Proceedings of the Sixth California Islands Symposium, Ventura, California, December 1 – 3, 2003

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National Park Service

Proceedings of the Sixth California Islands Symposium, Ventura, California, December 1 – 3, 2003. National Park Service Technical Publication CHIS-05-01, Institute for Wildlife Studies, Arcata, California.

Published in the United States of America
Arcata, California

Library of Congress Cataloging in Publication Data

Proceedings of the Sixth California Islands Symposium. 2005. D. K. Garcelon and C. A. Schwemm (editors). National Park Service Technical Publication CHIS-05-01, Institute for Wildlife Studies, Arcata, California

Includes bibliographical references and indexes
ISBN 0-9766018-1-8

1. Natural history—California. 2. Islands—California.
3. Archeology—California. 4. Channel Islands (Calif.)—Congresses.
I. Garcelon, David K.

PRELIMINARY REPORT ON THE ARCHAEOLOGY AND PALEOECOLOGY OF THE ABALONE ROCKS ESTUARY, SANTA ROSA ISLAND, CALIFORNIA

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Abstract—Although California's mainland coast was once punctuated by numerous large embayments, estuaries are rare or absent on the Channel Islands. Recent archaeological and paleoecological research, however, confirm the presence of an estuary near Abalone Rocks, Santa Rosa Island. Preliminary survey and small-scale excavations suggest that early island peoples harvested shellfish (e.g., venus clams [*Chione* spp.], Washington clam [*Saxidomas nuttalli*], California oyster [*Ostrea lurida*]) from this estuary between about 8,000 and 5,900 calendar years BP. Rocky intertidal shellfish appear to dominate many of these assemblages, but the high proportion of estuarine shellfish is unique among Channel Islands archaeological sites. Our preliminary investigations suggest that the Abalone Rocks Estuary persisted for at least 2,000 years, with its transition to a freshwater/estuarine marsh possibly occurring around 5,000 years ago. This estuary, nearby Torrey pine grove, and other diverse coastal environments made the eastern portion of Santa Rosa Island an attractive place for ancient human settlement. Future work will investigate the nature of these sites, hypothesized to be either relatively permanent habitations or temporary encampments used by people living elsewhere on the islands.

Keywords: archaeology, estuary, harvest, history, paleoestuary, shellfish

INTRODUCTION

The Chumash and their predecessors lived on the northern Channel Islands for over 12,000 years, leaving behind a lengthy and continuous archaeological record. The Channel Islands have hundreds of shell middens that contain the remains of a variety of fishes, marine and terrestrial mammals, shellfish, birds, and other organisms. The animal remains from these sites provide valuable indicators of local and regional environmental changes and human impacts on marine and terrestrial ecosystems (Glassow 1993, Kennett and Kennett 2000, Erlandson et al. 2004). Therefore these assemblages provide an excellent opportunity to investigate broad ecological and cultural issues with great time depth and relatively high resolution.

Archaeological research in sites spanning the last 10,000 years suggests that ancient Channel Islanders exploited a relatively similar suite of marine resources throughout the Holocene (Kennett 1998, Erlandson et al. 1999, Erlandson et al. 2004). Channel Island faunal assemblages are primarily dominated by the remains of rocky intertidal shellfish (California mussel [*Mytilus californianus*], black abalone [*Haliotis cracherodii*] and red abalone [*H. rufescens*], turbans [*Tegula* spp.], etc.), rocky near shore or kelp bed fishes (rockfish [*Sebastes* spp.], perch [Embiotocidae], California sheephead [*Semicossyphus pulcher*], etc.), marine mammals, and birds, with the frequency of various resources often indicating environmental shifts or human impact on local environments (Erlandson et al. 2004). These data stand in sharp contrast to many early Holocene archaeological sites located on the adjacent mainland coast where a number of large estuaries were a focus of early human settlement and subsistence (Erlandson 1994). After sea level rise slowed around 6,000 to 5,000 years ago (Inman 1983) most of these estuaries disappeared, with only a few of the larger embayments persisting into the late Holocene (e.g., Goleta Slough).

In this paper, we summarize current archaeological evidence for the presence of a

paleoestuary, Abalone Rocks Marsh, near the mouth of Old Ranch Canyon on eastern Santa Rosa Island. Several archaeological sites clustered around the former estuary, now a marsh, contain abundant estuarine shellfish species that are practically non-existent in other Channel Islands sites. We begin by providing a brief environmental and cultural overview of Santa Rosa Island and the Abalone Rocks estuary and marsh system. We then describe the archaeological sites that contain estuarine shellfish species and speculate on the extent, productivity, and history of this ancient estuary. Our data illustrate the importance of archaeology for reconstructing ancient environments and the role of people in influencing and tracking environmental changes.

ENVIRONMENTAL AND CULTURAL CONTEXT

With an area of roughly 217 km^2, Santa Rosa Island is the second largest of the northern Channel Islands. It is situated about 44 km off the mainland coast, about 5 km east of San Miguel Island and 9 km west of Santa Cruz Island. With a number of relatively well-watered streams, mountain peaks up to 508 m high, and several distinct vegetation communities, Santa Rosa Island contains some of the greatest biological and environmental diversity on the Channel Islands. Introduced grasses currently dominate island vegetation, but there is also unique coastal beach and dune vegetation, island chaparral, oak and riparian woodland, and an island endemic species of Torrey pine (*Pinus torreyana insularis* Schoenherr et al. 1999, p. 278).

The eastern portion of Santa Rosa Island is among the most ecologically diverse areas of the Channel Islands. Old Ranch Canyon, positioned on the east coast between Skunk and East Points, is the largest drainage on the island (11.83 km^2) and has a broad plain at its mouth. Just beyond the upper reaches of Old Ranch Canyon is a relict Torrey pine grove and nearby Skunk Point is a surf-swept sand spit with abundant habitat for seabirds and other animals. Located throughout this area are numerous archaeological sites, including the Chumash village of *Qshiwqshiw* (Kennett 1998, Johnson 1999) and sites spanning at least the last 8,000 years.

The Abalone Rocks marsh/estuary system was named by Cole and Liu (1994) because of its close proximity to Abalone Rocks. For this paper, we refer to the Abalone Rocks Estuary as the estuary and marsh complex located at the mouths of both Old Ranch and adjacent Old Ranch House canyons. The Abalone Rocks Marsh is frequently described as an estuarine marsh, but the limited open ocean input suggests it is predominantly a freshwater system today. The marsh has been cored for paleoecological research by Cole and Liu (1994) and Anderson (2002), producing records spanning roughly 5,200 and 6,150 RYBP, respectively (ca. 7,000 calendar years). Both studies suggest that during the middle Holocene the system was dominated by marine rather than freshwater conditions (Cole and Liu 1994, Anderson 2002). The late Holocene sequence is characterized by greater freshwater input into the marsh and more vegetation on the surrounding uplands (Cole and Liu 1994, p. 332; Anderson 2002, p. 8). These records also contain evidence of local fire history and dramatic environmental changes (e.g., introduced vegetation and higher sedimentation) following Euroamerican settlement of the island.

Recent research has shown that Santa Rosa Island was occupied by people for over 12,000 calendar years (Johnson et al. 2000) and a number of shell middens have been dated to around 9,000 years old (Erlandson 1994, Kennett 1998, Erlandson et al. 1999). Santa Rosa also has a continuous and well preserved archaeological record of Native American occupation spanning the Holocene through the early 19th century. These factors make Santa Rosa Island an excellent laboratory for studying the effects of humans on aquatic ecosystems over broad periods of time (historical ecology; Crumley 1994), including an archaeological history of the Abalone Rocks Estuary.

ARCHAEOLOGY OF THE ABALONE ROCKS ESTUARY

Currently, seven archaeological sites located on eastern Santa Rosa Island contain a high proportion of estuarine shell. These sites are located over a relatively large area with most on or near the former shoreline of the estuary. However,

two of the sites (SRI-77 and SRI-667) are located near Beecher's Bay about 3–4 km from the estuary. The chronology, location, and nature of the shellfish assemblages from each of these sites provided evidence of the extent, productivity, and history of the Abalone Rocks Estuary. Most of these sites have yet to be excavated in detail, but radiocarbon dates are available from several of the sites and bulk midden samples from two of the sites provided preliminary quantitative data on the importance of various shellfish taxa.

We relied on the presence and abundance of a variety of shellfish to determine the availability and productivity of local marine habitats (Table 1). Changes in shellfish species are a valuable indicator of ancient environments (Shackleton and van Andel 1986, Claassen 1998). A number of archaeologists on the Channel Islands have recently used data from shell middens to reconstruct ancient environments (e.g., Glassow 1993, 2000, Glassow et al. 1994, Sharp 2000, Erlandson et al. 2004), and our preliminary study of the Abalone Rocks Estuary adds to this growing body of research.

All of the shellfish remains analyzed in this study were identified using collections and reference materials housed at the Department of Anthropology, University of Oregon. We calculated Minimum Number of Individuals (MNI) using the highest number of non-repetitive elements present in the samples (e.g., sided hinges for bivalves and apices for gastropods). In the following section, we briefly synthesize the setting, chronology, and nature of the shellfish assemblages from each of these sites.

CA-SRI-77

SRI-77 is a dense shell midden located on a prominent terrace on the east side of Beecher's Bay about 3–4 km from the mouth of Old Ranch Canyon. SRI-77 is bisected by a road and by a drainage formed by the Santa Rosa Island fault, which run through the site and expose dense

Table 1. Habitats of major shellfish species discussed in the text.

Shellfish Taxon[a]	Habitat[b]
Astraea undosa (wavy turban)	Low rocky intertidal, more common subtidally in kelp beds.
Chione californiensis (California venus)	Just below the surface in sandy bays/mudflats of bays/sloughs, low intertidal to 50 m.
Chione fluctifraga (smooth California venus)	Just below the surface in sandy bays/mudflats of bays/sloughs, low intertidal to 50 m.
Chione undatella (frilled California venus)	Just below the surface in sandy bays/mudflats of bays/sloughs, low intertidal to 50 m.
Haliotis cracherodii (black abalone)	High rocky intertidal to 6 m.
Haliotis rufescens (red abalone)	Low rocky intertidal to over 180 m.
Mytilus californianus (California mussel)	Rocky intertidal on surf exposed coasts.
Ostrea lurida (California oyster)	Low intertidal in quiet bays and estuaries.
Protothaca staminea (Pacific littleneck)	Intertidal shallow burrows in coarse sand/sandy mud in bays or coves, and in gravel under larger rocks on open coast.
Saxidomus nuttalli (Washington clam)	Low intertidal in bays/lagoons, buried to depths of 30 cm in sand/mud. Also in sandy areas near rocks on outer coast.
Septifer bifurcatus (platform mussel)	Rocky intertidal on exposed shores.
Strongylocentrotus purpuratus (purple sea urchin)	Low rocky intertidal and subtidal to 160 m.
Tegula funebralis (black turban)	Tidepools and on rocks, middle intertidal in protected coastal areas.

[a] Species and common names follow Morris (1966) and Morris et al. (1980).

[b] The habitat data are from Morris et al. (1980).

midden strata. Steep sea cliffs bracket the northern site boundary and a terrace rises to the south of the site. A few surface depressions visible in the northern site area appear to be the remains of house pits associated with a late Holocene occupation.

Four radiocarbon dates from this large, multicomponent site suggest an early Holocene occupation at roughly 7,500 years ago and late Holocene occupation between about 1,150 and 1,000 cal BP (see Kennett 1998). Along the eastern site margin, the early Holocene component is visible roughly 1 m down in the sea cliff and exposed in a small shelf. This early Holocene component is visible for roughly 15 m in the sea cliff and extends for an unknown distance to the east. The lower midden deposits are roughly 10 to 20 cm thick and contain scattered pockets of shellfish remains, including estuarine and rocky intertidal taxa, and lithic artifacts. Radiocarbon dating of a frilled California venus clam (*Chione undatella*) shell from this lower component provided a conventional age of 7,220 ± 90 RYBP and a calibrated intercept of 7,480 cal BP (Table 2).

A bulk sample (0.015 m^3) obtained from the lower component during summer 2003 produced a large shellfish assemblage that is dominated by estuarine taxa (Table 3). From the roughly 706 g sample of shell and bone, at least 12 different shellfish taxa were identified. About 53% of the shellfish assemblage by weight and 58% by MNI were from estuarine species, including venus (frilled California, California [*C. californiensis*], smooth California [*C. fluctifraga*]) and Washington clams. Rocky intertidal shellfish (mostly red abalone and California mussel) made up about 44% of the shell weight, but only about 30% of the MNI. Vertebrate remains were relatively limited in this sample, with just three specimens weighing about 2.5 g. These included an undifferentiated bird bone and a California sheephead tooth. By the late Holocene, the shellfish assemblage at the site was dominated by California mussel, platform mussel (*Septifer bifurcatus*), black abalone, and other rocky intertidal shellfish, with no estuarine shellfish, suggesting that the estuary was probably no longer a viable habitat for these shellfish species.

CA-SRI-81

This large shell midden is situated on a low terrace overlooking the mouth of Old Ranch Canyon. The site is located about 0.5 km from the current coastline along the margins of the estuary. Most of the site is covered by dense introduced grasses, with patches of shell midden and lithics visible in a road exposure and underneath the vegetation. In exposed areas, a dark loamy soil contains California mussel and moderate amounts of frilled California venus clam. Auger tests suggest that the site deposits range from 20–60 cm deep. Radiocarbon dating of a frilled California venus shell from Auger 3 at 40–60 cm below the surface produced a conventional age of 7,090 ± 70 RYBP, with a calibrated intercept of 7,400 cal BP (Kennett 1998). Dating of this sample confirmed the presence of the estuary during the early Holocene and is roughly comparable in age to the earliest deposits at SRI-77. Future testing of this

Table 2. Radiocarbon dates on sites with a high proportion of estuarine shell on Santa Rosa Island, CA.

Site	Provenience	Lab Number[a]	Materials	Uncorrected ^{14}C Date	$^{13}C/^{12}C$ Adjusted	Calibrated Age BP (1 Sigma)[b]
SRI-77	Sea cliff exposure	B-180926	*Chione*	6,790 ± 90	7,220 ± 90	7,570 (7,480) 7,410
SRI-81	A3, 40-60 cm	B-109770	*Chione*	6,640 ± 70	7,090 ± 70	7,430 (7,400) 7,300
SRI-84	Unit 2, 40-50 cm	OS-34564	*Saxidomus*	-	7,750 ± 40	8,020 (7,960) 7,930
SRI-191	Red ab. midden	OS- 37594	*Chione*	-	5,740 ± 45	5,930 (5,900) 5,860
SRI-192	South site probe	B-183138	*Ostrea*	6,020 ± 70	6,440 ± 70	6,730 (6,650) 6,560
SRI-666	Sample A	B-47626	*Saxidomus*	7,350 ± 70	7,780 ± 70	8,100 (7,990) 7,930
SRI-667	Stratum 3	OS-41894	*Chione*	-	5,990 ± 45	6,260 (6,180) 6,120

[a] B=Beta Analytic and OS=National Ocean Sciences AMS Facility.

[b] All dates were calibrated using Calib 4.3 (Stuiver and Reimer 1993, 2000) and applying a ΔR of 225 ± 35 years for all shell samples (Kennett et al. 1997). $^{13}C/^{12}C$ ratios were either determined by the radiocarbon labs, or an average of +430 years was applied (Erlandson 1988).

Table 3. Midden constituents (1/8-inch) from CA-SRI-77, Bulk Sample 1, lower component, Santa Rosa Island, CA.

Taxon	Wt. (g)	% Wt.	MNI	% MNI [a]
Astraea undosa	0.82	0.1	1	2.8
Balanus spp.	4.67	0.7	-	-
Chione californiensis	74.54	10.6	4	11.1
Chione fluctifraga	18.86	2.7	1	2.8
Chione undatella	184.09	26.1	10	27.8
Chione spp.	45.09	6.4	1	2.8
Chiton undiff.	1.21	0.2	-	-
Clam undiff.	20.45	2.9	2	5.6
Crepidula spp.	0.26	<0.1	1	2.8
Haliotis rufescens	192.02	27.2	1	2.8
Mytilus californianus	104.74	14.8	6	16.7
Olivella biplicata	0.26	<0.1	1	2.8
Ostrea lurida	30.22	4.3	3	8.3
Tegula funebralis	4.7	0.7	2	5.6
Undiff. Nacre	6.16	0.9	-	-
Undiff. Shell	15.79	2.2	-	-
Subtotal	703.88	99.7	33	91.7
Bird Bone	1.35	0.2	1	2.8
Mammal Bone	0.62	0.1	1	2.8
Semicossyphus pulcher	0.12	<0.1	1	2.8
Undiff. Bone	0.37	0.1	-	-
Subtotal	2.46	0.3	3	8.3
Total	706.34	-	36	-

[a] Minimum Number of Individuals.

site should provide important details on the history of the Abalone Rocks Estuary and its significance to ancient human economies and settlement.

CA-SRI-84

Located on a prominent sand dune directly above the ocean, this dense, eroding shell midden is fairly well vegetated, but patches of bare sand and midden are visible across the site. A small swale separates SRI-84 from SRI-187 to the west. The mouth of Old Ranch House Canyon is also located west of the site just beyond SRI-187. freshwater is visible seeping out of the sediments immediately below the archaeological deposits at several locations.

On the surface, the shellfish assemblage appeared to be dominated by California mussel and other rocky intertidal shellfish with scattered bits of purple olive (*Olivella biplicata*) shells. Much of the deposits date to the middle and late Holocene and do not contain estuarine shellfish species. However, during excavation of Unit 2 along the eastern site margin a dense layer containing abundant Washington clams was encountered about 40 cm below the surface. Radiocarbon dating of a Washington clam shell from this level provided a conventional age of 7,750 ± 40 RYBP and a calibrated intercept of 7,960 cal BP. This is one of the oldest dates for an estuarine shell midden on Santa Rosa Island and roughly 1,000 years older than the earliest dates obtained from the cores by Cole and Liu (1994) and Anderson (2002).

Table 4. Midden constituents (1/8-inch) from CA-SRI-84, Unit 2, Stratum 2 (40–50 cm), Santa Rosa Island, CA.

Taxon	Wt. (g)	% Wt.	MNI	% MNI [a]
Balanus spp.	8.89	2.8	-	-
Crab undiff.	0.62	0.2	-	-
Mytilus californianus	192.34	61.1	26	68.4
Ostrea lurida	25.99	8.3	3	7.9
Pollicipes polymerus	0.29	0.1	-	-
Protothaca spp.	4.19	1.3	1	2.6
S. nuttali	75.91	24.1	4	10.5
Septifer bifurcatus	0.10	<0.1	1	2.6
Strongylocentrotus purpuratus	0.51	0.2	-	-
Tegula funebralis	4.33	1.4	1	2.6
Undiff. Nacre	0.59	0.2	-	-
Undiff. Shell	0.83	0.3	-	-
Subtotal	314.59	99.9	36	94.7
Bird Bone	0.04	<0.1	1	2.6
Fish Bone	0.06	<0.1	1	2.6
Undiff. Bone	0.08	<0.1	-	-
Subtotal	0.18	0.1	2	5.3
Total	314.77	-	38	-

[a] Minimum Number of Individuals.

Analysis of 315 g of shell and bone from Unit 2 (0.0063 m^3), revealed at least 10 different shellfish taxa (Table 4). About 32% of this sample by weight was made up of Washington clam and oyster, with most of the assemblage composed of California mussels and other rocky intertidal shellfish. The Washington clams and oysters were probably obtained from the nearby estuary, but Washington clams are also occasionally found in pocket beaches on the outer coast (see Table 1). The upper late Holocene deposits are dominated by

California mussel and other rocky intertidal shellfish with no estuarine taxa.

CA-SRI-191

Located on a dune about 200 m north of the Old Ranch Canyon mouth, SRI-191 contains what appear to be three shell midden components exposed in different parts of the dune. Intact shell midden caps the south and west sides of the dune, but determining the extent of these deposits is prevented by sand and vegetation cover. Along the southern portion of the dune, a discrete red abalone midden with venus and Washington clams is located slightly above the base of the dune. Red abalone middens are a unique site type with valuable paleoenvironmental implications (see Glassow 1993, Glassow et al. 1994, Sharp 2000), and the mix of estuarine taxa in a red abalone midden adds to the variability of this site type. Near the western edge of the dune is a roughly 20 cm thick midden deposit dominated by California and platform mussels, sea urchins (*Strongylocentrotus* spp.), and no estuarine taxa.

Radiocarbon dating of a frilled California venus clam shell from the red abalone midden provided a conventional age of 5,740 ± 45 RYBP and an intercept of 5,900 cal BP. This is currently the youngest dated site with estuarine shell on Santa Rosa Island, and roughly corresponds with a slowing of sea level rise in the area between about 6,000 and 5,000 years ago (see Inman 1983). A California mussel shell from the mussel and urchin deposit was dated to 4,450 ± 35 RYBP (OS-41895), with a calibrated intercept of 4,340 cal BP. This date suggests that the decline of shellfish productivity in the estuary had occurred by at least 4,300 years ago. A 0.5- x 1-m unit excavated from an eroding exposure in the red abalone lens and a bulk sample obtained from the mussel lens are currently being analyzed and should provide details on local environmental changes over this time span.

CA-SRI-192

Situated on a terrace about 125 m from the mouth of Old Ranch House Canyon overlooking the Abalone Rocks Marsh, SRI-192 extends from the canyon floor onto a plateau. A small rock shelter is positioned on the northeastern boundary of the site. Midden cascades down slope to the canyon floor, but it is difficult to determine the depth of the midden because of vegetation cover. It appears that the site may have at least two components, one containing California mussel and purple olive shells on top of the plateau and another with estuarine taxa located down slope. A small probe was excavated into intact midden deposits along the hillside. The midden in this area was at least 20 cm deep and is dominated by California oyster shells, but mixed with small amounts of California mussel. Radiocarbon dating of a complete oyster shell from this probe provided a conventional age of 6,440 ± 70 RYBP and a calibrated intercept of 6,650 cal BP. These dates again confirm the presence of the estuary during the early/middle Holocene with fairly extensive mudflats capable of supporting oysters.

CA-SRI-666 (SRI-91-15)

This large shell midden and lithic scatter sits on a low-lying terrace roughly 2–3 m high. Once covered by dune sand, much of the site now consists of a consolidated soil with scoured and cemented patches of shell and associated lithics (see Erlandson 1994, p. 192–193, Kennett 1998). The site is badly eroding and roughly elliptical in shape with its largest dimensions trending east-west. Several cemented clusters of shell midden sit in pockets roughly 1–2 m in diameter across the surface and are dominated by California mussel and smaller amounts of abalone, Washington and venus clams, and oyster. Chipped stone artifacts on the site surface are diverse with abundant metavolcanic and chert debitage and several Monterey chert bifaces. Radiocarbon dating of a Washington clam shell from these deposits produced a conventional age of 7,780 ± 70 RYBP and a calibrated intercept of 7,990 cal BP (Erlandson 1994, p. 193). This is the oldest date in our sample and is roughly contemporary with the basal occupation of SRI-84.

CA-SRI-667

This large shell midden is located in a sand dune complex near the western margins of Skunk Point about 3 km from the estuary. SRI-667 appears to have at least three components, including intact deposits capping both dunes, a middle stratum about halfway down the dune, and a lower basal component containing estuarine shell on the northern side of the site. The two upper

components are largely composed of California mussel and other rocky intertidal shellfish, with only the lowest site component containing estuarine shell. Much of the site has been deflated and a scatter of eroding shell, rock, and occasional bone fragments covers the site surface. During summer 2003, bulk samples and ^{14}C samples were obtained from the three site components. A well preserved frilled California venus clam shell from the lowest site deposit was dated to 5,990 ± 45 RYBP, with a calibrated intercept of roughly 6,180 cal BP. This ^{14}C date correlates well with the other dated components with estuarine shell, suggesting a middle and early Holocene age for the estuary. The bulk midden samples are currently being analyzed and should provide further evidence on the evolution of the estuary and marsh system and changes in human subsistence strategies.

DISCUSSION AND CONCLUSIONS

Our preliminary investigations of archaeological sites on the east coast of Santa Rosa Island document human use of the Abalone Rocks Estuary during the early and middle Holocene. The use and availability of an estuary on eastern Santa Rosa Island is unique on the Channel Islands, where rocky intertidal and kelp bed habitats dominated throughout the Holocene. The Abalone Rocks Estuary, nearby Torrey Pine grove, overall size of Old Ranch Canyon, and abundant rocky intertidal and kelp bed habitats make this area one of the most diverse and productive on the Channel Islands. The early presence of people in this region support this idea, but future work is needed to determine the nature of these sites, hypothesized to be either relatively permanent habitations or temporary encampments used by people living elsewhere on the islands.

Radiocarbon dating of estuarine shells from seven archaeological sites, along with paleoecological cores obtained from the Abalone Rocks Marsh (Cole and Liu 1994, Anderson 2002), provide a relatively detailed chronology of the history and productivity of this estuary. Our data indicate that a viable estuary with mudflats and other habitats supported three species of venus clams, oysters, and Washington clam and persisted for at least 2,100 years (8,000 to 5,900 years ago). Similar to many other early sites on the Channel Islands, these sites illustrate a subsistence focus on shellfish, with relatively limited use of fish, mammals, or birds (see Erlandson 1994, Kennett 1998, Erlandson et al. 1999). Our research on eastern Santa Rosa Island sites dated to after 5,000 years ago, including some with older estuarine components (e.g., SRI-77, -84, and -191), suggests that people focused on rocky intertidal shellfish, with little or no evidence of later use of estuarine shellfish. These data suggest that by around 6,000 to 5,000 years ago the Abalone Rocks Estuary was a less favorable habitat for estuarine shellfish and, if present, they were not collected by people in the area.

Records provided by Cole and Liu (1994) and Anderson (2002) suggest that marine conditions dominated over freshwater conditions until around 3,500 years ago. This is incongruent with the available archaeological data suggesting the extinction of the Abalone Rocks Estuary by ~5,000 cal BP. Assuming that this pattern does not result from chronological discrepancies or sampling error, we offer two alternative explanations for this inconsistency. First, the estuary may have remained open to the sea between 5,000 and 3,500 cal BP, but did not support shellfish beds because of reductions in habitat/circulation and salinity changes caused by periodic (seasonal) closure. Second, shellfish were present in the estuary during this interval but their population levels were so low (due to a combination of human predation and habitat loss) that coastal peoples turned to more economically viable alternatives (e.g., shellfish from the rocky intertidal and fish). Further archaeological and paleoenvironmental work will be required to explore these alternatives. Regardless, environmental changes in the estuary between 5,000 and 3,500 cal BP reduced its productivity, a phenomenon that is evident in many of the smaller estuaries that once punctuated the California coast (see Erlandson 1994).

The composition of estuarine taxa at the sites we investigated also varied. For example, venus clams dominated the bulk sample from SRI-77, while Washington clams were the most abundant estuarine taxa in the SRI-84 sample. Surface observations at SRI-192 suggest that oyster dominates this assemblage. The red abalone midden with scattered venus and Washington clams at SRI-191 also presented a unique mix of

estuarine and rocky intertidal taxa. Colten (1989) argued that increases in the abundance of venus clams and decreases in Washington clams in Goleta area sites may indicate changes in the size and composition of mudflats in the Goleta Slough. While such microhabitat changes may have occurred in the Abalone Rocks Estuary, additional research is needed in eastern Santa Rosa Island sites to investigate these changes.

Although our results are still preliminary in nature, they provide important data on the history and dynamics of the Abalone Rocks estuary and marsh complex. Our research joins recent studies by Jones (2002) on the archaeology of the Elkhorn Slough in central California, and work by Colten (1989), Erlandson (1985, 1994) and Glassow (1997) in sites on the mainland coast at Santa Barbara that provided insight on changing marine and estuarine ecosystems of mainland California. When used in concert with paleoecological data, these studies illustrate the importance of archaeological data for reconstructing ancient environments and landscape evolution, and for understanding human decision making under changing conditions (see van der Leeuw and Redman 2002). Future archaeological research around the ancient estuary complex should provide important information on the history and evolution of Channel Islands environments and the role of people in influencing and adapting to those changes.

ACKNOWLEDGMENTS

Our research was supported by Channel Islands National Park, the National Science Foundation, and the University of Oregon. We thank G. Hawley, A. Huston, D. Morris, and M. Senning for logistical support during our research and for supplying funds for some of the radiocarbon dates. M. Glassow and M. Hill provided comments that greatly improved the content of this manuscript. Finally, we thank D. Garcelon and C. Schwemm for editorial assistance with this manuscript.

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