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Weathering the storm: Coastal subsistence and ecological resilience on Late Holocene Santa Rosa Island, California

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ABSTRACT

Archaeological research on California's Channel Islands has significantly enhanced understanding of the diversity and variability of coastal hunter-gatherers and the shell middens these people left behind. On the Channel Islands, the Late Holocene was a time of substantial population growth, territoriality, and the emergence of social hierarchies. The role of marine and terrestrial climate change, population growth, human environmental impacts, and other variables in driving Late Holocene cultural and ecological developments is a subject of considerable debate. Analysis of faunal remains (especially finfish and shellfish), complemented by human skeletal and stable isotope analyses, from a massive shell midden and village complex (CA-SRI-2) on Santa Rosa Island provides insight into Late Holocene human responses to coastal resource stress and environmental change. Despite significant population growth, the emergence of social stratification, and increased pressure on local resources and ecosystems, these data demonstrate that there is significant continuity in the coastal resources Channel Island peoples exploited through time. These results document the long-term resilience and adaptability of coastal hunter-gatherers, the marine resources they harvested, and Channel Island ecosystems.

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1. Introduction

Archaeological investigations of coastal hunter-gatherers are important for understanding the diversity and variability of the hunter-gatherer paradigm, often challenging preconceived notions about the limitations and ramifications of forager life ways (Ames, 2003; Arnold, 1996; Bailey and Milner, 2002; Erlandson, 2001). Detailed studies of coastal hunter-gatherers come from the southern California Coast and Channel Islands where rich archaeological and ethnographic datasets provide a wealth of information on the coastal Chumash and other tribes (Arnold, 1992, 2001; Erlandson and Rick, 2002; Gamble, 2008; Kennett, 2005; Perry, 2003; Raab et al., 2009; Rick, 2007a). With an archaeological record spanning over 10,000 years, data from California Channel Island shell middens have been used to explore a variety of issues, including the interactions and impacts of hunter-gatherers on coastal resources and ecosystems, human responses to marine and terrestrial climate change, and the emergence of cultural complexity (Arnold, 2001; Kennett, 2005; Erlandson and Rick, 2010; Rick et al., 2005).

The Late Holocene appears to have been a particularly important period of population growth and heightened sociopolitical complexity on the Channel Islands. The role of climate change and human impacts on local resources and ecosystems in driving these developments remains hotly contested, with most researchers focusing on cultural and environmental developments during the Medieval Climatic Anomaly (MCA) between about AD 800 and 1350 (Arnold, 1992, 2001; Gamble, 2005, 2008; Jones and Schwitalla, 2008; Jones et al., 1999; Kennett, 2005; Kennett and Kennett, 2000; Kennett et al., 2009; Raab et al., 1995, 2009; Rick, 2007a). The effects of extended droughts and overall climatic instability during the MCA have been a focus of research (see Jones and Schwitalla, 2008), but questions remain about the interactions between people and Channel Island ecosystems and resources after the MCA beginning ~AD 1350. This is a time when Chumash peoples on the Channel Islands and mainland were at their zenith, had high population densities and great potential for impacts on island resources and ecosystems, and ultimately had their first contacts with Europeans.

This paper presents the analysis of faunal remains from a massive shell midden and village complex (CA-SRI-2) on Santa Rosa Island, California (Fig. 1), placing these data in the context of human skeletal and stable isotope analyses from the site. The faunal assemblage is dominated by finfish and shellfish and dates from AD

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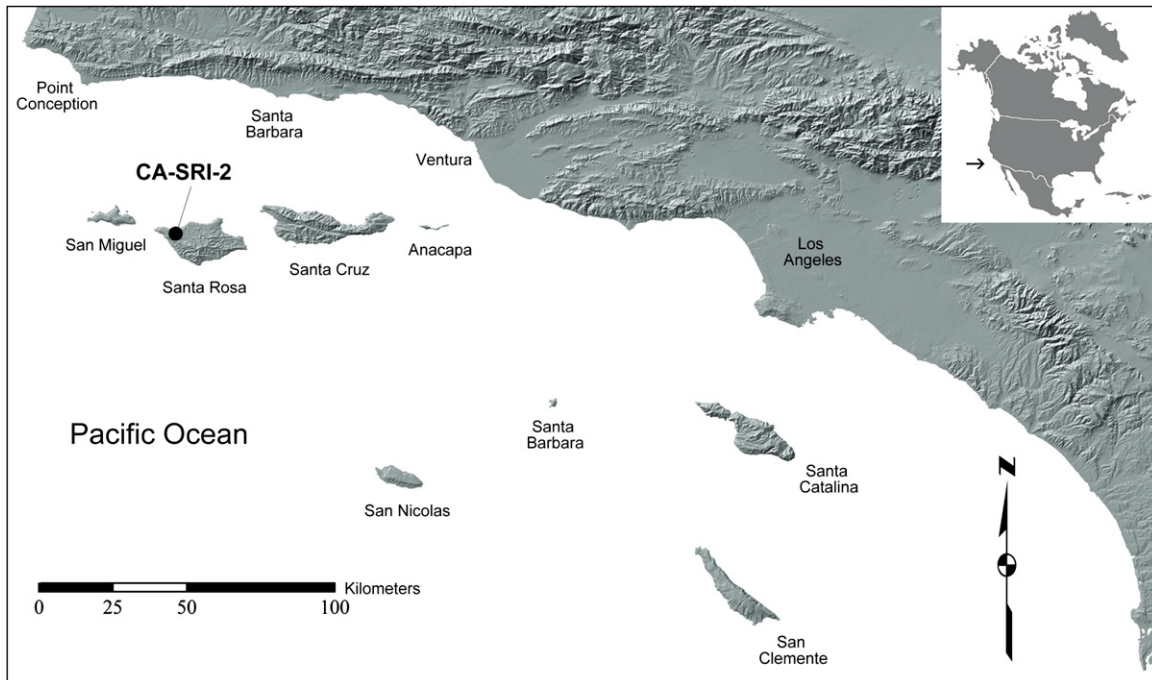


Fig. 1. Location of CA-SRI-2, Santa Rosa Island, and the southern California Coast.

1000–1820, with most of the assemblage spanning the Late and Historic periods from AD 1470–1820. These data provide an opportunity to investigate human subsistence strategies and interactions with island ecosystems during and after the climatic and social change of the MCA at a single site where local variation in resources, habitats, and other variables can be controlled. The CA-SRI-2 case study adds to a growing body of research focused on understanding the long-term resilience and adaptability of human cultural systems and the ecosystems in which ancient peoples lived and foraged for millennia (Campbell and Butler, 2010; Folke, 2006; Redman, 2005; Redman and Kinzig, 2003; Smith, 2009; Thompson and Turck, 2009).

2. Environmental and cultural context

Santa Rosa Island, located about 44 km from the mainland coast, is one of the eight California Channel Islands. The island is about 217 km² in area and has a number of relatively well-watered streams. Terrestrial ecosystems on the islands are generally diminished in flora and fauna compared to the adjacent mainland. For example, the diminutive island fox (*Urocyon littoralis*) and island spotted skunk (*Spilogale gracilis*) were the largest Holocene terrestrial mammals and oaks and other terrestrial plants are also more limited (Schoenherr et al., 1999).

The generally limited terrestrial resources were offset by diverse and productive marine ecosystems. Over 150,000 seals and sea lions are known to breed and haul out on adjacent San Miguel Island and northern elephant seals breed on western Santa Rosa Island. Kelp forest, rocky shore, and sandy beach habitats around the island foster a wide variety of marine finfishes and shellfish. Sea and land birds also breed and live on the islands.

The Channel Islands contain one of the longest coastal archaeological records in the Americas, spanning some 13,000 calendar years with scores of shell middens ranging from small scatters to dense deposits well over a meter deep (Erlandson et al., 2007; Rick et al., 2005). With a nearly continuous record of human occupation from over 10,000 years ago through the 19th century, the islands offer

a unique opportunity to investigate the nature of hunter-gatherer adaptations to island ecosystems with great time depth. Largely free of burrowing rodents and historical development that plague the adjacent mainland, Channel Island archaeological sites are often well preserved and stratified. Late Holocene Chumash peoples relied exclusively on hunting and gathering wild foods, lived in large villages with up to 1000 residents, had sophisticated mainland and island exchange networks using a shell bead currency, employed plank boats and other maritime technologies to pursue a variety of marine fishes, mammals, and other animals, and had hereditary leadership and status differentiation (Arnold, 1992; Gamble, 2008; Johnson, 2000; Kennett, 2005; Rick, 2007a; Rick et al., 2005).

3. CA-SRI-2: the village of *Niaqla*

Located on a marine terrace bisected by a series of gulches, CA-SRI-2 is a large village and cemetery complex situated near Tecolote, Garanon, and Arlington canyons. Based on kelp forest extent, watershed size, and length of coastline, Kennett et al. (2009, p. 306) ranked Tecolote and Arlington as the first and second most productive canyons for human settlement on the northern Channel Islands. Covering an area at least 250 × 200 m, shell midden deposits of varying density are found throughout CA-SRI-2 (Fig. 2). Twenty-eight radiocarbon dates bracket the site occupation between about AD 250–1820 (1 sigma), with an ephemeral component also dated to ca. 2400 BC. The faunal data reported here date from ca. AD 1000–1800 (Table 1). Ethnohistoric records and the presence of some 93 historic artifacts suggest that CA-SRI-2 is probably the historic Chumash village of *Niaqla* (Johnson, 1999; Kennett, 2005; Rick, 2004, 2007b). Orr (1968, p. 189) suggested that CA-SRI-2 contained as many as 70 house depressions, making it one of the largest Chumash villages on the Channel Islands. Rick (2004, 2007b) estimated there were only about 20–25 visible house depressions, an estimate similar to other villages in the area (Arnold, 2001; Kennett, 2005).

CA-SRI-2 is one of the most extensively excavated sites on the Channel Islands, but faunal remains have never been reported from the site. Phil Orr excavated CA-SRI-2 during the 1940s and 1950s

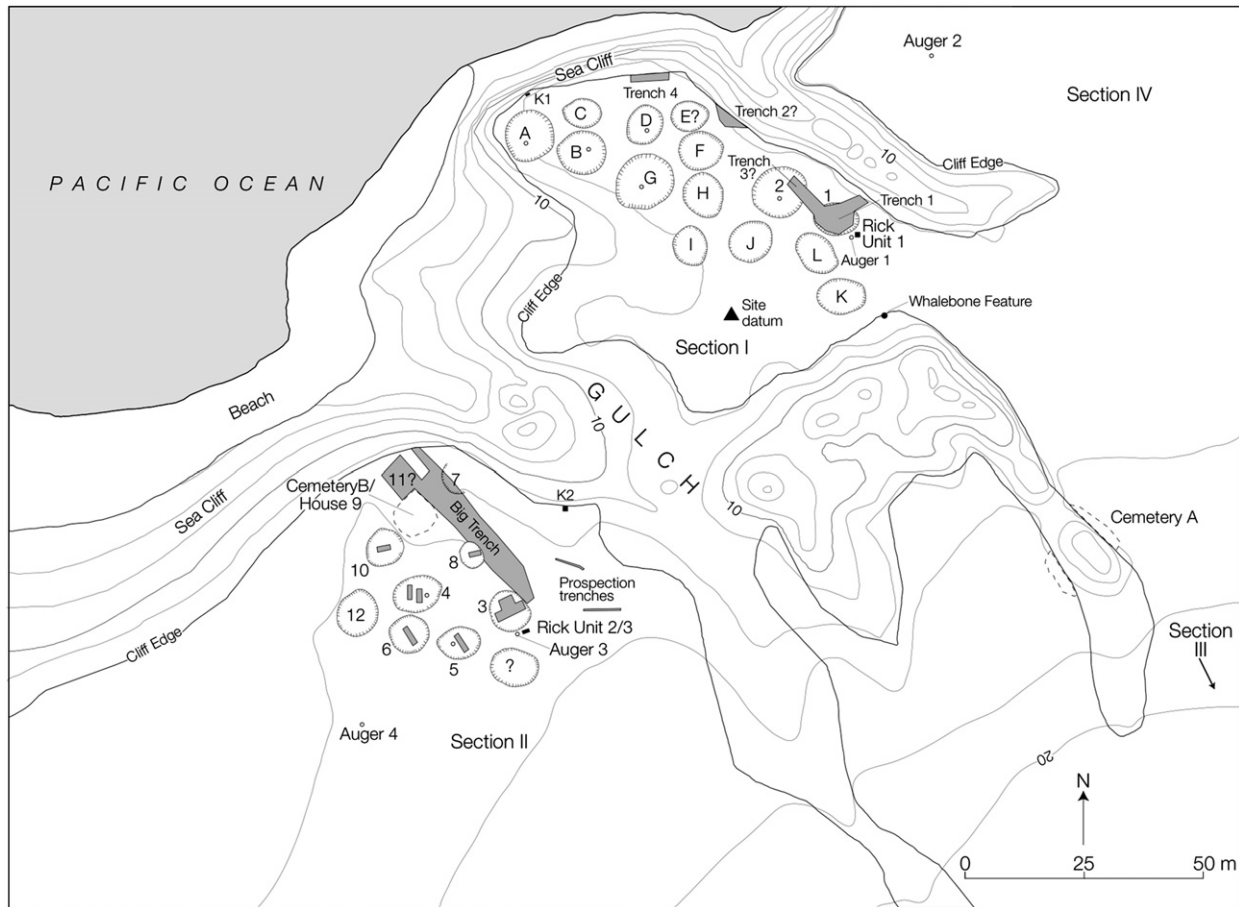


Fig. 2. Map of CA-SRI-2 showing location of Orr (tinted), Rick, and Kennett ("K") excavations, house depressions, and other surface features. The locations of Orr's excavation units and other features were estimated from his sketch maps and features visible on the present surface of the site. Contour interval in meters; small circles inside houses are auger tests.

with a few visits in the 1960s. Orr (1968) focused primarily on the data he gathered from approximately 100 burials from the site's two cemeteries. He also excavated two complete houses (Houses 1 and 3), about half of two other houses, and trenched through at least six additional houses. Rick (2004, 2007b) reanalyzed the artifacts Orr excavated from roughly 10 houses, but unfortunately Orr (1968) rarely collected faunal remains during his research and sufficient samples from these household areas were not available for analysis.

4. Materials and methods

Following protocols from the national park service, excavation of CA-SRI-2 in 2000–2001 was limited to relatively small test units designed to supplement Orr's (1968) extensive excavation of over 347 m³ of deposits (Rick, 2007b). Two units were excavated in intact deposits at CA-SRI-2, including a 1 m × 0.5 m unit (Unit 2/3) in the shell midden next to House 3 and a 0.5 m × 0.5 m unit (Unit 1) in midden adjacent to House 1. All deposits were screened over 1/16 or 1/8-inch mesh, with 1/8-inch residuals analyzed for this study.

These units produced a large assemblage of artifacts and faunal remains, including nearly 53 kg of shellfish and over 3800 finfish bones identified to family, genus, or species. These assemblages are comparable to or larger than other recent studies on the northern Channel Islands, and are the largest available for a Santa Rosa Island site during any time period (Braje, 2010; Braje et al., 2007; Colten, 2001; Glassow et al., 2009; Rick, 2007a). Best represented in the samples are fish and shellfish remains, with smaller amounts of

mammals and birds, which tend to be more widely dispersed in site deposits and generally more limited than fish or shellfish remains in Late Holocene Channel Island sites (Braje et al., 2007; Colten and Arnold, 1998; Rick, 2007a). The vast majority of the faunal remains appear to be cultural in origin, though it is possible that some of the smaller fish and shellfish could have been introduced to the site as stomach contents of larger animals or as incidental riders on other larger shellfish.

Identification of faunal remains relied on a broad suite of comparative specimens from numerous institutions (see Rick, 2004). Shellfish and vertebrate remains were identified using collections housed at the Department of Anthropology, University of Oregon (shellfish, finfish, mammals, and birds), the Santa Barbara Museum of Natural History (mammals and finfish), the Department of Anthropology, University of California, Santa Barbara (finfish), National Marine Mammal Laboratory, Seattle (marine mammals), and the California Academy of Sciences (finfish). Number of identified specimens (NISP) are presented for all vertebrates and weights are presented for all shellfish. Additional weight and minimum number of individuals (MNI) tallies are available in Rick (2004), but do little to alter or enhance the data presented here. To investigate the diversity and evenness of the assemblages, the Shannon diversity (H) and evenness (V) function (Lyman, 2008, pp. 192–198) was calculated for fish and shellfish: 1) $H = -\sum(p_i)(\log_e p_i)$, where p_i is the NISP (finfishes) or weight (shellfishes) of an individual taxonomic category divided by the total NISP or weight of all the taxonomic categories; and 2) $V = H/\log_e S$, where S is the total number of taxonomic categories.

Table 1
Radiocarbon chronology for CA-SRI-2.^a

Lab # ^b	Provenience	Material ^c	Uncorrected ¹⁴ C Age	¹³ C/ ¹² C Adjusted Age	1 Sigma Age Range (cal AD/BC)
B-158147	Unit 1: 63 cm (R)	BA	170 ± 70	600 ± 70	A.D. 1690–1950
B-158148	Unit 1: 14 cm (R)	CM	310 ± 80	740 ± 80	A.D. 1690–1950
OS-37590	House D, auger, 45–47 cm	CM	–	770 ± 40	A.D. 1690–1840
OS-37589	House 2, auger, 48 cm	BA	–	780 ± 40	A.D. 1680–1830
OS-57591	House 5, auger, 41 cm	BA	–	820 ± 55	A.D. 1660–1810
B-158146	Unit 2: 12 cm (R)	CM	420 ± 70	850 ± 70	A.D. 1630–1720
OS-37244	House 3, level 5	PO	–	920 ± 35	A.D. 1540–1670
UCLA-134	Hearth, 56 cm	Charcoal	330 ± 50	330 ± 50	A.D. 1480–1640
OS-37588	House 4, auger	CM	–	980 ± 40	A.D. 1490–1630
B-120072	Cemetery B, Burial 92	PO	580 ± 60	1010 ± 60	A.D. 1460–1620
OS-33373	Unit 2: 60–61 cm (R)	CM	–	1020 ± 35	A.D. 1470–1540
OS-37146	Cemetery B: Mass Interment	RAB	–	1040 ± 45	A.D. 1450–1530
OS-37245	House 1 Orr collection	PO	–	1060 ± 30	A.D. 1450–1510
UCLA-104	House 1	Wood	400 ± 80	400 ± 80	A.D. 1430–1630
OS-37593	House G, auger 48 cm	CM	–	1140 ± 45	A.D. 1400–1460
S-1286	Burial 11 (long bone)	HBC	865 ± 65	865 ± 65	A.D. 1330–1440
UCLA-102	Burial 13	Seeds	600 ± 70	600 ± 70	A.D. 1300–1410
UCLA-178	Tr. 4B, Level 2, Cem. A	PO	900 ± 100	1330 ± 100	A.D. 1210–1390
OS-35532	Burial 13 or House 8	Seeds	–	735 ± 40	A.D. 1260–1290
OS-32373	Seacliff: 50–60 cm (K)	MS	–	1420 ± 40	A.D. 1170–1280
OS-32372	Unit 2: 20–30 cm (K)	MS	–	1490 ± 30	A.D. 1070–1210
OS-37592	Sec. III auger, 28 cm	CM	–	1560 ± 55	A.D. 1000–1160
B-158145	Unit 2: 120 cm (R)	CM	1190 ± 80	1620 ± 80	A.D. 920–1070
UCLA-103	Postholes, House 3	Wood	1230 ± 60	1230 ± 60	A.D. 690–890
OS-39335	Eastern margin, Sec. IV	CM	–	1990 ± 30	A.D. 610–680
UCLA-135	Midden over Cemetery A	CM	1820 ± 90	2250 ± 90	A.D. 250–460
CT-038	Trench 4, 30 inches	MV	1860 ± 340	2290 ± 340	80 B.C.–A.D. 680
OS-39336	Middle fork, Sec. III	CM	–	4460 ± 35	2450–2300 B.C.

^a All dates were calibrated using Calib 5.0.1 (Stuiver and Reimer, 1993) and applying a ΔR of 225 ± 35 years for all shell samples. Beta-158147 is just beyond the calibration range of Calib 5.0.1. The calibrated age range provided for Beta-158147 is the same as Beta-158148. ¹³C/¹²C ratios were determined by the radiocarbon labs, or an average of +430 years was applied. K indicates units excavated by D. Kennett and R denotes units excavated by T. Rick. The human bone date was calibrated using 50% terrestrial and 50% marine carbon, applying a ΔR of 225 ± 35 years (see Walker et al., 2005).

^b B=Beta, OS = NOSAMS.

^c CM = California mussel, BA = black abalone, PO = *Olivella* shell, RAB = red abalone bead, HBC = human bone collagen, MS = marine Shell, MV = marine vegetation.

5. Faunal remains from CA-SRI-2

5.1. Shellfish

Nearly 36 kg of shellfish and other invertebrates from at least 30 different types of shellfish were recovered in 1/8-inch residuals from Unit 1 (Table 2). Shellfish were extremely dense throughout the unit with between 55 and 148 kg/m³ in each of the four samples. Rocky intertidal shellfish dominate the unit, suggesting that people were primarily exploiting local intertidal habitats. The most abundant shellfish in the unit were California mussel (~49%), followed by black turban (~14%), black abalone (~6%), wavy top turban (~6%), and crab (~4%) (Fig. 3). *Olivella biplicata*, a small gastropod, also makes up about 4% of the assemblage, but these were used primarily to make shell beads and are probably non-dietary.

About 17 kg of shell were analyzed from Unit 2, Strata 1, 2, and 3. California mussel dominates the assemblage, with about 59% of the weight in Stratum 1, 46% in Stratum 2, and 52% in Stratum 3. This is followed by black turban with about 7% of the weight in Stratum 1, about 2% of the weight for Stratum 2, and 10% of the weight for Stratum 3. Crab contributed about 3–6% of the total for Strata 1 and 3, with a peak of 11% in Stratum 2. Black abalone constituted only about 2–4% of the total shell weight with comparable values for each stratum. Sea urchins account for about 5% in Stratum 2, and 6% in Stratum 3, but only about 1% in Stratum 1 and Unit 1, suggesting a decrease in the importance and/or availability of this resource through time.

To evaluate potential harvest pressure on shellfish stocks, 1644 whole California mussels, black and red abalones, and owl limpets were measured from the deposits (see Erlandson et al., 2008). The largest samples come from California mussels and the smallest come from red abalones, with some of the samples producing no suitable specimens for measurement (Table 3). The average size of

black abalones (averaging between 54 and 60 mm) and owl limpets remained comparable (averaging between 31 and 37 mm) across the 800 years represented by the samples. California mussels are also similar in size ranging from 40 to 49 mm during the occupation. Although the difference in size is fairly modest, all four of the shellfish assemblages show an increase in size through time, with the largest specimens found in Unit 1 and the smallest generally found in Unit 2, Strata 2 and 3.

5.2. Finfishes

Fish remains were also extremely abundant in the four samples, with between 6 kg/m³ and 26 kg/m³ of fish bone. A total of 3883 bones was identified to family level or better in the four samples (Table 4). The majority of fishes could have been obtained from rocky near shore and kelp bed ecosystems, with some fishes also coming from sandy beach habitats and deeper waters. Rockfish are the most abundant fish represented in Unit 1 with about 80% of the identifiable NISP. These are followed by surfperch and pile perch, combining for 9% (Fig. 4). Cabezon, midshipman, and lingcod each account for about 1–2% of the total identifiable NISP. The presence of a few probable billfish spine fragments and vertebrae in other levels suggests that billfish were captured, consumed, and/or used for making tools.

Similar to Unit 1, most of the identified fish remains in Unit 2 are from rockfish, which account for some 47% of the NISP in Stratum 1, 70% of the NISP in Stratum 2, and only about 34% of the NISP in Stratum 3. Surfperch and pile perch (combined) rank second in Strata 1 (36%) and 2 (19%) and third in Stratum 3 (25%). Labrids (probably seniorita) rank second in Stratum 3 (28%), but less than 1–2% in Strata 1 and 2. Labrids and other small fish are also fairly abundant in other MCA (late Middle period) samples on San Miguel Island. This may suggest an increased use of nets at this time, but as

Table 2
Shellfish and invertebrates from CA-SRI-2 (1/8-inch residuals, weight in grams).

Taxon	Unit 1		Unit 2						Total	
	Wt.	% Wt.	Stratum 1		Stratum 2		Stratum 3		Wt.	% Wt.
			Wt.	% Wt.	Wt.	% Wt.	Wt.	% Wt.		
<i>Astraea undosa</i> (wavy top turban)	2011.9	5.6	52.0	0.5	82.2	2.2	39.8	1.6	2185.9	4.1
Barnacle undif.	1062.7	3.0	206.7	2.0	108.9	2.9	54.2	2.2	1432.5	2.7
<i>Calliostoma</i> spp. (top snail)	–	–	0.2	<0.1	3.8	0.1	–	–	4	<0.1
Chiton undif.	1413.0	3.9	433.2	4.1	245.9	6.5	154.1	6.4	2246.2	4.3
<i>Corallina</i> spp. (coralline algae)	6.3	<0.1	7.5	0.1	7.3	0.2	11.0	0.5	32.1	0.1
Crab undif.	1528.6	4.3	327.5	3.1	419.7	11.0	146.2	6.0	2422	4.6
<i>Crepidula</i> spp. (slipper shell)	61.0	0.2	4.6	<0.1	4.1	0.1	3.6	0.1	73.3	0.1
<i>Cryptochiton stelleri</i> (gumboot chiton)	133.1	0.4	46.0	0.4	1.9	<0.1	0.2	–	181.2	0.3
<i>Dendraster excentricus</i> (sand dollar)	–	–	–	–	0.2	<0.1	–	–	0.2	<0.1
<i>Fissurella volcano</i> (volcano limpet)	3.0	<0.1	2.2	<0.1	2.3	0.1	0.5	<0.1	8	<0.1
Gastropod undif.	12.6	<0.1	10.6	0.1	8.6	0.2	0.7	<0.1	32.5	0.1
<i>Glans</i> spp.	0.2	<0.1	–	–	0.9	<0.1	–	–	1.1	<0.1
<i>Haliotis cracherodii</i> (black abalone)	1970.2	5.5	392.1	3.7	120.2	3.2	43.9	1.8	2526.4	4.8
<i>Haliotis rufescens</i> (red abalone)	432.6	1.2	105.5	1.0	37.3	1.0	1.6	0.1	577	1.1
<i>Haliotis</i> spp. (abalone)	127.7	0.4	51.8	0.5	–	–	0.3	<0.1	179.8	0.3
<i>Hinnites multirugosus</i> (purple hinged scallop)	39.8	0.1	–	–	–	–	–	–	39.8	0.1
Land snail	0.4	<0.1	–	–	0.1	<0.1	–	–	0.5	<0.1
Limpet undif.	764.7	2.1	222.5	2.1	60.0	1.6	44.7	1.8	1091.9	2.1
<i>Lottia gigantea</i> (owl limpet)	384.8	1.1	35.8	0.3	17.9	0.5	8.2	0.3	446.7	0.8
<i>Marginella californica</i> (California marginella)	0.1	<0.1	–	–	–	–	–	–	0.1	<0.1
<i>Megathura crenulata</i> (giant keyhole limpet)	1.7	<0.1	1.9	<0.1	0.9	<0.1	2.0	0.1	6.5	<0.1
<i>Mitrella gausapata</i> (dove shell)	–	–	–	–	0.2	<0.1	–	–	0.2	<0.1
<i>Mytilus californianus</i> (California mussel)	17627.4	49.1	6283.2	59.4	1766.0	46.4	1252.9	51.8	26929.5	51.1
Nacre undif.	309.1	0.9	155.3	1.5	62.7	1.6	32.8	1.4	559.9	1.1
<i>Norrisia norrisii</i> (Norris top)	212.1	0.6	5.7	0.1	18.1	0.5	12.0	0.5	247.9	0.5
<i>Nucella</i> spp. (dogwinkle)	1.0	<0.1	–	–	0.7	<0.1	4.5	0.2	6.2	<0.1
<i>Olivella biplicata</i> (purple olive)	1338.9	3.7	912.4	8.6	368.2	9.7	103.9	4.3	2723.4	5.2
<i>Pollicipes polymerus</i> (gooseneck barnacle)	765.3	2.1	193.0	1.8	72.9	1.9	25.4	1.1	1056.6	2.0
<i>Protothaca staminea</i> (common littleneck clam)	0.6	<0.1	–	–	–	–	–	–	0.6	<0.1
<i>Saxidomus nuttalli</i> (Washington clam)	–	–	1.1	<0.1	–	–	–	–	1.1	<0.1
<i>Septifer bifurcatus</i> (platform mussel)	401.8	1.1	141.9	1.3	54.6	1.4	49.8	2.1	648.1	1.2
<i>Serpulorbis squamigerus</i> (tube worm)	3.5	<0.1	0.7	<0.1	1.0	<0.1	0.8	<0.1	6	<0.1
<i>Strongylocentrotus</i> spp. (sea urchin)	255.8	0.7	109.0	1.0	176.3	4.6	134.6	5.6	675.7	1.3
<i>Tegula brunnea</i> (brown turban)	27.9	0.1	36.5	0.3	15.1	0.4	11.7	0.5	91.2	0.2
<i>Tegula funebris</i> black turban)	4844.4	13.5	762.1	7.2	83.2	2.2	252.5	10.4	5942.2	11.3
cf. <i>Tegula montereyi</i> (Monterey turban)	12.4	<0.1	0.4	0.0	46.0	1.2	1.1	<0.1	59.9	0.1
<i>Tegula</i> spp.	96.1	0.3	45.3	0.4	19.1	0.5	18.5	0.8	179	0.3
Undif. Shell	62.4	0.2	26.3	0.2	3.1	0.1	7.2	0.3	99	0.2
Total	35913.1	–	10573.0	–	3809.4	–	2418.7	–	52714.2	–

other studies have noted net use appears to correlate largely with habitat availability (sandy beaches) rather than fishing intensification, specialization, or other variables (see Bowser, 1993; Pletka, 2001; Rick, 2007a). Most of the other taxa, including California sheephead, mackerel, barracuda, yellowtail, and thornbacks occur in low proportions.

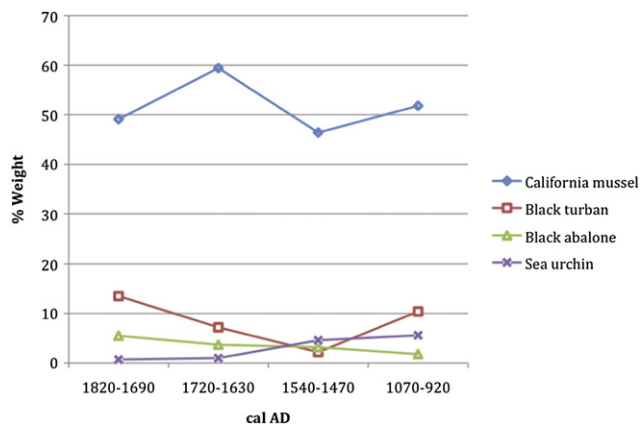


Fig. 3. Relative abundance of four important shellfish through time at CA-SRI-2 (percentages are based on the weight of the species divided by the total weight of shellfish).

5.3. Mammals and birds

Compared with fish and shellfish, mammal and bird remains are relatively rare at CA-SRI-2, a pattern consistent with many Late Holocene Channel Island assemblages (Braje, 2010; Colten and Arnold, 1998; Rick, 2007a). In Unit 1, sea otters rank first (55%), followed by otariids (36%), Guadalupe fur seals (5%), and northern fur seals and large/medium cetaceans (1%) (Table 5). Mammal bones are also relatively rare in Unit 2 totaling about 402 specimens, mostly small undiagnostic fragments. Marine mammals dominate the assemblage (86%), including sea otter (57%), otariids (14%), and harbor seal and medium/large cetaceans (7.1% each). One island spotted skunk femur and a splinter of land mammal bone were also identified.

Relatively few bird remains were recovered in Unit 1, including just 97 bones from a minimum of 3 individuals and 3 taxa (Table 5). The identified bird remains include 2 gull bones, 3 cormorant bones, and 1 western grebe bone. All of these birds occur around the island today and could have been scavenged off the beach or hunted. A small sample of bird bone was also recovered from Unit 2 with 80 bones, including cormorant and gull remains.

6. Stable isotopes and human diet

Stable isotope (C and N) analyses of human and other animal bone collagen provide a means to estimate ancient diet and feeding

Table 3
Sample size and measurements (mm) for select CA-SRI-2 shellfish.

	Unit 1	Unit 2		
		Str. 1	Str. 2	Str. 3
<i>California Mussel</i>				
<i>n</i>	1087	320	72	–
Mean	49	42	40	–
Max	143	97	73	–
Min	6	7	12	–
<i>Black Abalone</i>				
<i>n</i>	57	16	4	–
Mean	60	54	54	–
Max	109	89	84	–
Min	29	36	36	–
<i>Red Abalone</i>				
<i>n</i>	3	1	–	–
Mean	110	85	–	–
Max	113	–	–	–
Min	105	–	–	–
<i>Owl Limpet</i>				
<i>n</i>	72	7	2	3
Mean	37	37	33	31
Max	61	45	35	33
Min	11	32	30	29

behavior that can complement traditional faunal analysis. In coastal regions, they are particularly useful for estimating the amount of marine versus terrestrial foods that people consumed (Walker and DeNiro, 1986). Walker and DeNiro (1986) and Goldberg (1993) used stable isotopes to track changes in human diet on the Channel Islands and adjacent mainland coast, noting that through time people became increasingly focused on marine resources. During the Late Holocene, people on the Channel Islands appear to have eaten high concentrations of marine foods (especially finfish), such that their isotopic signatures are similar to pinnipeds (seals and sea lions) (Goldberg, 1993; Walker and DeNiro, 1986).

Goldberg (1993, p. 87, 197) analyzed stable C and N isotopes from 17 individuals (11 females, 3 males, 3 juveniles, an infant, 13 adults) at CA-SRI-2. The isotopic signatures of these people are nearly identical to those of pinnipeds, demonstrating that these people focused primarily on marine resources, especially finfish (Fig. 5; Goldberg, 1993). These data support the faunal remains which are overwhelmingly dominated by marine fishes, followed by shellfish, marine mammals, and sea birds. Dietary reconstructions using the weight method are consistent with the stable isotope data, demonstrating that fish contributed some 79 to 93% of the edible meat represented in the samples, supplemented by shellfish, mammals, and birds (Rick, 2004). This focus on finfish appears to have had a variety of ramifications for changes in human health that are apparent in the human skeletal remains.

7. Human skeletal analyses

Phil Orr (1968) focused much of his research at CA-SRI-2 on the excavation of the site's two cemeteries (Cemetery A and B). Orr (1968) argued that Cemetery A was the older of the cemeteries dating to about 1800–900 years ago and Cemetery B was the younger one dating to about 600–400 years ago. This general pattern holds true today, though the site chronology has become more complicated and Cemetery B may extend into the Historic period (Rick, 2004, 2007b; Walker et al., 2005). Several important studies of human skeletal remains, including analyses of human health, disease, and violent conflict have been conducted at CA-SRI-2 (Lambert, 1993, 1994; Lambert and Walker, 1991; Walker, 1978, 1986, 1989; Walker and Erlandson, 1986; Walker and Hollimon, 1989; Walker et al., 2005).

These studies suggest that people at CA-SRI-2 had shorter stature than earlier peoples in the region, had high levels of cribra orbitalia (porotic hyperstosis) probably from anemia and had cranial injuries and a few projectile wounds from violent conflict (Lambert, 1994; Walker, 1986, 1989; Table 6). There was also evidence of infection or trauma manifested in periosteal lesions, including two human skeletons with treponemal lesions consistent with venereal syphilis that were originally thought to be precontact in age (Cybulski, 1980; Walker et al., 2005). Walker et al. (2005) argued that these skeletons may date to the Protohistoric period and could indicate early incidence of European disease among the Chumash. Analyses of human teeth from CA-SRI-2 suggest that, compared to earlier island sites, dental carries decline and dental attrition rates were also lower than similar aged sites on the mainland, reflecting a lower carbohydrate contribution to the diet (Walker, 1978; Walker and Erlandson, 1986).

Collectively, these and other regional data suggest that human health appears to have been most compromised during the late Middle period (overlapping with MCA) even though human population growth peaked in the Late period (Lambert, 1994, pp. 194–195). One caveat is that the chronology for many of these and other burials remains relatively coarse as few burials have been directly dated. Lambert (1994; Lambert and Walker, 1991) and Walker (1986, 1989) argued that climatic instability, including drought and marine perturbations may have forced people to congregate around water sources with poor water quality and other variables resulting in higher incidences of infection. A diet increasingly focused on fish and perhaps less diversified diets also contributed to these health declines (Lambert, 1993). Human health appears to be comparatively better in some Late period samples, however, suggesting perhaps improving conditions (Lambert, 1994).

8. Discussion and conclusions

The CA-SRI-2 case study enhances our understanding of the interactions between ancient Channel Island peoples and island resources and ecosystems, especially the strategies that emerged following the instability of the MCA. Along with climatic changes, recent research suggests that ancient Channel Islanders were a fundamental component of most island ecosystems, influencing declines in shellfish sizes, reducing pinniped populations, translocating terrestrial mammals (e.g., dogs, mice, and foxes), and causing landscape alteration from anthropogenic fires (see Anderson et al., in press; Braje, 2010; Erlandson and Rick, 2010; Erlandson et al., 2009; Rick et al., 2008, 2009). These impacts may have been particularly pronounced during the Late Holocene when human populations were at their height and people were increasingly territorial (Braje, 2010; Erlandson and Rick, 2010; Erlandson et al., 2008, 2009; Kennett, 2005; Rick, 2007a). Despite such human impacts, Channel Islanders appear to have used a similar suite of resources across the Holocene (Erlandson and Rick, 2010). However, we are just beginning to learn how human environmental interactions varied across space and through time.

Specifically, the CA-SRI-2 research provides insight into the interactions between Late Holocene peoples and two fundamental resources used throughout the Holocene—finfish and shellfish. Faunal data from CA-SRI-2 and elsewhere suggest greater taxonomic richness and expanding diet breadth during the Late Holocene, including up to 25% or higher increases in the types of finfish and shellfish being exploited during the last 1500 years (Braje, 2010; Erlandson et al., 2007; Kennett, 2005; Rick, 2007a; Rick et al., 2005). This is evident within the CA-SRI-2 assemblage as well, where the faunal remains post dating the MCA have slightly higher taxonomic richness ($N = 46–59$) than the MCA sample ($N = 41$) (Table 7). However, this may be influenced by the smaller

Table 4
Fish remains from CA-SRI-2.^a

Taxon	Unit 1		Unit 2						Total	
	NISP	% NISP	Strat. 1		Strat. 2		Strat. 3		NISP	% NISP
			NISP	% NISP	NISP	% NISP	NISP	% NISP		
<i>Teleost</i>										
Atherinidae (silversides)	27	1.5	11	1.9	1	0.1	8	1.9	47	1.2
Clinidae (kelpfish)	11	0.6	3	0.5	14	1.3	1	0.2	29	0.7
Clupeidae (sardines)	7	0.4	2	0.3	–	–	–	–	9	0.2
Cottidae (sculpin)	3	0.2	–	–	–	–	4	0.9	7	0.2
<i>Damalichthys vacca</i> (pile perch)	6	0.3	8	1.4	1	0.1	8	1.9	23	0.6
Embiotocidae (surfperch)	166	9.1	200	35.0	199	18.6	97	22.9	662	17.0
Hexagrammidae (greenling)	1	0.1	–	–	10	0.9	3	0.7	14	0.4
Labridae (senorita or wrasse)	2	0.1	9	1.6	3	0.3	118	27.9	132	3.4
Mackerel undif.	9	0.5	7	1.2	61	5.7	3	0.7	80	2.1
<i>Ophiodon elongatus</i> (lingcod)	29	1.6	13	2.3	6	0.6	4	0.9	52	1.3
<i>Porichthys</i> spp. (midshipman)	14	0.8	5	0.9	12	1.1	–	–	31	0.8
<i>Scorpaenichthys marmoratus</i> (cabezon)	24	1.3	25	4.4	11	1.0	5	1.2	65	1.7
<i>Sebastes</i> spp. (rockfish)	1453	80.0	267	46.7	748	69.8	145	34.3	2613	67.3
<i>Semicossyphus pulcher</i> (California sheephead)	14	0.8	9	1.6	1	0.1	17	4.0	41	1.1
<i>Seriola lalandi</i> (yellowtail)	–	–	–	–	2	0.2	–	–	2	0.1
<i>Sphyræna argentea</i> (California barracuda)	9	0.5	2	0.3	–	–	4	0.9	15	0.4
Stichæidae (prickleback)	12	0.7	7	1.2	–	–	–	–	19	0.5
cf. Xiphiidae/Istiophoridae (billfishes)	13	0.7	–	–	–	–	–	–	13	0.3
Xiphister sp.	10	0.6	2	0.3	–	–	3	0.7	15	0.4
Teleost	13,058	–	4335	–	3992	–	3024	–	24409	–
Subtotal	14,868	–	4905	–	5061	–	3444	–	28278	–
<i>Elasmobranch</i>										
<i>Myliobatis californica</i> (California bat ray)	2	0.1	2	0.3	–	–	–	–	4	0.1
<i>Platyrhinoïdis triseriata</i> (California thornback)	–	–	–	–	2	0.2	–	–	2	0.1
Triakidae (smoothhounds, soupfin, etc.)	5	0.3	–	–	–	–	3	0.7	8	0.2
Elasmobranch undif.	2	–	3	–	–	–	1	–	6	–
Subtotal	9	–	5	–	2	–	4	–	20	–
Total	14,877	–	4910	–	5063	–	3448	–	28298	–

^a Based on 1/8-inch recovery. Percentages based on specimens identified to family, genus, and species. Unit 1 sample include newly analyzed sample not reported in Rick (2004).

size of the CA-SRI-2 MCA sample (Stratum 3). This general increase in richness is also associated with the emergence of finfish as the top food resource. Finfish increase greatly throughout the region around 3000 to 2500 years ago and by about 1500–1000 years ago form the vast majority (~80–90% of meat yields) of faunal remains in most sites (Kennett, 2005; Rick, 2007a).

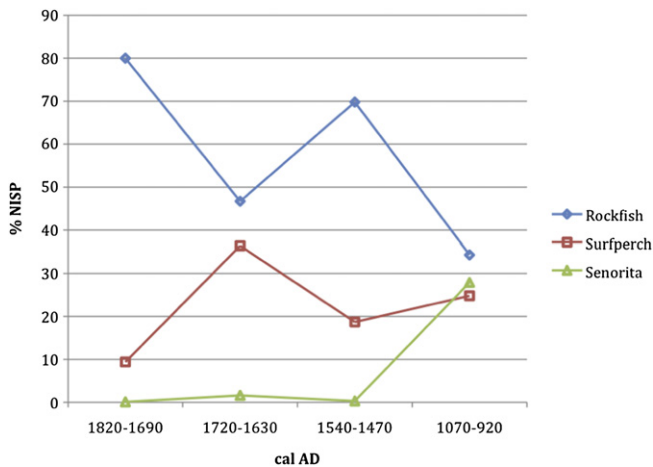


Fig. 4. Relative abundance of three important finfish through time at CA-SRI-2 (percentages are based on the rockfish, surfperch, or senorita NISP divided by the total NISP of fish identified to family, genus, or species).

While taxonomic richness increases, the finfish identified at CA-SRI-2 demonstrate that through time people also increasingly focused on a few key fishes (i.e., rockfish and perch) particularly following the MCA. This is evident in the diversity (*H*) and evenness (*V*) values for the finfish from CA-SRI-2 (Table 7). The fish *H* and *V* values across the 800-year period are fairly low with reduced evenness and diversity after the MCA, probably reflecting the dominance of rockfish in the Late period compared to the more balanced assemblage of rockfish, perch, and labrids in the MCA sample. An increase in the *H* value in Stratum 2 probably results from higher concentrations of perch, but still supports the trend towards targeting rockfish in the Late and Historic periods. While sample size can influence evenness (Lyman, 2008), the dominance of rockfish is a pattern repeated at other Late Holocene sites on Santa Cruz, Santa Rosa, and San Miguel islands, where rockfish (and perch) dominate many assemblages after about AD 1000, especially after AD 1400 (see Braje, 2010; Colten, 2001; Noah, 2005; Paige, 2000; Rick, 2007a). Rockfish are also among the most common fishes found in Early and Middle Holocene sites, demonstrating that they were an important resource for over 10,000 years (Braje et al., in press; Rick et al., 2001). In a recent survey of rockfish exploitation on the Northern Channel Islands during the last 10,000 years, Braje et al. (in press) found that rockfish were the top ranked fish in 15 of 29 (52%) site components, were second in 9 components (31%), and never ranked below fourth in overall abundance. Colten's (2001, p. 207) data were taken from multiple site components and were excluded from the Braje et al. (in press) analysis, but at several Santa Cruz Island sites spanning the MCA through Historic period, Colten noted that rockfish contributed between 68 and 88% of the

Table 5
Mammal and Bird Remains from CA-SRI-2.^a

	Unit 1		Unit 2						Total	
	NISP	% NISP	Strat. 1		Strat. 2		Strat. 3		NISP	% NISP
			NISP	% NISP	NISP	% NISP	NISP	% NISP		
<i>Mammals</i>										
<i>Arctocephalus townsendi</i> (Guadalupe fur seal)	4	5.1	–	–	–	–	–	–	4	4.3
<i>Callorhinus ursinus</i> (Northern fur seal)	1	1.3	–	–	–	–	–	–	1	1.1
Otariidae	28	35.9	1	12.5	1	16.7	–	–	30	32.6
<i>Phoca vitulina</i> (harbor seal)	–	–	1	12.5	–	–	–	–	1	1.1
Pinniped	1	1.3	–	–	–	–	–	–	1	1.1
<i>Enhydra lutris</i> (sea otter)	43	55.1	3	37.5	5	83.3	–	–	51	55.4
Medium/Large Cetacean	1	1.3	1	12.5	–	–	–	–	2	2.2
<i>Spilogale gracile</i> (island spotted skunk)	–	0.0	1	12.5	–	–	–	–	1	1.1
Large Land Mammal	–	–	1	12.5	–	–	–	–	1	1.1
Mammal	649	–	131	–	62	–	111	–	953	–
Undif. Bone	4	–	6	–	5	–	–	–	15	–
Total	731	–	145	–	73	–	111	–	1060	–
<i>Birds</i>										
<i>Aechmophorus occidentalis</i> (western grebe)	1	16.7	–	–	–	–	–	–	1	10.0
Large gull cf. Glaucos wing	1	16.7	–	–	–	–	–	–	1	10.0
Large gull cf. Western	1	16.7	1	50.0	–	–	–	–	2	20.0
<i>Phalacrocorax</i> spp. (Brandt's/Double crested cormorant)	2	33.3	1	50.0	–	–	2	100.0	5	50.0
<i>Phalacrocorac pelagicus</i> (pelagic cormorant)	1	16.7	–	–	–	–	–	–	1	10.0
Aves	91	–	24	–	9	–	28	–	152	–
Total	97	–	26	–	9	–	30	–	162	–

^a Based on 1/8-inch recovery. Percentages are based on specimens identified to family, genus, or species.

total fish NISP, with the highest values in the Late and Historic periods like CA-SRI-2. Expanding taxonomic richness, including supplemental use of offshore species (swordfish, etc.) is an important feature that differentiates Late Holocene peoples from most Early and Middle Holocene peoples (Braje, 2010; Erlandson et al., 2009; Pletka, 2001; Rick, 2007a). However, it is the abundance of rockfish and, to a degree perch, in Late period and Historic samples on Santa Rosa Island, on San Miguel Island (Rick, 2007a, p. 111, 121), and on Santa Cruz Island (Colten, 2001, pp. 202–203; Noah, 2005, p. 286) that appears to have formed the backbone of Island Chumash subsistence at many sites during the last 500 years (or more) through the Historic period.

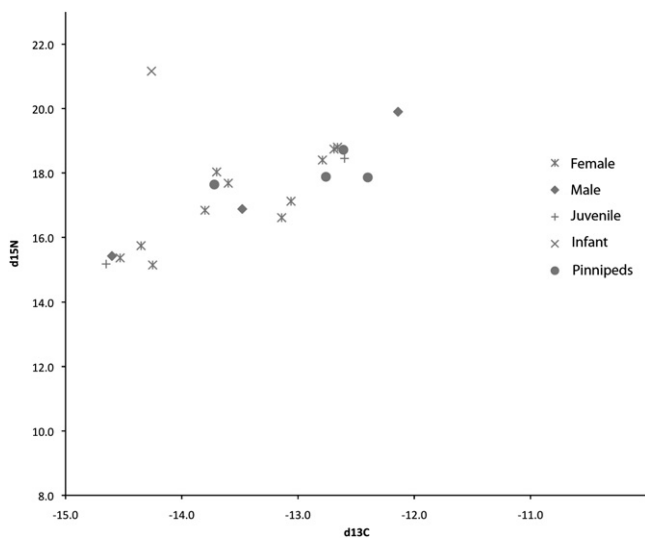


Fig. 5. Stable nitrogen (N) and carbon (C) isotopes on human and pinniped (seals and sea lions)/Guadalupe fur seal remains run by Goldberg (1993, p. 181, 197). The human data are separated out by male and female adults, infant, and juveniles. Note similarity between pinniped (seal and sea lion) data and humans, indicating a heavy focus on marine foods by the people who lived at CA-SRI-2.

The intensified focus on finfish is part of a much longer trend of “fishing up the food web”—where Channel Island peoples exploited increasingly higher trophic level marine foods through time (Erlandson et al., 2009). Much of the Early and Middle Holocene were characterized by an emphasis on lower trophic level shellfish with generally much smaller amounts of finfish, marine mammals, and birds, while finfish emerged as the dominant food source in the Late Holocene (Erlandson et al., 2009; Kennett, 2005; Rick et al., 2005). The intensified Late Holocene use of finfish—marine organisms that are capable of yielding considerably higher biomass than shellfish—also indicates increased predation pressure on shellfish, marine mammals, and sea birds and the inability of smaller shellfish and more widely dispersed pinnipeds and sea birds to support growing human populations (Braje, 2010; Erlandson et al., 2009; Kennett, 2005; Raab et al., 1995, 2009; Rick, 2007a). Although not without consequences for human health, the intensification of finfish was a strategy or adaptive adjustment that helped Chumash peoples transcend the challenges of growing population densities, declining shellfish and other resource abundance, and changes in cultural complexity (see also Erlandson et al., 2009). In this case, the Island Chumash made a choice that had consequences for human health, social organization, and other variables, but provided greater food yields. While intensified finfish use appears to have emerged as a strategy to combat the shortfalls of other resources, it is also likely that the focus on the high biomass yields of finfish reduced predation pressure on other resources (e.g., shellfish).

Intensified use of salmon has long been seen as an important component of social change in the Northwest Coast of North America, though salmon use varies highly across the region and was a component of broader subsistence practices (Ames, 2003; Butler and Campbell, 2004). Finfish are clearly not the only reason for changing social and political systems in the Channel Islands or Northwest Coast, but the high yields of finfish clearly helped provide greater surplus to support higher population densities in increasingly circumscribed land and seascapes. Finfish also promoted communal efforts such as building weirs and other fishing

Table 6
Summary of Human Skeletal Data from CA-SRI-2.^a

Skeletal Characteristic		SRI-2A	SRI-2B	References
Dental Carries (number of teeth)	Present	27	59	Walker and Erlandson, 1986, p. 377
	Absent	224	875	
Dental Attrition (Sample = 21)	Dentine Exposure	–	0.308 (mm ²)	Walker, 1978, p. 104
	Mandibular molar area (summed)	–	30.31 (mm ²)	
Periosteal Lesions (number of elements)	Present	–	16	Walker et al., 2005, p. 283
	Absent	–	229	
Cribræ Orbitalia	Present	3	22	Walker, 1986 ^b , p. 348
	Absent	9	39	
Projectile Wounds	Present	–	3	Lambert, 1994, p. 253
Cranial Injuries	Present	1	6	Walker, 1989
	Absent	12	60	
Stature (Average Femur Length in mm)	Female (n = 9)	–	384.2	Lambert, 1994, p. 190
	Male (n = 5)	–	412.0	

^a Data on osteoarthritis from CA-SRI-2 were presented by Walker and Hollimon (1989), and dental enamel hypoplasia by Lambert (1994) but it is unclear which of these specimens were from CA-SRI-2 and which are from other sites.

^b Lambert (1994, p. 170) also reports 38 without cribræ orbitalia and 30 with from SRI-2b.

technologies. While weirs and large communal fishing structures are not known from the Channel Islands, fishing nonetheless was an important part of the social fabric of the islands, with a variety of people likely involved in making nets, fishhooks, other tackle, and watercraft, and the capture, processing, preparation, and distribution of fishes. An example of this comes from ethnohistoric accounts of Chumash tomols (plank canoes) and their use in fishing pursuits (Hudson et al., 1978, pp. 125–130). Here a few individuals will go out fishing in a tomol, with some tending the lines, or steering and rowing, and one for bailing (Hudson et al., 1978, pp. 127–128). When the fishing journey returns, the relatives of the tomol owner will help transport the fish and boat ashore, with the fish then divided among the canoe owner's relatives, those who caught the fish, and perhaps other members of the village (Hudson et al., 1978, pp. 129–130). Intensified use of finfish, therefore, was not just a response to combat declines in other resources and growing human populations, but likely worked in concert with island/mainland bead production and exchange networks to facilitate changing social conditions, interactions, and relationships (see Arnold, 2001; Kennett, 2005; Rick, 2007a). In the Beagle Channel of South America, Zangrandon (2009) cautioned that finfish intensification should be viewed as a multi-dimensional process that does not necessarily result in increased sociopolitical complexity. This is an important point in the Channel Islands as well, where finfish may have provided the food base that made population growth possible and may have helped solidify social bonds, but was not necessarily the catalyst for changing social organization.

Changes in shellfish are also evident over the last several thousand years on the Channel Islands, though at CA-SRI-2 *H* values are fairly similar ranging from 1.58 to 1.97 and *V* values remain consistently low from 0.48 to 0.58 (Table 7). These evenness values demonstrate the dominance of California mussels, a resource that, like rockfish, was usually the most abundant shellfish harvested on the Channel Islands for over 10,000 years (Braje, 2010; Erlandson and Rick, 2010; Rick, 2007a). Braje et al. (2007) ranked Channel

Island shellfish based on the return rate, ease of harvest, and other variables, noting that California mussels were the number 1 ranked shellfish followed by black and red abalones, with turban ranked 5. The people who occupied CA-SRI-2 harvested the top ranked California mussel throughout the sequence of occupation, with limited contributions of the second (black abalone), third (red abalone), fifth (turban), and sixth ranked species (sea urchins). These findings suggest fairly robust California mussel assemblages available for local harvest at CA-SRI-2 despite intensive human predation. The average size of California mussels are consistent with the sizes of Late Holocene mussels on adjacent San Miguel Island, which are generally smaller than Early and Middle Holocene samples—part of a long-term decline in shellfish sizes from human predation (Erlandson et al., 2008). However, the average size of California mussels is also about 1–2 cm larger than those reported by Braje et al. (2007) during a similar time period on Santa Rosa Island's south coast. At CA-SRI-2, the average size of mussels and other shellfish increases slightly through time, suggesting perhaps a hiatus in local harvesting just prior to the occupation of Unit 1 (AD 1700–1820).

One possibility for the larger shellfish sizes is that human populations had declined from early incidence of European diseases during the Protohistoric period (16th to 17th centuries). Considerable debate persists about potential population declines during the Protohistoric period or earliest phases of European contact in the Channel Islands and beyond (see Erlandson et al., 2001). At CA-SRI-2, Walker et al. (2005) speculated that venereal syphilis from early contact with Europeans may have occurred in the latter part of the 16th century following initial contact with Europeans in AD 1542–1543. Interestingly, the faunal remains from CA-SRI-2 are the most dense and abundant in the Unit 1 deposits dating to the late 18th and early 19th centuries following the Protohistoric period. This may be a result of lower population densities during the immediate period prior to this occupation, which allowed local resources to rebound slightly. Broughton (1999) and Butler (2000)

Table 7
Taxonomic richness, diversity, and evenness in Late Holocene components from CA-SRI-2.^a

Component/Age	Shellfish <i>N</i>	Fish <i>N</i>	Mammal <i>N</i>	Bird <i>N</i>	Total <i>N</i>	Shellfish <i>H</i>	Shellfish <i>V</i>	Fish <i>H</i>	Fish <i>V</i>
Unit 2, Str. III AD 920–1070	25	15	–	1	41	1.80	0.56	1.68	0.62
Unit 2, Str. II AD 1470–1540	30	14	2	–	46	1.97	0.58	1.01	0.38
Unit 2, Str. I AD 1630–1720	26	16	5	2	49	1.58	0.48	1.47	0.53
Unit 1 AD 1690–1820	30	20	4	5	59	1.88	0.55	0.93	0.31

^a *N* = Richness measured by number of taxa (family, genus, or species) identified in each sample. *H* is diversity and *V* is evenness.

have argued that population declines after early contact with Europeans resulted in rebounds in key prey in the San Francisco Bay and Columbia River areas, respectively. This remains an interesting possibility, but larger samples of faunal remains from CA-SRI-2, other Channel Island sites, and better chronological resolution of local human skeletal data are needed to test this.

Collectively, the faunal remains from CA-SRI-2 paint a complex picture of Chumash subsistence strategies, environmental impacts, and sociocultural changes that fall at the end of a greater than 10,000 year adaptive cycle on the Channel Islands. By the onset of the Late Holocene, ancient Channel Islanders had placed considerable pressure on local ecosystems, reduced some primary prey, and were probably the top predator in most near shore ecosystems (Erlandson and Rick, 2010; Raab et al., 2009). The most common and intensively harvested species remain fairly consistent through time, however, with California mussels generally the most abundant shellfish throughout the last 10,000 years and rockfish and perch also common throughout the Holocene. Underlying patterns of change and alteration of Channel Island ecosystems and resource use, therefore, is a trend of continuity, resilience, and stability in the types of resources (especially finfish and shellfish) that people harvested and utilized for their primary subsistence (Erlandson et al., 2009). Campbell and Butler (2010) have also tracked long-term resilience in northeastern Pacific Coast salmon populations despite intensive Native American harvest over 7500 years. Similarly, Braje et al. (2009) documented long-term resilience in the Northern Channel Island red abalone fishery. On the Channel Islands, this apparent resilience may partly relate to the lower population densities and technological limitations of the Chumash compared to today, but the Chumash had some of the densest populations known for hunter-gatherers and a sophisticated maritime toolkit. This suggests that these patterns may speak to the long-term resilience of Channel Island ecosystems and resources despite millennia of relatively intensive predation by hunter-gatherers. One factor supporting this is the diverse and complex food webs of contemporary kelp forest habitats in the region, which may make them more resilient to human impacts and quicker to recover from disturbance than other kelp forests (e.g., the Aleutians) (Graham et al., 2008; Steneck et al., 2002). Human skeletal analyses from CA-SRI-2 and elsewhere, however, demonstrate the challenges that people faced including health declines and increased rates of violence—patterns that may have somewhat improved after the MCA. Together the skeletal and faunal data demonstrate the complex interplay between human health and subsistence, alterations of local resources and ecosystems, and climatic changes.

This relative continuity in marine resource use over a few centuries is also important given climatic changes during the preceding MCA (Arnold, 1992, 2001; Gamble, 2005, 2008; Kennett and Kennett, 2000; Kennett, 2005; Raab et al., 2009). High-resolution marine climate records indicate that on average the Late Holocene was a period of some of the coldest and most unstable marine climate during the last 10,000 years, though these cold periods generally support higher marine productivity (Kennett and Kennett, 2000; Kennett, 2005). On land, this was a time of generally dry conditions, with particularly intense droughts during the MCA (AD 800–1350)—droughts that appear to have had significant effects on ancient peoples, including heightened sociopolitical complexity among the Island Chumash (see Jones and Schwitalla, 2008; Kennett, 2005; Kennett and Kennett, 2000). After about 500 years ago marine conditions appear to have warmed (Kennett, 2005). Debates continue to rage over the nature of environmental and climatic changes during the MCA and their effects on ancient peoples on the Channel Islands and elsewhere in California. Jones and Schwitalla (2008; see also Raab et al., 2009) have reviewed the state of this debate, concluding that drought during the MCA was a prominent environmental variable

that was likely a catalyst of social change, with further research needed to determine if these droughts were more punctuated and had rapid influence on human social systems, or if they were more gradual resulting in incremental changes. Kennett and Kennett (2000; Kennett, 2005; Kennett et al., 2009) also highlight the influence of MCA droughts, augmented by unstable, yet generally productive marine conditions. Arnold (1992, 2001) has posited that drought along with marine perturbations (e.g., warmer SST) were components of increased sociopolitical complexity during the MCA or Transitional period (aka Middle to Late period Transition). At the other end of the spectrum, Gamble (2005) has argued that the Chumash and other groups had faced millennia of environmental challenges and that these climatic perturbations likely had limited influence on changes to Chumash society especially when compared to how they would have affected agriculturalists.

While the data from CA-SRI-2 are too localized in nature to explain the regional effects of climate change and environmental variables, they provide important details that expand our thinking on human responses to the environmental developments during the latter half of the Late Holocene. The continuity of marine resources, especially the major shellfish and finfish that were targeted at CA-SRI-2 and other Channel Island sites suggests that MCA marine conditions, at least on archaeological time scales, did not have an overarching, negative effect on Late Holocene human subsistence (Jones and Schwitalla, 2008; Rick, 2007a). Short-term events (e.g., El Niño) undoubtedly influenced local resources, but the specifics of these events are difficult to track in archaeological deposits. The marine faunal data presented here do not speak directly to the effects of MCA droughts, but several lines of evidence show correlation between drought and climatic instability and changes in settlement, craft production, and social organization on the Northern Channel Islands (see Arnold, 2001; Kennett, 2005). However, these cultural developments were also intricately linked to longer-term patterns of population growth and circumscription on the islands and beyond (Erlandson and Rick, 2002; Gamble, 2005). With new research continuing to document Transitional period sites on the Channel Islands (see Rick, 2007a; Rick et al., 2005), the time is right for more focused investigation of the variability of human responses to MCA and broader Late Holocene climatic developments (Jones and Schwitalla, 2008). This includes regional, diachronic analysis and quantification of asphaltum water bottle fragments and other direct material correlates of human responses to the inferred droughts (Gamble, 2005, p. 102).

Ultimately, the data from CA-SRI-2 and elsewhere suggest the Chumash were able to weather the storm of climatic and environmental change and transcend this instability by continuing to harvest a similar suite of resources, especially finfish and shellfish. Although the cultural and environmental circumstances varied, the Chumash and their predecessors had responded to and transcended climatic and environmental uncertainty during the more than 10,000 years of occupation preceding the data presented here (Gamble, 2005). A primary hypothesis put forth here is that much of the cultural adaptability and resilience of the Island Chumash was facilitated by the resilience, diversity, and productivity of southern California marine ecosystems, especially kelp forests. This does not mean that the Channel Islands were a bountiful and limitless paradise (see Raab and Jones, 2004) as recent work documents many of the ways Channel Islanders manipulated and altered ancient island ecosystems including kelp forests (Braje, 2010; Erlandson and Rick, 2010; Rick et al., 2008, 2009), and physical anthropological data indicate the great challenges faced by ancient Channel Islanders (see Lambert, 1994). However, on long time scales (i.e., centuries or more) ancient island kelp forests and rocky intertidal zones were resilient and adaptable to many of the perturbations of ancient human predation and natural climatic changes that afforded opportunities

for people to switch to other resources or intensify use of higher biomass yielding organisms (e.g., finfish) in the wake of growing populations, human environmental degradation, and climatic change (see also Braje et al., 2009; Erlandson et al., 2009).

This apparent resilience in the wake of unstable environmental variables, social networks, and other aspects of the natural and cultural world is an important feature that had played out on the Channel Islands and beyond for millennia. Investigations into the long-term resilience and adaptive cycles of local ecosystems and human social structures are an important aspect of archaeological research moving into the second decade of the new millennium (see Redman, 2005). Research on the Georgia Coast (Thompson and Turk, 2009), in the Mississippi River Valley (Smith, 2009), on marine invertebrates in Europe (Bailey and Milner, 2008), on California Channel Island red abalones (Braje et al., 2009), on salmon in the Northwest Coast of North America (Campbell and Butler, 2010), and beyond document the complex patterns of human environmental impacts or influence on local ecosystems and the resilience and adaptability to change of animal and plant resources. On the Channel Islands, such developments played out over 10,000 years from mobile hunter-gatherers to the complex and relatively densely populated foragers of the Late Holocene.

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