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Middle Holocene Fishing and Maritime Adaptations at CA-SNI-161, San Nicolas Island, California

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Along the southern California coast, the development of intensive fishing has long been considered to be a relatively recent phenomenon. In this article, we present dietary reconstructions from CA-SNI-161, a multicomponent San Nicolas Island archaeological site occupied between about 5,400 and 2,900 years ago. We focus on the contribution of edible meat and animal protein to the diet of the islanders and examine dietary changes through time. Our dietary reconstructions suggest that fish and shellfish provided most of the meat and protein consumed at the site. Birds were of minor dietary significance and sea mammals of intermediate importance. The data suggest that at some localities along the southern California coast, relatively intensive fishing developed earlier than previously believed.

COASTLINES provide ideal situations to address questions about how people adapted to aquatic environments (Bailey and Parkington 1988). The abundance of shell middens, in particular, provides archaeological contexts conducive to the preservation of a wide range of both artifacts and ecofacts. Although the biological productivity of marine environments varies geographically and temporally (Perlman 1980; Yesner 1980), people living in coastal settings are faced with similar opportunities and challenges. From the plants and animals they harvest to the tools they use to acquire and process them, coastal people throughout the world have for millennia developed many similar methods of survival.

Along the California coast, thousands of shell mound sites offer testimony to the importance of the marine environment. Ecofacts and artifacts from such sites provide valuable data on how California's coastal environments varied through space and time—and how humans chose to adapt to such variation and dynamism. Over the years archaeologists have learned much about the lifestyles and histories of California's coastal tribes, but a tremendous amount remains to be learned. It is now

known that the southern California coast has attracted people for over 10,000 years (Jones 1991; Moss and Erlandson 1995; Erlandson et al. 1996) and a general outline of maritime cultural developments has been established. Shell midden studies have also begun to identify general patterns in the way people used various resources for food (e.g., Glassow and Wilcoxon 1988; Erlandson 1991, 1997a; Glassow 1992, 1993; Raab 1992; Colten 1993, 1995; Vellanoweth 1996), but significant spatial and temporal gaps remain in the available data. Erlandson (1994) investigated Early Holocene adaptations along the California coast, for instance, and Colten (1993, 1995) examined Late Holocene subsistence on Santa Cruz Island. Compared to the Early and Late Holocene, however, Middle Holocene cultural sequences are still poorly understood (Moss and Erlandson 1995:33; Erlandson 1997b:2). As Glassow (1997:160) recently noted:

Although we have learned a great deal about Middle Holocene cultural systems along the California coast, our overall knowledge is still meager. Comparatively few sites have witnessed more than small-scale test excavations, and the number of

sites associated with radiocarbon dates is still small. Furthermore, because of problems with identifying Middle Holocene sites . . . the nature of settlement systems remains obscure.

Some areas of the southern California coast, San Nicolas Island prominent among them, are also poorly represented in the archaeological record, leading to an incomplete picture of the diversity of maritime adaptations in the larger region. Yet another gap involves the early development of fishing strategies along the southern California coast. Erlandson (1994) and Colten (1991) have shown that fishing took place among mainland peoples during the Early and Middle Holocene, but most scholars have suggested that intensive fishing did not develop in the area until the Late Holocene (e.g., Orr 1968:100; Glassow 1980:89). Glassow's (1993) dietary study of column samples from a number of Santa Cruz Island shell middens spanning the past 7,000 years suggests that fishing did not provide a majority of the animal protein represented at these sites until after about 2,500 RCYBP. Does this pattern hold for a broader area of the southern California coast?

This article addresses these problems by presenting dietary reconstructions from the excavation of four discrete occupational components at CA-SNI-161 (the Bird Blind site), located on the northwest coast of San Nicolas Island. Using animal remains from these Middle and Late Holocene components, changes are traced in the amount of edible meat provided by four marine faunal classes: shellfish, fish, sea mammals, and birds. These data are then related to regional patterns and their possible implications are discussed. An analysis of this sort provides fundamental information on how the occupants of a site utilized the surrounding landscape. In short, the subsistence data presented here fill important gaps regarding trends in marine resource use throughout the Holocene, and specifically outline the nature of these adaptations as seen from San Nicolas Island during the Middle Holocene.

SAN NICOLAS ISLAND

Environmental Setting

San Nicolas, the outermost and most isolated of the California Channel Islands, is located about 120 km. southwest of Los Angeles and 98 km. from the nearest point on the mainland (Fig. 1). The island, only about 13 km. long by 3.7 km. wide (58 km.²), lies about equidistant from the northern Channel Islands and the more dispersed southern Channel Islands of Santa Catalina and San Clemente. Little Santa Barbara Island lies to the northeast and may have served as a stopping point for voyages between San Nicolas and the other islands and/or the mainland.

San Nicolas Island is composed primarily of uplifted Eocene sandstones and shales modified by marine erosion that formed several Pleistocene terraces (Meighan and Eberhart 1953; Vedder and Norris 1963). Topographically, the island is dominated by a low (276 m. maximum elevation), wind-swept plateau surrounded by escarpment slopes, narrow coastal plains, and mosaics of sandy and rocky beaches. Eolian activity continues to shape the sand dunes that cover much of the island. The island vegetation is sparse and plant diversity is low, with few edible endemic species (Junak and Vanderwier 1988). Other than humans, only six land animals are native to San Nicolas Island: the island fox (*Urocyon littoralis*), the white-footed deer mouse (*Peromyscus maniculatus*), the island night lizard (*Xantusia riversiana*), the southern alligator lizard (*Elgaria multicarinata*), the side-blotched lizard (*Uta stansburiana*), and the land snail (*Micrarionta* sp.).

Six species of pinnipeds inhabit the coast, including California sea lions (*Zalophus californianus*) and northern elephant seals (*Mirounga angustirostris*), which breed on the island today. Harbor seals (*Phoca vitulina*), sea otters (*Enhydra lutris*) and both large and small cetaceans can also be found in waters around the island. Western gulls (*Larus occidentalis*) and Brandt's cormorants (*Phalacrocorax penisillatus*) breed on the island

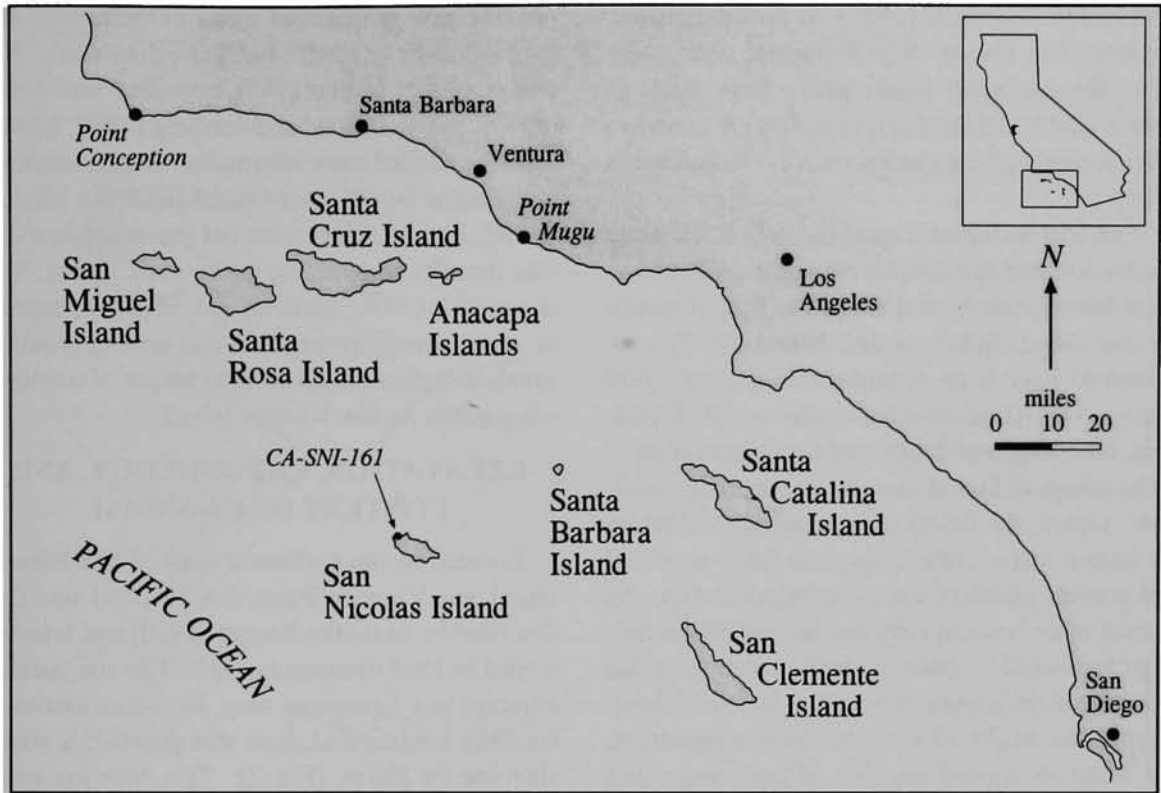


Fig. 1. The location of San Nicolas Island and CA-SNI-161.

and many other seabirds feed on the rich marine life offshore. Kelp beds are abundant, providing rich habitat for an array of fish, sea mammals, and some shellfish. The island is ringed by sandy bottom and rocky intertidal shores that are home to a variety of economically important marine plant, shellfish, and fish species.

Cultural and Archaeological Background

At the time of European contact (ca. A.D. 1542 to 1800), San Nicolas Island was occupied by people who are sometimes referred to as the Nicoleño, Uto-Aztecan speakers related to the Gabrielino (Tongva or Kumivit) Indians of the Los Angeles Basin area. Except for the famous "lone woman" of San Nicolas Island, the Nicoleño were removed to the mainland in A.D. 1835. According to Bean and Smith (1978:539-540; also see McCawley 1996), San Nicolas Island was called Sonygna by the Gabrielino, and the island population may have

ranged between about 600 and 1,200 people during the centuries prior to Spanish conquest. Unfortunately, historical and ethnographic accounts of the Nicoleño are extremely rare, leaving archaeology and biological anthropology as virtually the only means to gain a detailed understanding of the history and adaptations of these maritime peoples.

Systematic archaeological research on San Nicolas Island began only 35 years ago, although casual explorations by antiquarians began as early as the late 1800s (Schwartz and Martz 1992). In the 1950s, Meighan and Eberhart (1953) conducted a brief survey of the island that set the stage for more sophisticated and specialized investigations carried out by archaeologists from California State University, Los Angeles (CSULA), and other institutions. Reinman and Townsend (1960) conducted work on San Nicolas Island burials, Gloria Lauter (1982) on cultural chronologies, Joyce Clevenger (1982) on lithic artifacts, and Dana Bleitz-Sanburg

(1987) and Roy Salls (1988) on faunal remains. Evidence has shown that the largest sites occur along the northwest coast, where fresh water is most available and there is relatively easy access to rich intertidal and kelp bed resources (Vellanoweth 1996).

San Nicolas Island is an ideal place to examine the development of intensive maritime adaptations. Over 500 archaeological sites have been recorded on the island (Schwartz and Martz 1992), now known to have been occupied for at least 7,000 years. The island contains numerous shell middens, both large and small, and the preservation of archaeological faunal remains is generally excellent. Due to the dearth of burrowing animals on the island, many of these sites are finely stratified and provide excellent stratigraphic resolution. As a result of the low diversity and limited productivity of terrestrial resources, marine foods provided the bulk of the human diet on San Nicolas Island. Despite the wealth of available marine resources, the isolation, limited supplies of fresh water and fuel, strong winds, and poor quality lithic sources of the island combined to make survival a challenge.

Until recently, there was relatively little detailed quantitative information available on the nature of maritime subsistence on San Nicolas Island. Integrated dietary analyses, in which the economic significance of all faunal classes represented at a site are evaluated together, have been especially rare. Reinman (1964) examined some general patterns in marine resource use on San Nicolas Island, but his study predated the development of systematic recovery techniques and was based primarily on qualitative data. Salls (1988) incorporated San Nicolas Island data into his analysis of prehistoric fishing along the southern California coast, and Bleitz-Sanburg (1987; see also Bleitz 1993) analyzed sea mammal and bird remains from CA-SNI-11. Goldberg (1993) analyzed the isotopic composition of 19 San Nicolas Island human skeletons from CA-SNI-16 (ca. 3,300 RCYBP) and CA-SNI-40 (ca. 4,000 RCYBP), but such analyses

provide only generalized views of the human diet over a decade or more of an individual's life. Recent reports by Martz (1994), Rosenthal and Padon (1995), and Rosenthal and Jertberg (1997, 1998a, 1998b) provided some information on systematically collected faunal assemblages from San Nicolas Island, but their data were not presented in a format directly comparable to our own. Thus, Vellanoweth's (1996) study of CA-SNI-161, aspects of which are summarized in this article, provided invaluable data on the general nature of maritime adaptations on San Nicolas Island.

EXCAVATION, CHRONOLOGY, AND CONTEXT OF CA-SNI-161

Located on the northwest coast of San Nicolas Island near Vizcaino Point, CA-SNI-161 was first described by Malcolm Rogers (1930) and later recorded by Fred Reinman in 1984. The site, located adjacent to a freshwater seep, lies on an east-west trending longitudinal dune that parallels a rocky shoreline for 200 m. (Fig. 2). This dune has accumulated on a Pleistocene terrace fronted by a 10 m. high sea cliff. The crest of the dune is stabilized by vegetation, but the slopes are covered with deflated shell midden debris.

Investigation of CA-SNI-161 was conducted between 1991 and 1993 by archaeologists from CSULA (Vellanoweth 1996). The site was excavated to mitigate the effects of constructing a bird blind for biological observations on the site. In 1991, the placement of Units 1, 2, and 3 was dictated by construction plans for the blind. In 1992, two more test units (4 and 5) were excavated, followed by Unit 6 in 1993. All test units were 1.5 m. x 1.5 m. wide and excavated stratigraphically, using 10-cm. levels within strata. To help define the internal structure of the site, 28 auger holes were excavated along the top of the dune and in three north-south transects perpendicular to the crest. All excavated sediments were dry-screened in the field over 1/8-in. mesh, minimally sorted, then transported to the environmental laboratory on San Nicolas Island. All residuals were then wet-

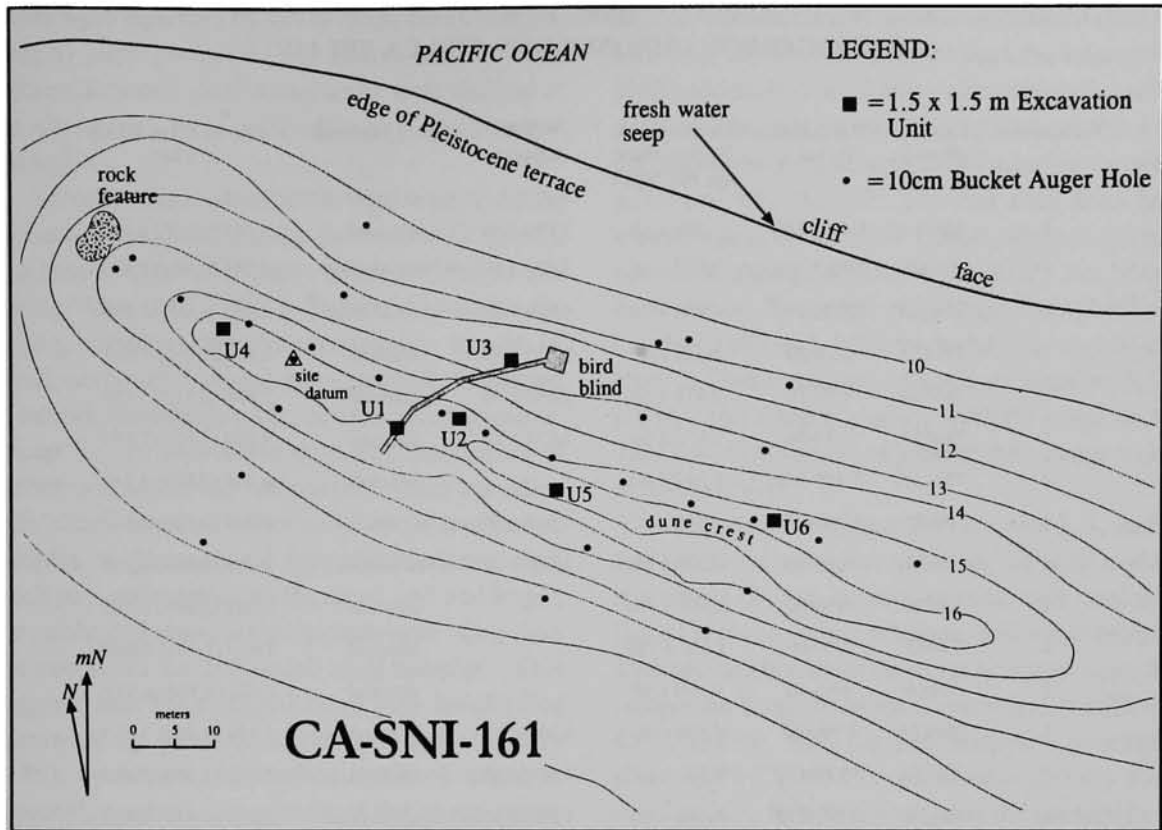


Fig. 2. Map of CA-SNI-161, showing placement of test units.

screened, dried, weighed, and further screened over a series of graduated sieves. All recovered faunal remains were then sorted to the lowest taxon identifiable, weighed, and catalogued.

The six test units produced over 53 kg. of marine shell and more than 5.4 kg. of bone. While shellfish, mammal, and bird remains have been analyzed in detail (Vellanoweth 1996), identification of fish bones (other than otoliths) is not yet complete. For this article, we use the raw shell and bone weights for the major shellfish taxa and marine vertebrate classes (fish, sea mammals, sea birds) to estimate the edible meat and protein yields of the faunal remains from CA-SNI-161.

Analysis of CA-SNI-161 demonstrated that it is a complex, multicomponent shell midden, with four discrete occupations radiocarbon dated to between about 5,400 and 2,900 calendar years before present (CYBP; Table 1). In the central site area,

these deposits are characterized by excellent stratigraphic integrity. The linear dune crest contained the largest concentration of intact cultural deposits, probably because relatively thick vegetation protects the dune from wind and water erosion. Analysis of the shellfish assemblage showed that the Middle Holocene shoreline in the site vicinity was dominated by rocky coastline. The overall assemblage was dominated by the rock-perching taxa, especially black abalone (*Haliotis cracherodii*), red abalone (*H. rufescens*), sea urchin (*Strongylocentrotus* sp.), and turban (*Tegula* sp.), with smaller amounts of California mussel (*Mytilus californianus*), platform mussel (*Septifer bifurcatus*), owl limpet (*Lottia gigantea*), and a few other taxa in minor quantities (see Vellanoweth 1996). As expected, the 5.43 kg. of bone recovered is dominated by the remains of marine vertebrates—including 4.15 kg. of fish bone, 1.23 kg. of sea mammal

Table 1
RADIOCARBON CHRONOLOGY FOR CA-SNI-161^a

| Component | Lab No. (Beta-) | Unit/Level (in cm.) | Uncorrected Radiocarbon Age (RCYBP) | ¹³ C/ ¹² C Adjusted | Dated Material | Calibrated Age Range (CYBP) |
|-----------|--------------------|------------------------|---|--|-----------------------|----------------------------------|
| 4 | 78668A | 5/92.5-100 | 2,880 ± 60 | 2,890 ± 60 | charcoal | 3,085 (2,980) 2,930 |
| 4 | 78669 | 5/92.5-100 | 2,970 ± 60 | 3,420 ± 60 | black abalone | 3,085 (2,975) 2,880 |
| 4? | 78670A | 5/100-110 | 4,850 ± 80 | 4,870 ± 80 | charred wood | 5,665 (5,605) 5,580 |
| 3 | 78662A | 2/20-30 | 3,520 ± 60 | 3,520 ± 60 | charcoal | 3,700 (3,760) 3,860 ^b |
| 3 | 78664A | 4/10-20 | 3,470 ± 50 | 3,490 ± 50 | charcoal | 3,840 (3,715) 3,680 |
| 3 | 78665A | 4/40-50 | 3,650 ± 60 | 3,670 ± 60 | charcoal | 4,080 (3,975) 3,895 |
| 3 | 78671A | 5/180-190 | 3,540 ± 60 | -- | charcoal | 3,895 (3,840) 3,715 |
| 3 | 78672 | 5/180-190 | 3,560 ± 70 | 4,010 ± 70 | red abalone | 3,825 (3,700) 3,610 |
| 3 | 78673 | 6/40-50 | 3,520 ± 60 | 3,960 ± 70 | red abalone | 3,735 (3,645) 3,555 |
| 3 | 78674 | 6/50-60 | 3,540 ± 100 | -- | charcoal | 3,925 (3,835) 3,685 |
| 2 | 78663 | 2/50-60 | 4,030 ± 100 | -- | charcoal | 4,410 (4,475) 4,800 ^b |
| 2 | 78666 | 4/60-70 | 4,160 ± 90 | -- | charcoal | 4,835 (4,760) 4,535 ^b |
| 1 | 78667A | 4/90-100 | 4,540 ± 60 | 4,550 ± 60 | charcoal | 5,310 (5,290) 5,055 |
| 1 | 78675A | 6/120-130 | 4,540 ± 60 | 4,580 ± 60 | charcoal | 5,315 (5,300) 5,080 |
| 1 | 78676 | 6/120-130 | 4,480 ± 70 | 4,940 ± 70 | black abalone | 5,035 (4,920) 4,835 |
| 1 | 78677A | 6/120-130 | 4,780 ± 60 | 5,210 ± 60 | OGR bead ^c | 5,415 (5,300) 5,255 |
| 1 | 78678A | 6/130-140 | 4,530 ± 40 | 4,560 ± 40 | charcoal | 5,305 (5,290) 5,080 |
| 1 | 78679 | 6/130-140 | 4,480 ± 80 | 4,940 ± 80 | black abalone | 5,045 (4,920) 4,830 |
| 1 | 78680A | 6/140-150 | 4,550 ± 60 | 4,570 ± 60 | charcoal | 5,315 (5,295) 5,070 |
| 1 | 78681 | 6/140-150 | 4,600 ± 70 | 5,050 ± 70 | black abalone | 5,250 (5,065) 4,975 |

^a All samples were calibrated by Beta Analytic using the Pretoria Calibration Procedure program (Vogel et al. 1993). All marine shell samples and most charcoal samples were adjusted for ¹³C/¹²C ratios to compensate for the differential uptake of carbon isotopes (isotopic fractionation). Marine shell samples were calibrated using a deltaR value of -225 ± 35 years for the effects of the local marine reservoir effect (see Stuiver et al. 1986). All lab numbers ending with A were analyzed via Accelerator Mass Spectrometry (AMS). Beta-78670 may have been contaminated by asphaltum or the old wood problem.

^b Calendar dates with multiple midpoint intercepts on the calibration curves.

^c OGR bead = *Olivella* Grooved Rectangle bead (per Bennyhoff and Hughes 1987:141-142).

bone, and 50.7 g. of seabird bone. Analysis of 173 otoliths suggests that a variety of surfperches (*Embiotocidae*) and rockfish (*Sebastes* sp.) were taken by the site occupants, along with sheephead (*Semicossyphus pulcher*) and combfish (*Zaniolepis frenata*). Seasonality data, mostly from otolith growth ring analysis, suggest that the site was occupied primarily during spring and fall, with little evidence

for occupation during midsummer and midwinter (Vellanoweth 1996:155).

Stratigraphy and Chronology

The stratigraphy of CA-SNI-161 consisted of layers of windblown dune sand punctuated by several weakly developed but anthropically enriched soil horizons. In most instances, shell midden de-

posits were separated by sterile dune sands that appear to mark periods of site abandonment. Four discrete archaeological components were defined at the site, which were referred to as Components 1 through 4.

Twenty radiocarbon dates were used to define an occupational chronology for the site (Table 1), expressed in calendar years after calibration following Vogel et al. (1993). Before submission for dating, charcoal samples (consisting mostly of small, carbonized twigs) were carefully examined to remove asphaltum, roots, or other contaminants. Except for one anomalous date on a small piece of carbonized wood, the radiocarbon dates are internally consistent and coherent. For all five paired samples of charcoal and unmodified marine shell (each pair collected from the same unit and level), the calibrated charcoal midpoints were older than the midpoints for associated shell samples. This suggests that the charcoal dates may be affected somewhat by the "old wood" problem (Schiffer 1986), by which radiocarbon dates on wood or charcoal measure the growth of the wood rather than its use by humans. The midpoints for the five paired charcoal dates range between 0 and 380 years too old, with an average offset of +211 years, suggesting that some of the charcoal samples may have included fragments of older burned driftwood. Some variation between shell and charcoal dates could also be due to random counting errors in the laboratory or to temporal fluctuations in the local marine reservoir effect (see Erlandson et al. 1996; Kennett et al. 1997).

The radiocarbon chronology and site stratigraphy suggest that the site was occupied three times during the Middle Holocene and once more early in the Late Holocene, between about 5,400 and 2,900 CYBP. The earliest occupation, referred to as Component 1, was identified in the deepest levels in Units 4 and 6. Approximately 1.65 m.³ of this shell midden deposit were excavated. It was marked by a silty sand matrix intermixed with shell, bone, charcoal, asphaltum, and stone artifacts. The strata above and below this

deposit were essentially devoid of cultural material and their texture was coarser than the intervening shell midden matrix. Eight calibrated radiocarbon dates on charcoal and shell samples from this lowest component have midpoints ranging between 5,300 and 4,920 CYBP. The four shell dates have a mean age of about 5,050 CYBP, while four charcoal dates average about 5,290 CYBP. An *Olivella* Grooved Rectangle bead (see Bennyhoff and Hughes 1987:141-142) from the 120- to 130-cm. level in Unit 6 yielded one of two dates of 5,300 CYBP, and a black abalone from the same unit at the 130- to 140-cm. level yielded the youngest date at 4,920 CYBP.

Component 2 was identified in Units 2, 4, and 6, and produced a volume of 0.9 m.³ of shell midden in a matrix of dark, greasy, organic-rich sand with faunal remains, stone artifacts, and bead detritus. Two radiocarbon dates on wood charcoal from this component range between about 4,835 CYBP and 4,410 CYBP, with the two midpoints averaging about 4,620 CYBP. The calibrated midpoints differ by 285 years, however, and given the possibility of an "old wood" effect, the younger date may most accurately estimate the age of this component. In Unit 4, Component 2 was clearly separated from Component 1 by sterile sands about 20 cm. thick and from Component 3 by sands about 30 cm. thick. In Unit 2, Components 2 and 3 merged together and could not be separated effectively in the field. It appears that site soil formed continuously in this part of the site for over a millennium, with cultural debris from two separate components deposited and mixed on the same surface.

Deposits associated with Component 3 were found in Units 2, 4, 5, and 6. A total of approximately 1.8 m.³ of this shell midden was excavated, more than any other component at CA-SNI-161. Although the stratigraphic boundaries of Components 2 and 3 in Unit 2 were difficult to determine in the field, radiocarbon dates suggest that the upper 40 cm. of this unit were associated with Component 3. In Unit 4, Component 3 was the uppermost stratum in the unit and its matrix was a very

dark, silty sand in which shell, bone, stone, and charcoal were densely mixed. Wood charcoal from a fire pit encountered 40 to 50 cm. deep in Unit 4 was dated to 3,975 CYBP, with a calibrated range of 4,080 to 3,895 CYBP. Little cultural refuse was associated with this fire pit. Four other samples from Units 5 and 6, all associated with higher densities of cultural material, range in age between about 3,555 and 3,925 CYBP, with two shell dates averaging about 3,670 CYBP.

Component 4 was identified only in Unit 5, located on the highest crest of the dune in the central site area. From this component, only 0.6 m.³ of sediments were excavated. Once again, the matrix was a dark, silty sand mixed with shell, lithics, charcoal, and abundant bone. Two radiocarbon samples from Component 4, one wood charcoal and one black abalone shell, produced very similar calibrated midpoints of 2,980 CYBP and 2,975 CYBP, respectively. This suggests that the site was briefly occupied early in the Late Holocene, then abandoned.

DIETARY RECONSTRUCTIONS

Methods

To understand broad patterns of human subsistence at CA-SNI-161, it is necessary to convert raw faunal data into more meaningful units of analysis (Osborn 1977:145; Erlandson 1994). To do this, we chose the weight method to convert dry shell and bone weights into estimated meat yields using a series of conversion factors established by previous researchers (Table 2). Our conversions are based on general faunal data presented by Vellanoweth (1996), supplemented with specific mammalian identifications by Judith Porcasi of the Zooarchaeology Laboratory at the University of California, Los Angeles.

Dietary reconstruction via weight method conversions, like other zooarchaeological measures, is subject to a variety of problems (see Lyman 1982: 359-363; Klein and Cruz-Urbe 1984:26-29; Erlandson 1994:57-58; Mason et al. 1998). For

southern California shell middens, however, which often contain relatively large amounts of heavily fragmented and unidentifiable bone, Erlandson (1994:111) argued that the systematic use of the weight method can provide valuable data on the relative importance of various classes of fauna at a site and on subsistence variation between sites. Recently, a growing number of archaeologists working on the southern California coast have used such methods to identify evidence for spatial and temporal variations in faunal use patterns (e.g., Peterson 1984; Glassow and Wilcoxon 1988; Erlandson 1991, 1997a; Glassow 1992, 1993; Colten 1993, 1995; Vellanoweth 1996). It should be emphasized, however, that the dietary reconstructions for CA-SNI-161 are general approximations of the nutritional yield of the major classes of faunal remains recovered from each component, estimates subject to a variety of sources of error.

Despite these cautionary notes, this method of dietary conversion effectively illustrates a number of methodological problems encountered in traditional shell midden analyses. In analyzing faunal assemblages from California shell middens, for instance, different researchers generally analyze different classes of faunal remains (shell, fish, bird, mammal, etc.), often using different quantitative measures (MNI, NISP, weights). Therefore, the results of various faunal studies are often not directly comparable and are seldom integrated into any coherent picture of the overall diet or economy for a given site. In contrast, integrated studies of faunal remains using the weight method provide general measures of the relative importance of various types of animals within a stratum, between strata within a single site, or between sites within a region. Our reconstructions also illustrate how dry shell and bone weights bias perceptions of the dietary importance of various animal resources. Shellfish, for instance, make up over 92% of the total weight of the analyzed faunal remains from CA-SNI-161, but contribute only about one-third of the estimated protein yields. Conversely, fish bone comprises only about 6% of the total faunal

Table 2
MULTIPLIERS USED IN DIETARY
RECONSTRUCTION AT CA-SNI-161

| Faunal Taxon | Meat | Protein | Primary Reference |
|--|-------|---------|------------------------------------|
| black abalone (<i>Haliotis cracherodii</i>) | 1.36 | 0.187 | Koloseike 1969 |
| red abalone (<i>H. rufescens</i>) | 1.36 | 0.187 | Koloseike 1969 |
| owl limpet (<i>Lottia gigantea</i>) | 1.36 | 0.178 | Tartaglia 1976 |
| California mussel (<i>Mytilus californianus</i>) | 0.298 | 0.144 | Erlandson 1994:59 |
| platform mussel (<i>Septifer bifurcatus</i>) | 0.364 | 0.144 | Erlandson 1994:59 |
| sea urchin (<i>Strongylocentrotus</i>) | 0.583 | 0.109 | Kato and Schroeter 1985; Moss 1989 |
| turbans (<i>Tegula</i>) | 0.365 | 0.203 | Erlandson 1994:59 |
| limpets (Acmaeadae) | 0.308 | 0.143 | Erlandson 1988a |
| other shell ^a | 0.308 | 0.143 | Tartaglia 1976 |
| bird | 15.0 | 0.210 | Ziegler 1975 |
| fish | 27.7 | 0.185 | Tartaglia 1976 |
| sea mammal | 24.2 | 0.100 | Glassow and Wilcoxon 1988 |

^a Small shell fragments, mostly of limpets.

weight, but provides almost 60% of the overall protein yield.

Component 1

For Component 1, over 23 kg. of shell and bone were used to reconstruct the general patterns of faunal exploitation during the occupation of CA-SNI-161 ca. 5,300 years ago (Table 3). Our dietary reconstruction suggests that fish provided most (48%) of the animal meat represented in the sample, shellfish about 40%, with sea mammals (14%) and birds (0.3%) being supplemental and minor resources, respectively. Among the shellfish, black abalone dominated the sample, providing almost 30% of all edible meat and over 75% of the shellfish meat represented. Once again, this analysis clearly illustrates the utility of meat weight conversions as more realistic approximations of dietary importance than shell or bone weights alone. Here, sea urchin constituted 29% of the total shell and bone weight, but provided less than 5% of the

total estimated protein yield. Among the mammalian bones recovered, about 7% were sea otter,¹ 2% cetaceans, and the remainder either pinnipeds or undifferentiated mammals assumed to be of marine origin.

Component 2

For Component 2, deposited between about 4,500 and 4,700 years ago, the dietary reconstruction is based on the 9.7 kg. of shell and bone recovered (Table 4). Fish comprised 68% of the estimated edible meat yield, shellfish about 18%, sea mammals roughly 13%, and birds 1%. Once again, black abalone dominated the shellfish economy, providing over 60% of the estimated shellfish meat yield. Sea urchin provided roughly 22% of the edible shellfish meat, turbans about 6%, and limpets about 5%. Among the mammalian remains recovered, about 20% was identified as sea otter, 15% as cetaceans, and the rest as either pinnipeds or undifferentiated mammals of assumed marine origin.

Table 3
ESTIMATED DIETARY YIELDS FOR COMPONENT 1
FAUNAL SAMPLE AT CA-SNI-161

| Faunal Taxon | Shell or Bone | | Meat Yield | | Protein Yield | |
|-------------------|-----------------|-----------|-----------------|-----------|----------------|-----------|
| | Wt. (g) | % | Wt. (g) | % | Wt. (g) | % |
| black abalone | 12,093.2 | 52.2 | 16,446.7 | 28.5 | 3075.5 | 31.7 |
| red abalone | 84.9 | 0.4 | 115.5 | 0.2 | 21.6 | 0.2 |
| owl limpet | 308.4 | 1.3 | 419.4 | 0.7 | 74.7 | 0.8 |
| California mussel | 112.7 | 0.5 | 33.6 | 0.1 | 4.8 | <0.1 |
| platform mussel | 14.1 | 0.1 | 5.1 | <0.1 | 0.7 | <0.1 |
| sea urchin | 6,710.4 | 29.0 | 3,912.2 | 6.8 | 426.4 | 4.4 |
| turbans | 1,647.4 | 7.1 | 601.3 | 1.0 | 122.1 | 1.3 |
| limpets | 51.5 | 0.2 | 15.9 | <0.1 | 2.3 | <0.1 |
| other shell | 797.1 | 3.4 | 245.5 | 0.4 | 35.1 | 0.4 |
| bird | 11.7 | 0.1 | 175.5 | 0.3 | 36.8 | 0.4 |
| fish | 987.4 | 4.3 | 27,351.0 | 47.5 | 5,059.9 | 52.2 |
| sea mammal | 342.5 | 1.5 | 8,288.5 | 14.4 | 828.8 | 8.5 |
| Totals | 23,161.3 | -- | 57,610.2 | -- | 9,688.7 | -- |

Component 3

In Component 3, dated between about 4,200 and 3,800 CYBP, a faunal sample of over 29.8 kg. was available. The dietary reconstruction for this sample suggests that shellfish provided about 54% of the estimated edible meat yield during this occupation (Table 5). According to our figures, fish and sea mammals each provided about 22% of the edible flesh represented. Among the mammalian remains, only about 3% are from sea otter, less than 1% from cetaceans, and the others are from pinnipeds or undifferentiated marine mammals. Due to the high percentage of blubber that pinnipeds contain relative to protein, fish may have provided almost twice as much protein to the overall diet. Once again, birds represent less than 1% of the estimated dietary yields.

Black abalone continues to be relatively important but red abalone dominated the shellfish assemblage from Component 3. Our reconstructions suggest that red abalone provided more than one-third of the edible meat represented in the total fau-

nal sample and almost two-thirds of the shellfish meat yields. Black abalone (23%), sea urchin (4.8%), limpets (2.2%), mussels (2.0%), and turbans (1.9%) provided the rest of the shellfish meat procured by the site occupants. The dominance of red abalone in Component 3, along with its minimal contribution in all other components at CA-SNI-161, suggests that a cool water interval may have occurred around 4,000 years ago, shifting the normally subtidal range of red abalone into the intertidal zone.² This phenomenon is well documented for certain periods on the northern Channel Islands (see Glassow et al. 1994). It is also possible, however, that the abundance of red abalone in Component 3 is related to a general diversification of shellfish exploitation, which may have included diving for subtidal red abalone.

Component 4

For Component 4, dated between about 3,000 and 3,100 years ago, 9.27 kg. of shell and bone were used to estimate the diet of the site occupants

Table 4
ESTIMATED DIETARY YIELDS FOR COMPONENT 2
FAUNAL SAMPLE AT CA-SNI-161

| Faunal Taxon | Shell or Bone | | Meat Yield | | Protein Yield | |
|-------------------|----------------|-----------|-----------------|-----------|----------------|-----------|
| | Wt. (g) | % | Wt. (g) | % | Wt. (g) | % |
| black abalone | 3,251.2 | 34.0 | 4,421.6 | 11.2 | 826.8 | 12.2 |
| red abalone | 91.7 | 1.0 | 124.7 | 0.3 | 23.3 | 0.3 |
| owl limpet | 262.3 | 2.7 | 356.7 | 0.9 | 63.5 | 0.9 |
| California mussel | 111.2 | 1.2 | 33.1 | <0.1 | 4.8 | <0.1 |
| platform mussel | 444.6 | 4.6 | 161.8 | 0.4 | 23.3 | 0.3 |
| sea urchin | 2,711.2 | 28.3 | 1,580.6 | 4.0 | 172.3 | 2.5 |
| turbans | 1,250.2 | 13.1 | 456.3 | 1.2 | 92.6 | 1.4 |
| limpets | 58.1 | 0.6 | 17.9 | <0.1 | 2.6 | <0.1 |
| other shell | 177.3 | 1.9 | 54.6 | 0.1 | 7.8 | 0.1 |
| bird | 26.3 | 0.3 | 394.5 | 1.0 | 82.8 | 1.2 |
| fish | 965.8 | 10.1 | 26,752.7 | 67.6 | 4,949.2 | 73.1 |
| sea mammal | 215.5 | 2.2 | 5215.1 | 13.2 | 521.5 | 7.7 |
| Totals | 9,565.4 | -- | 39,569.6 | -- | 6,770.5 | -- |

(Table 6). Conversion of these faunal remains to estimated meat yields suggests that fish provided about 84% of the meat represented by the faunal sample, with shellfish contributing about 10%, sea mammals about 6%, and birds less than 1%. Black abalone was the most important shellfish harvested, providing about 58% of all edible shellfish meat, with sea urchin (23%), turbans (14%), and limpets (8%) of progressively lesser importance. Of the mammalian remains, no cetacean bones were identified, but about 33% were sea otter, and the rest were identified as pinniped or undifferentiated mammal.

DISCUSSION

The integrated dietary reconstructions discussed above for four components at CA-SNI-161 suggest that San Nicolas islanders relied almost entirely on marine resources between about 5,300 and 3,000 CYBP. By combining reconstructions for all four site components, a general picture

emerges of the way humans adapted to the island environment during the latter portion of the Middle Holocene. Overall, fish was the most important source of animal protein, accounting for about 54% of all meat represented in the excavated samples. Shellfish, especially black abalone, provided roughly 32% of the meat, sea mammals about 14%, and birds less than 1%. The dominance of marine resources throughout the CA-SNI-161 sequence is consistent with our expectations given the impoverished terrestrial flora and fauna of San Nicolas Island and its isolation from other sources of terrestrial foods. It is also consistent with Goldberg's (1993) isotopic analysis of 19 human skeletons from San Nicolas Island dated between about 3,300 and 4,000 RCYBP, which suggested a diet very high in marine resources. The presence of some ground stone tools at CA-SNI-161 could indicate a reliance on plant foods, but such tools reportedly were used on San Nicolas Island to process abalone as well (e.g., Meighan and Eberhart 1953:113).

Table 5
ESTIMATED DIETARY YIELDS FOR COMPONENT 3
FAUNAL SAMPLE AT CA-SNI-161

| Faunal Taxon | Shell or Bone | | Meat Yield | | Protein Yield | |
|-------------------|-----------------|-----------|-----------------|-----------|----------------|-----------|
| | Wt. (g) | % | Wt. (g) | % | Wt. (g) | % |
| black abalone | 5,371.4 | 18.0 | 7305.1 | 12.6 | 1,366.1 | 14.4 |
| red abalone | 15,119.6 | 50.7 | 20,562.7 | 35.5 | 3,845.2 | 40.5 |
| owl limpet | 455.5 | 1.5 | 619.5 | 1.1 | 110.3 | 1.2 |
| California mussel | 804.2 | 2.7 | 239.6 | 0.4 | 34.5 | 0.4 |
| platform mussel | 1,061.6 | 3.6 | 386.4 | 0.7 | 55.6 | 0.6 |
| sea urchin | 2,599.9 | 8.7 | 1,515.7 | 2.6 | 165.2 | 1.7 |
| turbans | 1,644.4 | 5.5 | 600.2 | 1.0 | 121.8 | 1.3 |
| limpets | 232.8 | 0.8 | 71.7 | 0.1 | 10.2 | 0.1 |
| other shell | 1,513.0 | 5.1 | 466.0 | 0.8 | 66.6 | 0.7 |
| bird | 11.8 | <0.1 | 177.0 | 0.3 | 37.2 | 0.4 |
| fish | 463.5 | 1.6 | 12,839.0 | 22.2 | 2,375.2 | 25.0 |
| sea mammal | 540.7 | 1.8 | 13,084.9 | 22.6 | 1,308.5 | 13.8 |
| Totals | 29,818.4 | -- | 57,867.8 | -- | 9,496.3 | -- |

The overall dietary importance of fish, and especially its dietary dominance in Middle Holocene Component 2, is somewhat surprising. In fact, our reconstructions, based on the analysis of faunal remains recovered in 1/8-in. screens, may actually underestimate the importance of fish, since fish bones are the class of faunal remains most susceptible to loss in such screens (Erlandson 1994:112). Nevertheless, the importance of fish at CA-SNI-161 suggests that by at least 5,000 years ago, some southern California coastal groups had intensified their fishing activities to a level previously thought to be reserved for Late Holocene groups (Rick and Glassow 1999). Less surprising, perhaps, is the heavy reliance on fish in Component 4 about 3,000 years ago, since single-piece, curved (circular or j-shaped) fishhooks are known to have been used by about this time (Strudwick 1985; Koerper et al. 1988, 1995), an innovation that is thought to have increased the productivity of fishing significantly. Although the number of fishing implements recovered at CA-SNI-161 is too small

to be confident of the time when curved fishhooks were first used by the site occupants, it may be significant that the one example comes from Component 4 (Vellanoweth 1996). The earlier components produced only bone gorges.

Given the well-documented importance of shellfish to Early Holocene peoples of the southern California coast (Erlandson 1988b, 1991, 1994), the importance of shellfishing at CA-SNI-161 comes as no surprise. In two of the three Middle Holocene components, shellfish collecting appears to have been a major part of the site economy and probably represented a dietary staple. Only in Component 3, however, do shellfish appear to have provided a majority of the meat procured or consumed by the site occupants. The overall importance of shellfish seems to be consistent with Goldberg's (1993:132) suggestion that heavy shellfish consumption may account for the somewhat enriched carbon and nitrogen isotope values documented for Middle Holocene San Nicolas islanders.

Throughout the occupation of CA-SNI-161, sea

Table 6
ESTIMATED DIETARY YIELDS FOR COMPONENT 4
FAUNAL SAMPLE AT CA-SNI-161

| Faunal Taxon | Shell or Bone | | Meat Yield | | Protein Yield | |
|-------------------|----------------|-----------|-----------------|-----------|-----------------|-----------|
| | Wt. (g) | % | Wt. (g) | % | Wt. (g) | % |
| black abalone | 2,255.7 | 24.3 | 3,067.7 | 5.4 | 573.7 | 5.6 |
| red abalone | 27.1 | 0.3 | 36.9 | 0.1 | 6.9 | <0.1 |
| owl limpet | 346.4 | 3.7 | 471.1 | 0.8 | 83.9 | 0.8 |
| California mussel | 84.0 | 0.9 | 25.0 | 0.1 | 3.6 | <0.1 |
| platform mussel | -- | -- | -- | -- | -- | -- |
| sea urchin | 2,262.4 | 24.4 | 1,319.0 | 2.3 | 143.8 | 1.4 |
| turbans | 2,200.2 | 23.7 | 803.1 | 1.4 | 163.0 | 1.6 |
| limpets | 23.2 | 0.3 | 7.1 | <0.1 | 1.0 | <0.1 |
| other shell | 201.9 | 2.2 | 62.2 | 0.1 | 8.9 | 0.1 |
| bird | 0.9 | <0.1 | 13.5 | <0.1 | 2.8 | <0.1 |
| fish | 1,733.6 | 18.7 | 48,020.7 | 84.2 | 8,883.8 | 87.2 |
| sea mammal | 131.2 | 1.4 | 3,175.0 | 5.6 | 317.5 | 3.1 |
| Totals | 9,266.6 | -- | 57,001.3 | -- | 10,188.9 | -- |

mammals appear to have been a relatively minor source of protein, never comprising more than about 14% of the animal protein represented in the analyzed samples. However, this may underrepresent the overall strategic importance of sea mammals, since they may also have provided considerable amounts of edible blubber, as well as valuable nonfood products such as fuel oil, hides for clothing and shelter, and bone for tools and shelter. Nonetheless, our reconstruction suggests that sea mammals were a supplemental resource for the occupants of CA-SNI-161, at least during those seasons that they lived at the site. As is the case with other San Nicolas Island sites, the low incidence of sea mammal and bird remains may reflect the more incidental capture of such animals (Bleitz-Sanburg 1987). This faunal pattern is consistent with technological evidence: a few projectile points were recovered at CA-SNI-161, but no evidence for a specialized sea mammal or bird hunting technology was found (see also Bleitz 1993:520). The increas-

ing density of sea otter remains in the single Late Holocene Component 4 is also consistent with patterns identified at CA-SNI-11 (Bleitz 1993) and other coastal California sites.

CONCLUSIONS

In a broad sense, the data we have presented fall nicely into general schemes of the development of coastal adaptations along the southern California coast. In many ways, the subsistence data presented above seem to represent a logical transition from Early Holocene economies that relied heavily on shellfish (Erlandson 1994:259), to Late Holocene economies focused on fishing (Glassow 1993; Colten 1995). Nevertheless, while generally consistent with broad developmental patterns, the CA-SNI-161 data also differ significantly from Middle Holocene patterns elsewhere along the southern California coast (e.g., Glassow 1993, 1996; Erlandson 1997a). For Santa Cruz Island, in particular, Glassow (1993) found that fish provided an average of

less than 10% of the protein represented in samples from various Middle Holocene components, with a range falling between 0% and 28%. Our dietary reconstructions for CA-SNI-161 suggest that fishing may have intensified significantly earlier on San Nicolas Island, during the Middle Holocene 5,000 or more years ago.

What accounts for such local differences? Along the southern California coast, variations in subsistence patterns through space and time probably reflect the complex and dynamic interplay between changing environmental conditions, population growth and movements, the environmental and territorial circumscription of individual social groups, the development and spread of new ideas and technologies, and the increasingly pronounced effects of human overexploitation on key resources. In the specific case of CA-SNI-161, is the site anomalous or is it simply located adjacent to unusually productive fishing grounds? Or, for San Nicolas Island in general, did the even more restricted access to terrestrial resources force people to intensify their fishing activities earlier than northern Channel Island groups? On San Nicolas Island, did the near absence of mussels, which dominate most Middle Holocene faunal assemblages of the northern Channel Islands, force people to harvest more fish? Or did technological or other cultural differences between people living on various islands play a role in determining the importance of various resources?

It has been postulated, for instance, that Uto-Aztec speakers inhabited the southern Channel Islands as early as the Middle Holocene (Howard and Raab 1993; Vellanoweth 1995), when the northern Channel Islands were inhabited by peoples ancestral to the Chumash. If this is ultimately shown to be true, did the distinctive cultural practices of different ethnic groups influence their subsistence choices? Ultimately, more and better data are needed to address such questions.

For now, basic data on Middle Holocene subsistence economies provide us with a much needed understanding of the way people articulated with

the environment during this poorly understood time period along the California coast. For too long, California archaeologists have focused too much attention on the earliest (Early Holocene) and most complex (Late Holocene) stages in prehistory (see Erlandson and Glassow 1997). After all, the intriguing diversity and complexity of Native American cultures in southern California at the time of European contact has its antecedents in the Middle Holocene.

Finally, we have shown that the dietary reconstruction methods used in this article are a cost-effective and useful way of analyzing faunal constituents in order to determine their respective meat and protein yields. Although not without problems, they provide a reasonable account of the subsistence economy employed by islanders during the Middle Holocene. If archaeologists continue this type of research, it will be possible to compare and contrast sites through time and space, and to more fully document the nature and evolution of coastal adaptations along the California coast and beyond (see Moss 1989; Erlandson et al. 1998).

NOTES

1. Because sea otters lack large amounts of subcutaneous fat, our conversions of sea otter bone weights to meat weights using conversion factors determined from pinniped carcasses (see Glassow and Wilcoxon 1988) probably inflate the apparent meat yield of sea mammals slightly. This should have no significant effect on our protein yields, however, since the protein yield of sea otter flesh is correspondingly higher.

2. Although this is considered to be a period of relatively warm water in the Santa Barbara Channel, the oxygen isotope record available for a recent "high-resolution" core is based on sampling only every 50 years for varved sediments deposited prior to 3,000 years ago (Kennett 1998:122-123).

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