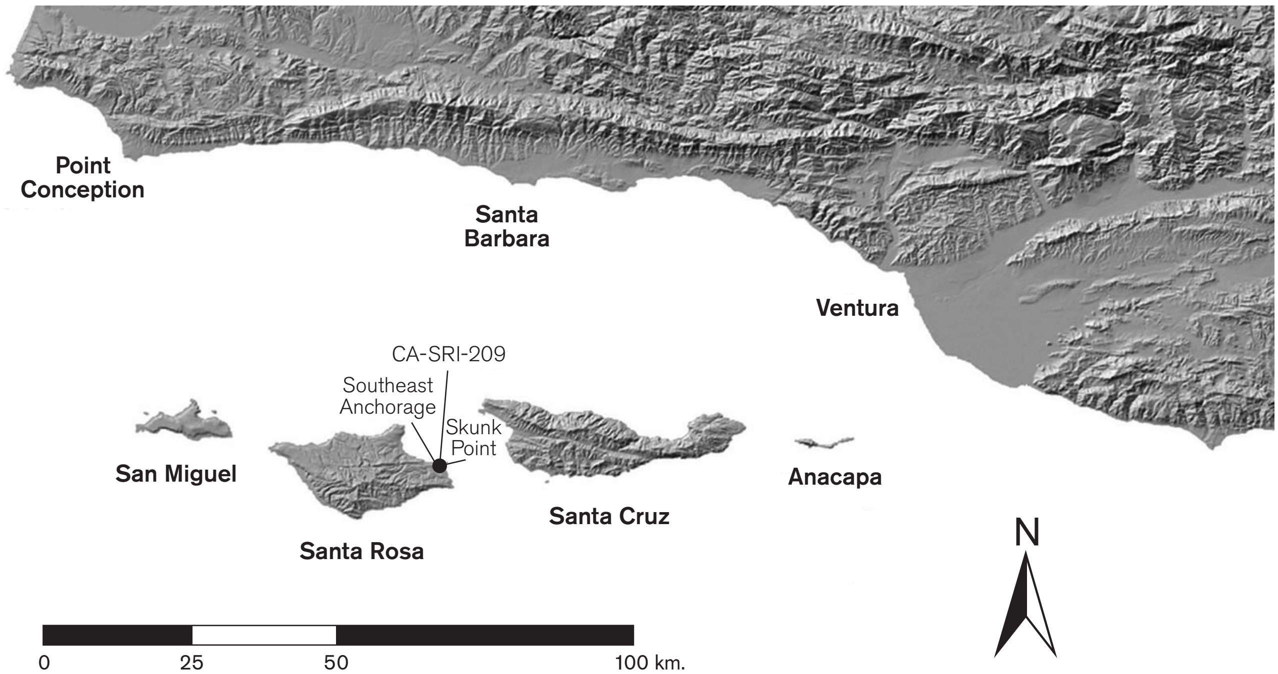

Figure 1. Location of CA-SRI-209 and the northern Channel Islands.

on data from a Late Holocene site (CA-SCRI-480) on Santa Cruz Island that contained both abundant Pismo clam remains and evidence of human overexploitation of the population. Here we build on these data by exploring the significance of Pismo clam harvesting at CA-SRI-209 for understanding human subsistence and settlement, sand beach accretion and ENSO, sea otter (*Enhydra lutris*) abundance, and human interactions with island ecosystems through time.

SANTA ROSA ISLAND AND CA-SRI-209

Santa Rosa Island has a land area of about 217 km.^{2} and is situated about 44 km. from the mainland coast, in between San Miguel and Santa Cruz islands. Owned and managed by the National Park Service, Santa Rosa Island contains a number of unique terrestrial and marine ecosystems, including several streams, oak and riparian woodlands, and a grove of Torrey pines (*Pinus torreyana insularis*). Terrestrial ecosystems are recovering from over a century of historical ranching and other land use, and terrestrial plant communities were likely more productive in the past. Near-shore marine ecosystems include rocky intertidal, kelp forests, sandy beaches, and mosaics of rocks and sand.

The Skunk Point and Southeast Anchorage areas of Santa Rosa Island contain the remains of numerous archaeological sites that span over 8,000 years of occupation (Rick 2009). This is an area with some of the most extensive sandy beaches on the Channel Islands, along with rocky intertidal habitats and offshore kelp forests. Estuarine shellfish (*Chione* spp., *Ostrea lurida*, etc.)—likely obtained from the Abalone Rocks Estuary located at the mouth of Old Ranch Canyon—were an important component of Early and Middle Holocene diets on this part of the island (Rick et al. 2005, 2006; Wolff et al. 2007). Red abalones, California mussels (*Mytilus californianus*), and other rocky intertidal shellfish are also common in Middle Holocene sites in the area. Along with Christy Beach on Santa Cruz Island, Southeast Anchorage is one of only two areas on the northern Channel Islands with definitive Pismo clam populations today, although additional surveys for Pismo clams may reveal other populations (Dugan et al. 2002; Richards 1995).

CA-SRI-209 is located on a terrace at an elevation of 200 feet, and it is about 0.5 km. from Southeast Anchorage and 1 km. from Skunk Point. Much of the site is currently well vegetated with lupine, grasses, coyote brush, and other plants that obscure surface visibility

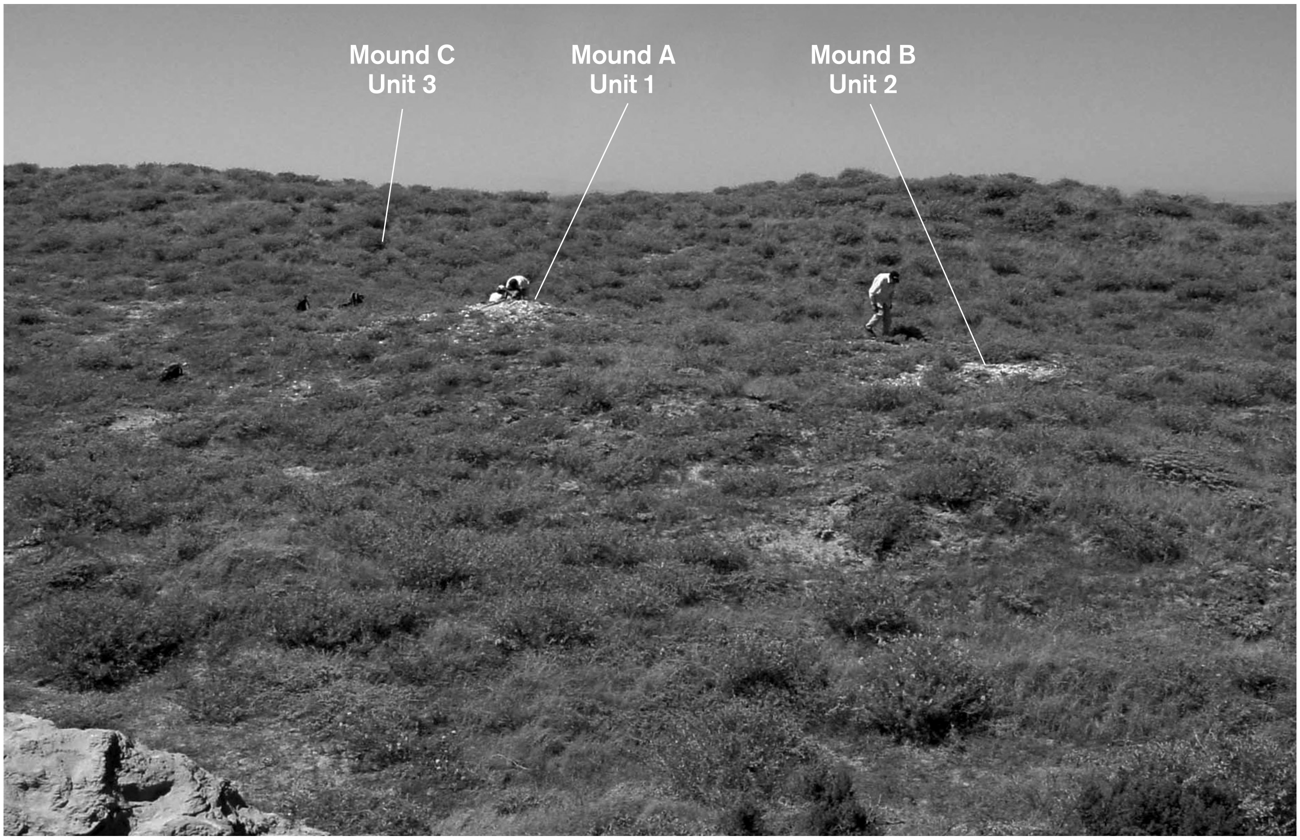

Figure 2. CA-SRI-209 (north aspect) showing location of three small midden mounds and excavation units.

(Fig. 2). However, three small "mounds" or loci (Mounds A, B, and C) contain midden deposits, with the surfaces of Mounds A and B dominated by Pismo clam and Mound C dominated by California mussel (Ovenden 1991). CA-SRI-209 is about 35 x 35 m. in area and is adjacent to CA-SRI-210, which also contains deflated Pismo clams and artifacts, suggesting that CA-SRI-209 and CA-SRI-210 may contain similar occupations. A Cico chert stemmed point and several bowl fragments were noted on the surface at CA-SRI-209, and a pestle and chert flakes were identified at CA-SRI-210, suggesting a Middle Holocene occupation. Ovenden (1991) also reported Pismo clam at nearby CA-SRI-207, a deflated site that produced bowl fragments, and that may be Middle Holocene in age like CA-SRI-209 and CA-SRI-210.

METHODS

We carried out fieldwork at CA-SRI-209 in 2006 during a survey of Old Ranch Canyon and the surrounding area (Rick 2009). This project was part of a cooperative agreement between Southern Methodist University and Channel Islands National Park. We excavated samples from eroding deposits in Mounds A, B, and C. The size of the units was based on the natural shape of the mounds and the presence of deposits on the surface. Unit 1 measured 1.3 x 1.3 m. in area and had a total excavated volume of 130 liters and a depth of about 15 cm. in dune sand. Unit 2 was a 1 x 1 m. unit placed in Mound B, and had a volume of 50 liters and a depth of about 10 cm. Finally, Unit 3 was a bulk sample excavated to a depth of about 33 cm. from an area of 50 x 35 cm. (volume = 50 liters). All deposits were screened over 1/8-inch mesh and volume was calculated using buckets marked with liters.

After excavation, all screen residuals were returned to Southern Methodist University and the Smithsonian Institution for analysis. All residuals were washed in tap water and poured through nested mesh sieves of 1/4 and 1/8-inch. As in other studies in the Channel Islands, we analyzed all residuals from the 1/4-inch and larger sizes. For the 1/8-inch residuals, we analyzed all of the

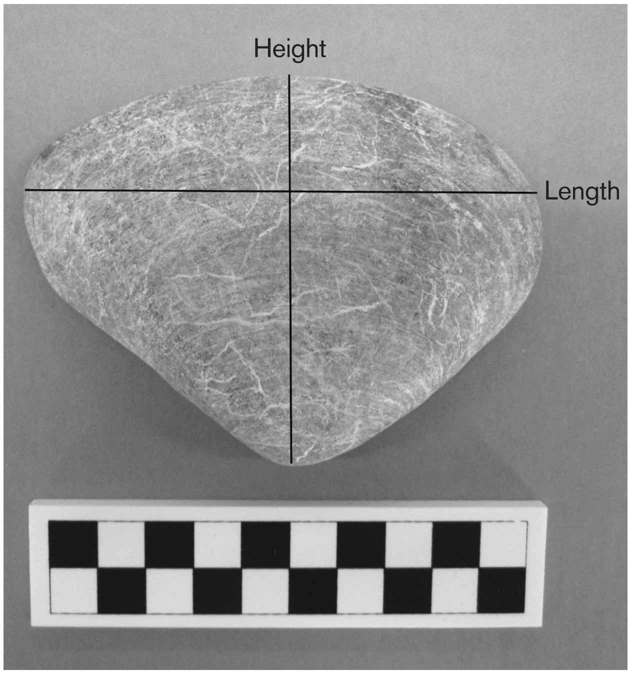

Figure 3. Measurements taken on Pismo clam valves from CA-SRI-209 following Weymouth (1923). Height is commonly reported by archaeologists as "length." Length as pictured above is the measurement reported in biological and fisheries studies.

materials from a random 25% sample and sorted the remaining 75% for artifacts, bone, and any unusual items (see Rick et al. 2006). All shellfish and vertebrates were identified to the most specific taxon possible (e.g., family, genus, or species). Artifacts were classified by material and tool type. All artifacts and faunal remains were weighed and the Minimum Number of Individuals (MNI) was calculated for many shellfish taxa based on a count of sided hinges (bivalves) and spires (gastropods). While we present MNI estimates, following Thakar (2011) we focus on shell weight for our analysis.

To evaluate the size of the Pismo clams recovered from CA-SRI-209, we measured the height and length of all whole valves from the site using digital calipers (Fig. 3). Archaeologists have routinely reported shell height (referred to as "length") from the umbo to the shell margin (Thakar 2011, 2012; Vellanoweth and Erlandson 2006). However, biologists and fisheries managers report shell length, which is the maximum width of the shell or the opposite dimension from the height reported by archaeologists. Pismo clams grow in equilibrium across both the height and width (Weymouth 1923), so both measures are valid indicators of size. Because of the way Pismo clams fracture, we noticed that at CA-SRI-209 more shells could be measured for height than length. Much of the Pismo clam assemblage from Units 1 and 2 was highly fragmented, probably a result of being located largely on the surface and experiencing weathering and trampling from introduced livestock. This fragmentation does not appear to be the result of tool making, since no formal tools or definitive worked-shell fragments were recovered, but we caution that more research on Pismo clam breakage from processing and tool making is needed. Unfortunately, the fragmentation resulted in a relatively small number of measureable specimens.

An MNI total of 69 clams was recovered from Unit 1 and 13 from Unit 2, but only nine shells from Unit 1 and none from Unit 2 were well preserved enough to be measured for height, and only one could be measured for length. An additional 17 whole valves from Mound A, but located outside of Unit 1, were also measured, making our Mound A/Unit 1 total 26 measured shells. A comparison of the size and thickness of the broken Pismo clam hinges to the 26 we measured suggests that most of the fragmented shellfish are probably from a similar size class to the ones we measured. Although anecdotal, these comparisons provide some support for the reliability of our relatively small sample of measured specimens.

CHRONOLOGY

Three radiocarbon dates were obtained for CA-SRI-209 and one for CA-SRI-210. These include one sample each from the three units and a third from deflated deposits at CA-SRI-210 (Table 1). Single marine shells were removed *in situ* from the deposits and sent to Beta Analytic, Inc. for conventional radiocarbon dating. All dates were calibrated using Calib 6.0 and applying a reservoir correction of 261 ± 21 (Jazwa et al. 2012). The four dates suggest a relatively narrow occupation spanning a period from as early as 5,030 to as late as 4,310 cal B.P. (1σ). Unit 3 produced the oldest date, from 5,030 to 4,820 cal B.P., followed by Unit 1 at 4,770 to 4,560 cal B.P., and Unit 2 at 4,490 to 4,310 cal B.P. The date from adjacent CA-SRI-210 of 4,620 to 4,410 cal B.P. overlaps closely with the date from Unit 1. Collectively, these data suggest some variation in the age of the deposits over a relatively short period of about 100–600 years.

Table 1

RADIOCARBON DATA FROM CA-SRI-209 AND CA-SRI-210

Site	Provenience	Lab #	Material	$^{13}C/^{12}C$ $^{13}C/^{12}C$ Adjusted	Calibrated age (cal B.P., 1σ)
CA-SRI-209	Mound B, Unit 2	Beta-232734	*T. stultorum*	4,540 ± 60	4,490 – 4,310
CA-SRI-209	Mound A, Unit 1	Beta-232733	*T. stultorum*	4,720 ± 50	4,770 – 4,560
CA-SRI-209	Mound C, Unit 3	Beta-232735	*M. californianus*	4,950 ± 80	5,030 – 4,820
CA-SRI-210	Deflated Midden	Beta-232736	*T. stultorum*	4,630 ± 70	4,620 – 4,410

Table 2

SHELLFISH REMAINS FROM UNITS 1, 2, AND 3 AT CA-SRI-209 (1/8-INCH RESIDUALS AND ALL WEIGHTS IN GRAMS)

	Unit 1				Unit 2				Unit 3			
Taxon	Wt.	%Wt.	MNI	%MNI	Wt.	%Wt.	MNI	%MNI	Wt.	%Wt.	MNI	%MNI
Barnacle undif.	56.5	0.3	–	–	21.4	0.4	–	–	30.1	1.6	–	–
Chiton	32.3	0.2	–	–	6.6	0.1	–	–	17.6	1.0	–	–
Cholorostoma funebralis	0.2	<0.1	8	1.4	1.0	<0.1	5	4.9	163.2	8.9	32	11.1
Crab undif.	20.2	0.1	–	–	4.4	0.1	–	–	13.1	0.7	–	–
Crepidula sp.	0.3	<0.1	1	0.2	–	–	–	–	–	–	–	–
Fisurella volcano	1.6	<0.1	1	0.2	0.4	<0.1	1	1.0	–	–	–	–
Gastropod undif.	0.2	<0.1	1	0.2	–	–	–	–	–	–	–	–
Haliotis cracherodii	–	–	–	–	0.7	<0.1	1	1.0	–	–	–	–
Haliotis sp.	–	–	–	–	–	–	–	–	2.0	0.1	–	–
Land Snail	4.2	<0.1	5	0.9	0.5	<0.1	2	1.9	0.3	<0.1	1	0.3
Limpet undif.	2.6	<0.1	15	2.7	0.1	<0.1	1	1.0	1.4	0.1	40	13.9
Mytilus californianus	4,871.0	29.3	437	77.2	775.9	15.5	66	64.1	1,560.7	84.7	204	71.1
Nacre	126.9	0.8	–	–	8.2	0.2	–	–	23.2	1.3	–	–
Nucella sp.	11.5	0.1	4	0.7	–	<0.1	–	–	–	–	–	–
Olivella biplicata	0.6	<0.1	4	0.7	–	–	–	–	–	–	–	–
Pectinidae	–	–	–	–	–	–	–	–	0.1	<0.1	4	1.4
Pollicipes polymerus	2.8	<0.1	–	–	0.6	<0.1	–	–	1.0	0.1	–	–
Septifer bifurcatus	42.0	0.3	21	3.7	13.2	0.3	14	13.6	2.7	0.1	4	1.4
Strongylocentrotus sp.	3.4	<0.1	–	–	2.1	<0.1	–	–	16.8	0.9	–	–
Tivela stultorum	11,475.5	68.9	69	12.2	4,185.8	83.4	13	12.6	9.0	0.5	2	0.7
Vermetidae	0.1	<0.1	–	–	–	–	–	–	0.8	<0.1	–	–
Shell undif.	–	–	–	–	0.6	<0.1	–	–	1.0	0.1	–	–
Total	**16,651.9**	**–**	**566**	**–**	**5,021.5**	**–**	**103**	**–**	**1,843.0**	**–**	**287**	**–**

RESULTS

A total of 23.5 kg. of shell was recovered from the three units, representing at least 18 different types of shellfish (Table 2). In all three units, however, California mussel and Pismo clam combine for between 84% and 99% of the assemblages by weight. Only black turban (*Chlorostoma funebralis*) in Unit 3 totals more than 5% of the assemblage, comprising about 8.9%. California mussels appear to decline in importance through time, with values ranging from 84.7% in Unit 3 to 29.3% in Unit 1 and 15.5% in Unit 2 (Fig. 4). In contrast, Pismo clams increase through time, with only 0.5% in Unit 3, but 68.9% in Unit 1 and 83.4% in Unit 2.

The mean height of the 26 Pismo clam shells we measured from Unit 1/Mound A was 83.3 mm. Their maximum height was 92.5 mm. and their minimum

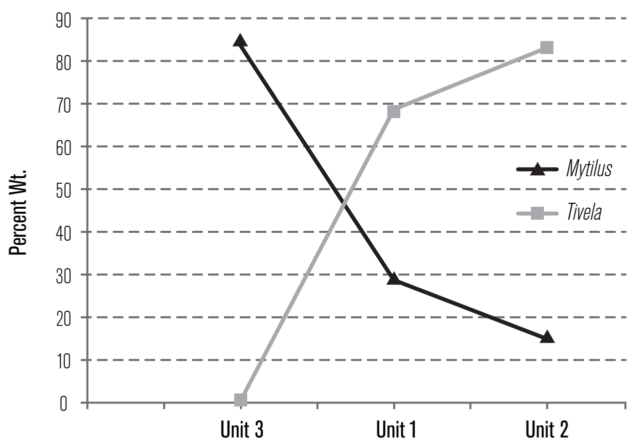

Figure 4. Relative proportions of California mussel (*Mytilus*) and Pismo clam (*Tivela*) in the Unit 3, Unit 1, and Unit 2 assemblages. Units are organized from oldest to youngest (left to right).

Table 3

HEIGHT AND LENGTH (mm.) MEASUREMENTS FOR PISMO CLAMS FROM CA-SRI-209

	Number	Mean	SD	Min.	Max.
Height					
Mound A	17	82.4	4.4	72.0	89.0
Unit 1	9	85.1	3.8	80.8	92.5
Combined	26	83.3	4.3	72.0	92.5
Length					
Mound A/Unit 1	15	102.6	6.4	93.0	115.0

was 72 mm. (Table 3). Because Pismo clams can reach maturity after 1–2 winters in California and be as small as 12.7 mm. (Pattison and Lampson 2008:6–5), we can assume that all of the clams in our assemblage were probably sexually mature. The average CA-SRI-209 Pismo clam length of 102.6 mm. is smaller than the current Pismo clam size limit for the recreational fishery (south of San Luis Obispo) of 114 mm., with only one clam reaching the legal limit at 115 mm.

Modest amounts of bone were recovered from the site, attesting to the focus on shellfish gathering. In Unit 1, 0.4 g. of fish bone, less than 0.1 g. of undifferentiated bone, and 0.2 g. of mammal bone were recovered. No bones were found in Unit 2, while 2.3 g. of fish bone and 5.5 g. of mammal bone were recovered from Unit 3.

Small amounts of stone debitage and a shell bead were also recovered from the units at CA-SRI-209. Since our focus was on shellfish collecting, the debitage was not completely analyzed, but six specimens from Unit 1, two from Unit 2, and 14 specimens from Unit 3 were primarily of Wima chert (Erlandson et al. 2012) and smaller amounts of metavolcanics. The only definitive shell or bone artifact was an Olivella barrel bead recovered from Unit 3, which—along with the bowl fragments and contracting stem projectile point noted on the surface—supports the Middle Holocene site chronology. Pismo clam shells were used for bead making by Island Chumash peoples, especially during the Late Holocene (Arnold and Graesch 2001; Arnold and Rachal 2002), but no evidence of bead making or beads was found at CA-SRI-209.

DISCUSSION

Our research at CA-SRI-209 suggests that the site was likely a temporary camp used by people to process and/or consume Pismo clams, California mussels, and other shellfish. The site may have been occupied at three or more separate times between about 5,030 and 4,310 cal B.P. The relative dearth of artifacts and vertebrate remains, and the focus primarily on Pismo clams and California mussels, supports a model involving a relatively short-term occupation by fairly mobile peoples who may have had a base camp located elsewhere. In addition to the shellfish and small amounts of fish and mammal bones, the bowl fragments found on the site surface suggest people may have also been processing terrestrial plants.

Previous research on eastern Santa Rosa Island has documented some of the most diverse shellfish assemblages identified on the Channel Islands, including a mix of estuarine and rocky shore shellfish harvested between about 8,000 and 4,000 cal B.P. (Rick et al. 2005, 2006; Wolff et al. 2007). Much of this diversity stems from the mix of habitats available on this part of Santa Rosa Island, especially the Abalone Rocks paleoestuary, which is currently the only known ancient estuary on the Channel Islands that had shellfish populations that were exploited by Native Americans (Rick et al. 2005). The CA-SRI-209 assemblage demonstrates that people on this part of Santa Rosa Island also took advantage of Pismo clams, probably from populations at nearby

Southeast Anchorage, and California mussel from the numerous rocky exposures in the area. Estuarine shellfish appear to drop out of the record on eastern Santa Rosa Island sometime around 5,000 cal B.P (Rick 2009; Rick et al. 2005). The exploitation of Pismo clam at CA-SRI-209 starting around this time may be related to changing habitats on the island and the search for other foods to fill the gap left by the lack of estuarine shellfish.

Elsewhere on Santa Rosa and the other Channel Islands, Pismo clams are extremely rare, including in other sites close to CA-SRI-209 (except CA-SRI-207 and -210). At CA-SRI-667, located on Southeast Anchorage, Wolff et al. (2007) provided shellfish data from three deposits dated to ca. 6,200, 4,700, and 4,300 cal B.P., with the 4,700-year-old deposit roughly corresponding to the occupation of Mound A at CA-SRI-209. At CA-SRI-667, Pismo clams are found in only trace amounts, however, making up just 5% of the 6,200-year-old deposit, none in the 4,700-year-old deposit, and less than 1% of the 4,300-year-old deposit. Instead, these deposits are dominated by California mussels and smaller amounts of estuarine shellfish. Similarly, at CA-SRI-191, located on southeastern Skunk Point, no Pismo clams were identified in ca. 6,000 and 4,400 cal B.P. deposits dominated by red abalones, California mussels, sea urchins (*Strongylocentrotus* sp.), and estuarine shellfish (Rick et al. 2006). The earliest evidence for Pismo clam harvesting on the Channel Islands comes from CA-SRI-568, a multi-component midden with an 8,960–8,580 cal B.P. deposit that is dominated by California mussels and small amounts of Pismo clam (Reeder-Myers 2012).

Beyond Santa Rosa Island, a concentration of Pismo clam in a midden at CA-SMI-181 near Harris Point on San Miguel Island suggests there was probably a prehistoric population of Pismo clams on San Miguel Island. Pattison and Lampson (2008) note that Pismo clams were present on San Miguel Island historically, but limited surveys on San Miguel Island have not yet identified a modern population there (Dan Richards, personal communication 2012). CA-SMI-181 contains Pismo clams and a mix of red abalone, California mussel, and a few other shellfish interspersed in at least two loci. The site has not been excavated, but two dates obtained from two different site loci by René Vellanoweth and Jon Erlandson (R. Vellanoweth, personal communication 2012) suggest that the site has at least two components. The first of these dates was on California mussel and dates to 6,720 ± 40 (OS-66799) with a 1σ calibrated age range of 7,020–6,880 cal B.P. The second date was on Pismo clam taken from the clam deposit at the site, which produced a date of 7,290 ± 40 (OS-66800) and a 1σ age range of 7,560–7,480 cal B.P. The date on Pismo clam suggests Pismo clam populations were available on San Miguel Island by 7,500 years ago. These clams were likely obtained from Cuyler Harbor, Simonton Cove, or another of the nearby sand beaches, though we cannot rule out the possibility that they were transported from Santa Rosa or another island.

At CA-SCRI-480, near Christy Beach on Santa Cruz Island, Pismo clams are a dominant component of the assemblage (Thakar 2011, 2012). Excavation at CA-SCRI-480 revealed a short period of deposition that lasted from roughly 1,100–900 cal B.P. (Thakar 2011), about 3,500 to 4,000 years after the occupation of CA-SRI-209. Despite this age difference, the two sites both primarily contain California mussels and Pismo clams. On Santa Cruz Island, Pismo clams constituted more than half of the total shell weight in each of the four earliest levels, but the proportion of California mussels increased through time, accounting for between 40–70% of the shellfish weight (Thakar 2012). This pattern is in contrast to CA-SRI-209, where California mussel is more common in the earliest deposit in Unit 3 and declines through time, while Pismo clam increases. This may be due in part to more intensive Pismo clam exploitation at CA-SCRI-480.

The CA-SCRI-480 deposits contain a large sample (n = 226) of whole shells suitable for measurement (height) and for a diachronic comparison of Pismo clam shell size. In the oldest levels of CA-SCRI-480 there are numerous small individuals, with Pismo clams averaging around 30–36 mm. in height (Thakar 2012). The demographics shifted through time so that there are a smaller number of larger individuals in the most recent levels (67–86 mm. in height). Although most researchers have suggested (see Erlandson et al. 2008) that size decreases through time in California mussels and red abalones are an indication of human overpredation, the size increase in Pismo clams at CA-SCRI-480 may also reflect human overexploitation (Thakar 2011). Thakar (2011) noted that Pismo clams move into deeper waters as they age, and that larger Pismo clams in the later deposits reflect human overharvest, since people collected Pismo clams from more difficult-to-access deeper water through time. Vellanoweth and Erlandson (2006:156) also presented size data for 285 Pismo clams from CA-SBA-72 on the mainland, dated to ca. 5,800 cal B.P., with an average height of 39.9 mm., a maximum of 75.1 mm., and a minimum of 19.2 mm. These sizes are similar to the small sizes reported by Thakar (2012) from the earliest levels of CA-SCRI-480. The average size of the CA-SRI-209 Pismo clams (83 mm.) was larger than that found at CA-SCRI-480 and CA-SBA-72, and was comparable only to three measurements from the very top of the CA-SCRI-480 sequence, which averaged 86 mm. (Thakar 2012). Without another assemblage from Santa Rosa for comparison, it remains difficult to explain the larger individuals at CA-SRI-209. This size distribution could result from a Pismo clam population that had not been harvested previously, the preferential selection or transport of larger clams, a deposition of smaller clams elsewhere, or from environmental variability. These issues are informed by a comparison of the archaeological Pismo clam assemblage with modern biological data from Southeast Anchorage.

Today, Pismo clams are found in large numbers at only two confirmed beaches on the northern Channel Islands—Southeast Anchorage and Christy Beach (Richards 1995:6). That these are the same beaches that produced the archaeological assemblages from CA-SRI-209 and CA-SCRI-480 indicates at least intermittent long-term continuity in Pismo clam populations at these two localities. Monitoring of the Santa Rosa and Santa Cruz Island populations between 1988 and 1996 found that the modern population has low recruitment occurring at intervals of 10 years or more (Dugan et al. 2002). Pismo clam monitoring at Southeast Anchorage in 1994 found 12 Pismo clams in ten transects ranging in size (length) from 79–152 mm., and additional clams from the subtidal zone were between 81–158 mm. in size (Richards 1995:2). A year later, 17 clams were measured that ranged in size from a small individual of 19 mm. to the largest at 147 mm. (Richards and Lerma 1996), and in 1999 80 subtidal clams measured between 98–158 mm. (Lerma et al. 2001). Some of these clams were marked from previous monitoring and some were from an introduction of 1,151 Pismo clams from Pismo Beach, California in 1989 (Richards 1995:5). The most recent monitoring of the population occurred in 2011, with 38 clams measuring between 78 and 151 mm., and notably none of the live clams or shells found in 2011 had markings from the previous monitoring (D. Richards, personal communication 2012). Richards (1995:6) further noted that the Channel Island Pismo clam population is fragile, stating that "just one charter dive boat could decimate the clam population at Southeast Anchorage." Monitoring has found, however, that the population remained stable from 1990–1999 (Lerma et al. 2001).

The CA-SRI-209 shell lengths range from 93–115 mm. with a mean of 102.6 mm., and fall within the reported length ranges of the modern Southeast Anchorage population. Because of the consistent size of the individuals at CA-SRI-209, it is possible that the Middle Holocene Pismo clam population also had relatively infrequent recruitment, and that the population at CA-SRI-209 may have been from a population not previously harvested by people. This would suggest an opportunistic harvesting of Pismo clams by people who for the most part focused on more common California mussels and previously had focused on estuarine shellfish.

Changes in marine climate have often been noted as a driving factor in changes in marine shellfish and other subsistence resources on the Channel Islands (e.g., Glassow et al. 1994; 2009). High resolution marine climate data from the Santa Barbara Channel demonstrate that the Middle Holocene was a period of warm sea surface temperature (SST) and reduced ENSO, with a cold snap occurring between 6,300 and 5,800 cal B.P. (Kennett et al. 2007). The CA-SRI-209 occupation occured during a period of warmer SST and presumed lower marine productivity. Since Pismo clams occur across a large area with a wide temperature range, there is no strong correlation between SST and Pismo clam abundance at CA-SRI-209, especially since Pismo clams are also found at CA-SRI-667 during the 6,300 to 5,800 cal B.P. cold period (see also Thakar 2012).

Along the southern California mainland, radiocarbon dates on Pismo clam shells from throughout southern California have been used as a proxy for Holocene sand beach accretion and ENSO periodicity (Masters 2006). Masters (2006:85) suggested that increased ENSO between 5,000–4,000, 3,000–2,000, and ~1,000 cal B.P. resulted in declines in Pismo clam dated sites and by proxy suitable sand beach habitats along the Santa Barbara Channel. Masters' (2006) model from the western Santa Barbara coast is supported by data from CA-SBA-72 in Tecolote Canyon and nearby CA-SBA-75 in Santa Barbara County, which document rapid changes in beach habitats from sandy beaches with abundant Pismo clams at 5,800 cal B.P. to California mussels from the rocky intertidal dominating after about 5,500 cal B.P. (Erlandson 1988; Vellanoweth and Erlandson 2006). The CA-SRI-209 deposits stand in contrast to these data, with mussels abundant in the early occupation at ca. 5,100 cal B.P., followed by dramatic increases in Pismo clams between ca. 4,800–4,300 cal B.P., when ENSO was thought to be more frequent. Moreover, the dense Pismo clam deposits at CA-SCRI-480 have modeled midpoint radiocarbon ages of ca. 1,000 cal B.P., or at roughly the same time as Masters' (2006) posited 1,000-year-old ENSO-induced decline in Pismo clams. The data from CA-SCRI-480 and CA-SCRI-209 suggest a limited response by these two populations to hypothesized greater ENSO frequency during the Middle and Late Holocene. For the Santa Barbara Channel, Masters (2006:85–86) suggested that eastern beaches in Rincon and Ventura may have had higher sand loads during the increased ENSO period from 3,000–2,000 cal B.P., as sands were removed from western beaches and deposited to the east. It is possible that this was also occurring on the Channel Islands between 5,000–4,000 and ~1,000 cal B.P., as sand beaches from San Miguel Island and western Santa Rosa may have been declining, while beaches were building on eastern Santa Rosa and Santa Cruz. Given that Pismo clams have been identified in modest amounts (5% of the assemblage) at ~6,200 cal B.P. at CA-SRI-667, it appears that Pismo clams occurred at Southeast Anchorage during times of both increased and decreased ENSO. The Pismo clam deposit at San Miguel Island at ~7,500 cal B.P. also correlates with a low ENSO period, and it is at about the same time that Masters (2006) documented Pismo clams on the Santa Barbara mainland coast following a period of human focus on estuaries.

A final variable to consider when evaluating the ancient Pismo clam fishery on the Channel Islands is the presence and abundance of sea otters. Based on the composition of Channel Island archaeological shellfish assemblages and a comparison with modern ecological data, Erlandson et al. (2005) argued that sea otters likely occurred on the Channel Islands in low densities throughout the Holocene. Sea otters are strong predators of Pismo clams, and researchers have noted that one sea otter can eat about 24 clams in 2.5 hours and that otters may have consumed 520,000 to 700,000 clams in one year in Monterey Bay, with their presence precluding a recreational Pismo clam fishery in that area (Pattison 2001:136; Shaw and Hassler 1989:8). Otters were potentially a strong predator of the relatively small clam populations on the Channel Islands, and (although speculative) the presence of abundant Pismo clams in island shell middens may lend further support to the suggestion that there was a dearth of sea otters in prehistoric island catchments.

CONCLUSIONS

Our research at CA-SRI-209 provides further evidence for the adaptive diversity of Middle Holocene peoples on California's Channel Islands, suggesting that people were harvesting a wide range of shellfish species from several different marine ecosystems. Although research at CA-SRI-209 and CA-SCRI-480 suggests that Pismo clams were occasionally common constituents of Channel Island sites, the general dearth of these clams suggests that most Pismo clam harvesting on the islands was opportunistic, with people getting much of their protein from other shellfish species or from vertebrates. Much of this stems from the limited number of sandy beaches in comparison with rocky intertidal habitats, a pattern that is present today—only 14–52% of the three largest northern island beaches are sandy compared to 74–93% of the beaches on the Santa Barbara and Ventura mainland (Dugan et al. 2002). The location of CA-SRI-209 near Southeast Anchorage and CA-SCRI-480 near Christy Beach, the only two spots with documented and sizable Pismo clam populations on the Channel Islands today, suggests some continuity in these sand beach habitats extending back to at least the Middle and Late Holocene. There is currently no strong correlation between the presence of Pismo clams and ENSO events on the Channel Islands, but more data are needed to help refine our understanding of this issue. Ultimately, our work at CA-SRI-209, a small temporary camp occupied for a relatively brief window of time, adds to the growing body of research in California that illustrates the importance of small sites for helping understand regional cultural and environmental developments (see Glassow 1995: Vellanoweth and Erlandson 2006).

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