Title
Faunal Exploitation During the Middle to Late Period Transition on Santa Cruz Island, California

Journal
Journal of California and Great Basin Anthropology, 17(1)

ISSN
0191-3557

Author
Colten, Roger H

Publication Date
1995-07-01

Peer reviewed

Journal of California and Great Basin Anthropology
Vol. 17, No. 1, pp. 93-120 (1995).

Faunal Exploitation During the Middle to Late Period Transition on Santa Cruz Island, California

ROGER H. COLTEN, Dept. of Anthropology, National Museum of Natural History, Smithsonian Institution, Washington DC 20560.

This paper presents the analysis of faunal remains from four sites on the west end of Santa Cruz Island, California; a discussion of other Channel Island subsistence data; and a comparison across the three broad ecological zones of the Santa Barbara Channel area: the islands, the mainland coast, and the interior regions. The faunal analysis indicates that the inhabitants of Santa Cruz Island relied almost exclusively on marine resources, with terrestrial mammals and birds contributing relatively little to the animal portion of the diet. These data also demonstrate the increasing importance of fish through time, with marine fish being the most important animal resource in all three ecological zones during the Late Period. New information on ancient sea temperature for the period from approximately A.D. 1150 to 1300 indicates environmental change during that time period. Some of this information was derived from analysis of fish otoliths, a new method that may have broader application in coastal areas. These data support models that invoke environmental change as a factor in prehistoric cultural evolution in the Santa Barbara area, but do not indicate a major decline in marine productivity during the Middle to Late Period transition.

THE Chumash Indians of the Santa Barbara Channel region of southern California and their prehistoric predecessors practiced a hunting and gathering subsistence pattern that varied across three broad ecological zones: the northern Channel Islands, the mainland coast, and the interior regions (Landberg 1965). During later prehistoric and ethnohistoric times, the Chumash practiced a distinctly marine-oriented subsistence economy on the northern Channel Islands and along the mainland coast, while the economies of the interior regions were focused more on terrestrial resources. Most of the archaeological research conducted in the region has been concentrated in the mainland coastal zone due to the high visibility of large middens, the focus of cultural resource management archaeology in this more developed zone, and the relative inaccessibility of the offshore islands. Until recently, little quantified faunal information from the northern Channel Islands was available to evaluate the subsistence strategies of Native American people living in that zone.

The broad patterns of prehistoric subsistence in the Santa Barbara region have been known for many years. Early researchers, such as Rogers (1929) and Olson (1930), noted the terrestrial orientation of early sites and the greater visibility of fish remains and fishing technology in later prehistoric sites. In recent years, systematic screening of archaeological deposits and more sophisticated dietary reconstructions have led to a more refined understanding of changes through time in subsistence. During the early Holocene, Native Californians of the Santa Barbara area relied on a diet of plant foods, shellfish, and a few vertebrates (Erlandson et al. 1988; Erlandson and Colten 1991; Erlandson 1994). Towards the end of the Early Period, acorns were added to the diet, and the Middle through Late periods were characterized by increasing reliance on marine animal resources, particularly fish. A frequently cited explanation for the increasing reliance on fish is Glassow's (1975) model in which rising population density led to expanded exploitation of marine habitats.

The transition from the Middle to Late periods has been the focus of much archaeological research because many scholars believe this is when complex social organization developed in the Santa Barbara Channel region. Additionally, there is clear evidence for economic changes, including the development of craft specialization, during this period (Arnold 1987, 1991, 1992; Arnold and Munns 1994). Arnold (1992) argued that under conditions of high population density, people on Santa Cruz Island were confronted with severe fluctuations in environmental conditions that reduced the reliability of food resources. In response to these conditions, the islanders increased control over microdrill and shell bead production on the island and intensified exchange for food with the adjacent mainland. Control over resources and labor, perhaps by politically opportunistic individuals, led to significant differences in status (Arnold 1992, 1993). The new organizational relationships remained in place after the return to relatively normal environmental conditions. Studies of mortuary variability (King 1969, 1982; Martz 1984, 1992) and physical anthropology (Walker 1986, 1989; Walker and Lambert 1989; Lambert and Walker 1991) also indicate a late emergence of complexity. In contrast, King (1990) believed that social complexity developed near the end of the Early Period without an environmental stimulus.

Despite broad trends in subsistence for the coastal and island regions, there is considerable intersite variability related to local environmental conditions (e.g., Glassow and Wilcoxon 1988), and the people of the interior regions apparently were never as reliant on marine resources as people from the islands and mainland coast. In order to understand the broad patterns of subsistence, it is important to examine quantified faunal data from all three zones. Until the completion of the current analysis, few quantified faunal studies incorporating all major classes of fauna were available from the islands, limiting regional scale analysis.

This paper presents the recently completed analysis of faunal remains from four sites on the west end of Santa Cruz Island, a discussion of other Channel Island subsistence data, and a comparison across the three broad ecological zones of the islands, the mainland coast, and the interior regions. Additionally, new information is presented on ancient sea temperature for the period from approximately A.D. 1150 to 1300, a period of cultural and environmental change in the Santa Barbara area. This new information is derived from analysis of fish otoliths, a new method that may have broader application in coastal areas. The information on paleoenvironment is particularly relevant for evaluating models of culture change that invoke climatic stimuli.

THE STUDY AREA

The archaeological material discussed here was recovered from several sites on Santa Cruz Island, the largest and most ecologically diverse of the four northern Channel Islands (Fig. 1). Santa Cruz Island is approximately 249 $km.^2$ (96 $mi.^2$) of rugged, mountainous terrain, receiving an average of 500 mm. of rain per year (Minnich 1980:123). The vegetation and native animal population on the island are similar to the adjacent mainland, although there are fewer plant and animal species on the islands (Minnich 1980). Plant foods that were economically useful to the native inhabitants of the island include acorns (primarily from the coast live oak [*Quercus agrifolia*]), brodaeia bulbs (*Dichelostemma pulchellum*), seeds, and numerous others (Timbrook 1984, 1993).

The terrestrial fauna of the island is very limited. The largest native mammal is the Santa Cruz Island fox (*Urocyon littoralis*), which is

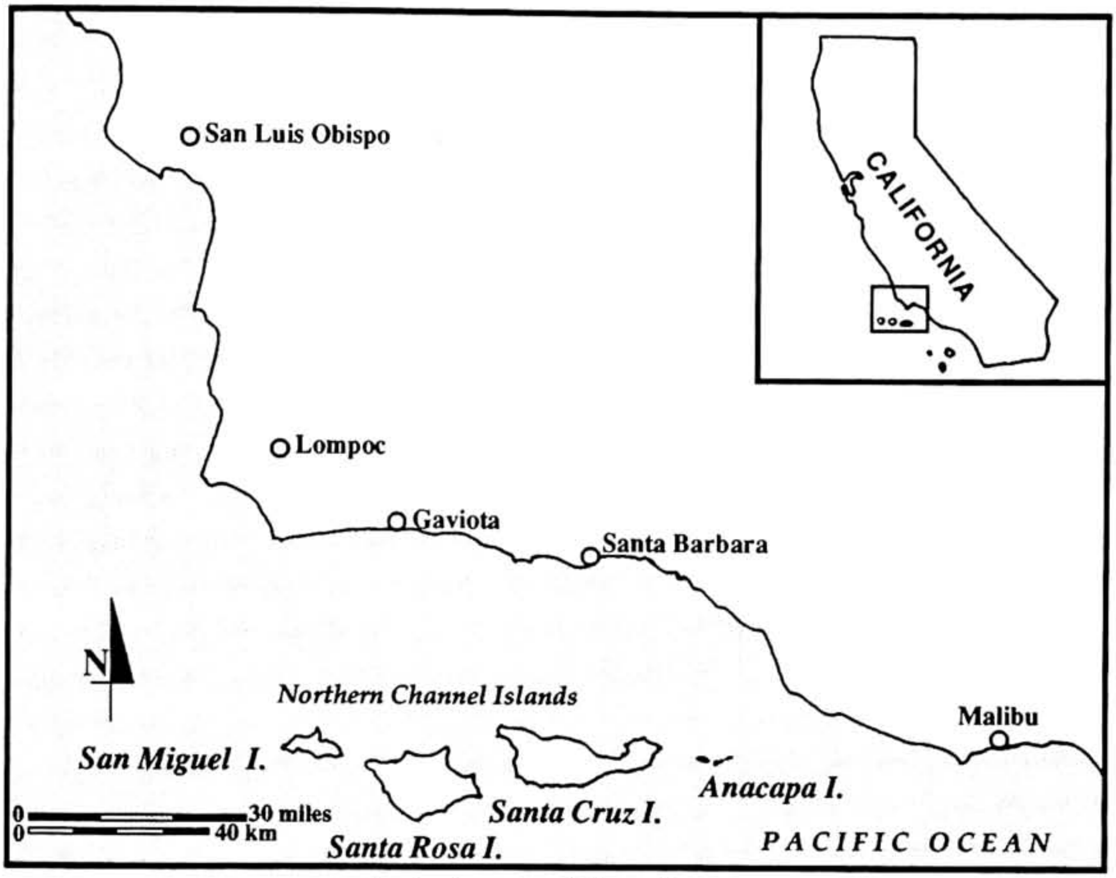

Fig. 1. Location of the study area.

about the size of a small house cat. Other fauna include the spotted skunk, nine species of bats, and a few reptiles (Collins MS). Birds are quite abundant, particularly seabirds, and about 60 bird species nest on the island (Collins MS). Several taxa of marine mammals inhabit the surrounding waters, and the marine fishery is particularly productive. The rugged coastline includes both rocky and sandy habitats, supporting a diverse array of shellfish and fish.

The ethnohistoric inhabitants of Santa Cruz Island were the Chumash (Johnson 1982), one of the most complex hunter-gatherer societies in California. Current data indicate that the island was occupied since about 8,000 B.P. (Glassow 1980), and the contact era population exceeded 1,500 individuals (Johnson 1982:110-114). The name Chumash refers to a series of related polities located along the southern California coast from San Luis Obisbo to Malibu, including the northern Channel Islands and the interior regions. The Chumash are known for their complex material culture, including beautiful basketry and elaborate rock art, as well as social, economic, and political organization that was highly complex for a hunter-gatherer group (Landberg 1965; Blackburn 1976; Johnson 1988). Some of the characteristics that identify the Chumash as a simple chiefdom include hereditary leadership, a two-tier settlement hierarchy, economic and religious integration of a broad region, craft and occupational specialization, and high population size and density.

THE SANTA CRUZ ISLAND ARCHAEOLOGICAL COLLECTIONS

The faunal collections discussed in this paper were recovered from four sites as part of Jeanne

Arnold's Santa Cruz Island Archaeological Project (Arnold 1991, 1992): CA-SCRI-330, near Forney's Cove; CA-SCRI-191 near Christy Beach; CA-SCRI-474 at Posa Creek; and CA-SCRI-192 at Morse Point (Fig. 2). Several contiguous 1 x 1-m. units were excavated at each site. All excavated material was passed through 1/8-in. mesh metal screens and the residue was retained and later sorted into midden constituents. Sites on Santa Cruz Island exhibit excellent stratification due to the absence of burrowing animals on the island and rare disturbance by modern development or nonscientific collecting. Faunal materials were analyzed from four time periods: Middle, Transitional, Late, and Historic (Fig. 3). This chronology is based on King's (1990) widely cited chronological scheme for the Santa Barbara Channel region and refinements to that scheme proposed by Arnold (1992), based on her stratigraphic excavations and numerous radiocarbon dates.

The faunal data presented here are derived from 75 levels from six excavation units at the four sites listed above. All four of these sites are very dense coastal shell middens that were locations of intense shell bead manufacturing during later prehistory (Arnold and Munns 1994). General characteristics of the deposits are summarized by time period in Table 1.

Characteristics of the Faunal Assemblage

The density of shellfish remains is very high, averaging over 300 kg. per cubic meter in the Late and Historic periods (Table 1) and exceeding 650 kg. per cubic meter in some levels (Colten 1991). These densities of shellfish remains are consistent with those reported by Glassow (1980:82-83) for other sites on Santa Cruz Island. The present analysis reveals a significant increase in shellfish density between the Transitional and Late periods.

Fish bone density, whether calculated as weight or count per cubic meter, is extremely high in these deposits. By weight, the density exceeds 10 kg. $m.^3$ in Late Period levels, and the density increases significantly between the Transitional and Late periods (Table 1).

The density of mammal and bird bones exceeds 5,600 bones per cubic meter during the Historic Period (Table 1). When considered either by count or weight, the density of bird and mammal bone is lowest in the Transitional Period levels while the density of shell and fish bone increases during this time period. Although many factors affect the composition of middens, the relatively low density of mammal and bird bone during this time period may reflect less intensive use of these resources, or a shift to fish and shellfish. This issue is discussed at greater length in the final section of this paper. The very high density of bones per cubic meter in the Historic Period levels is probably due to the high degree of fragmentation of bones near the surface of sites; these levels also have the *lowest* average bone weight of all the time periods (Table 1). This is probably due to greater impacts from domesticated animals crushing bones near the surface. This proposition is supported by data on the average bone weight per time period, which tends to decrease through time. Other than the greater fragmentation near the surface, bone is consistently well preserved throughout the deposits at these four sites.

The assemblage shows that, through time, a steadily declining percentage is burned (Table 1). This may indicate changes in processing, such as new cooking techniques, or perhaps changing site functions in which less emphasis is placed on consuming animals and more on procurement for trade. Brenda Bowser (personal communication 1994) argued that one should expect to see more evidence of roasting (burning) at temporary camps and less evidence of roasting at more permanent base camps, where larger family units gather and are more likely to be consuming soups. If her argument is correct, these data would indicate increasing permanence of occupation through time.

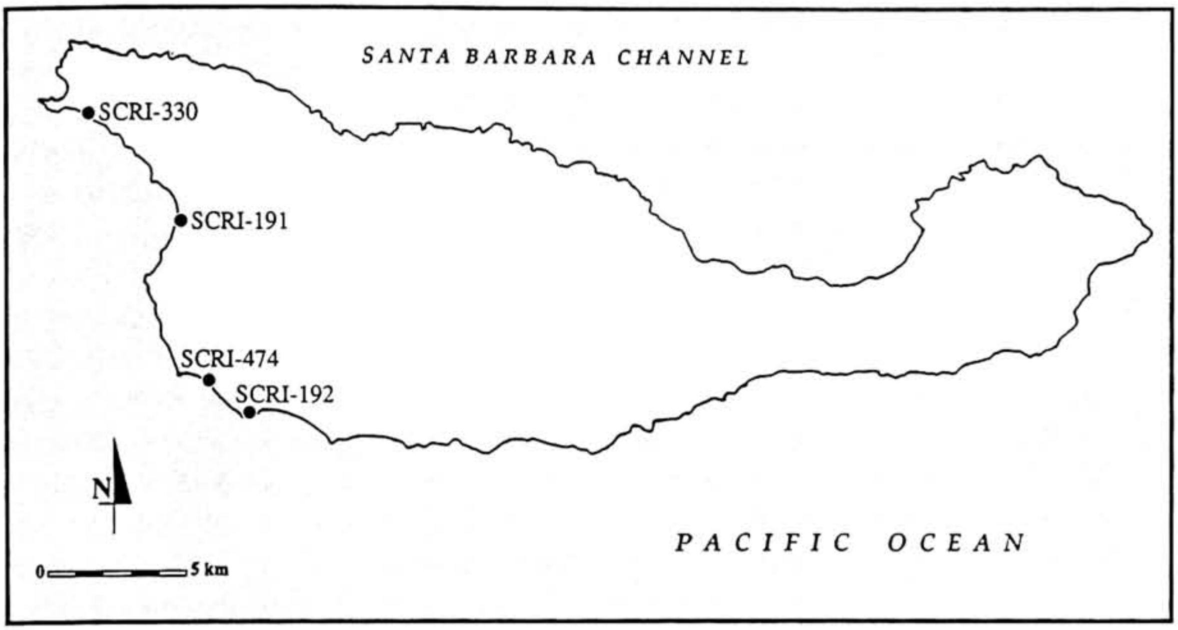

Fig. 2. Location of the four studied archaeological sites on Santa Cruz Island.

Chronological Period	Date
Historic	A.D. 1782 - Present
Late Period	A.D. 1300 - 1782
Transitional Period	A.D. 1150 - 1300
Middle Period	1400 B.C.-A.D. 1150
Early Period	6000 - 1400 B.C.
Early Holocene	8000 - 6000 B.C.

Fig. 3. A prehistoric chronology for the Santa Barbara Channel (after Arnold 1992:66).

Alternatively, bone may have been used as fuel in fires when wood was scarce. A comparison of the percentage of burned bone to the amount of charcoal in these levels indicates an

Table 1
CHARACTERISTICS OF THE FAUNAL ASSEMBLAGES FROM CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, AND CA-SCRI-474

Time Period	Volume of Excavated Soil (m.^{3})	Density of Shell[a]	Density of Fish Bones[a]	Density of Bird and Mammal Bones[b]	Density of Bird and Mammal Bone[c]	Average Bone Weight[d]	Percent Burned[e]
Historic	0.25	313,783.7	9,000.4	5,612.0	2,767.68	0.49	6.98
Late	2.12	310,034.2	10,006.95	3,275.47	2,851.23	0.87	8.64
Transitional	0.38	217,733.2	4,943.95	1,963.16	1,365.84	0.69	17.83
Middle	1.15	203,869.2	3,451.96	2,951.3	2,525.44	0.85	23.77

[a] g/m^3.
[b] count/m^3.
[c] g/m^3.
[d] for bird and mammal bone.
[e] for bird and mammal bone (by weight).

inverse relationship between the weight of charcoal and the percentage of bone that is burned (Fig. 4).

DIETARY RECONSTRUCTION

The development of the maritime focus of Chumash subsistence has fascinated scholars for decades, and the study of faunal remains from sites with deposits spanning several time periods can shed considerable light on this process. California archaeologists have been estimating the relative contributions to the diet of various classes of fauna for many years, using a variety of techniques. Dietary reconstruction from faunal remains may be derived from several sources, including meat weight estimates, bone weight, minimum number of individuals (MNI), or the number of identified specimens (NISP) for each taxon. While each of these methods is useful in different situations, the reconstruction of prehistoric diet from faunal remains from coastal sites is particularly challenging due to the presence of a wide array of taxa with significantly different skeletal structures, including shellfish, fish, birds, terrestrial and marine mammals, and reptiles.

A variety of methods of faunal analysis suited to the data and the research questions was used (Colten 1993:103-111). For the purpose of analyzing the dietary contributions of the various faunal classes, the bone weight method (Ziegler 1973) was used for estimating meat weight. This method relies on multiplying the raw weight of bone or shell by an empirically derived conversion factor that represents the bone (or shell) to flesh ratio for living animals of appropriate taxa. Although it has problems and some detractors (e.g., Grayson 1984), this method seems most appropriate for the purpose of estimating relative contribution to the diet of the broad faunal categories listed above. While it would be dangerous to assume that these estimates are rigorous calculations of the diet of prehistoric people, they are useful for comparing data from different places and different time periods, when applied consistently and explicitly.

Applying meat weight conversion factors commonly used by archaeologists in southern California (Table 2), the overall dietary composition for each of the four sites and for each time period was estimated. More detailed, level-by-level analyses for each site were presented elsewhere (Colten 1993). Not surprisingly, the dietary composition for the entire assemblage is dominated by marine resources (Fig. 5).[1] Fish and shellfish are by far the most

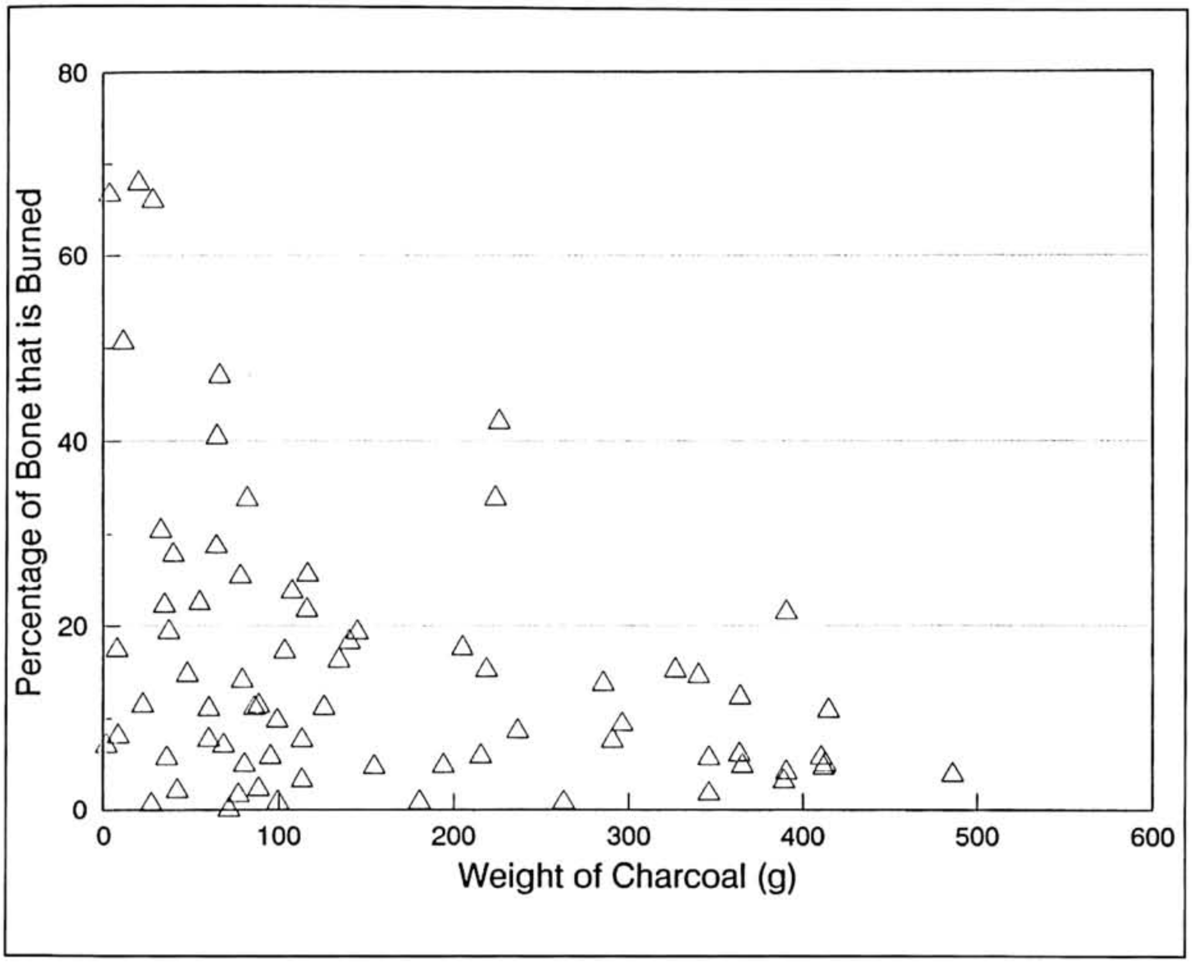

Fig. 4. Relationship between burned bone and charcoal at CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, and CA-SCRI-474 (data combined, each triangle represents one excavation level).

important categories of animals exploited, and marine mammals make up most of the rest of the estimated meat weight. Meat from terrestrial mammals and birds are minor contributors to the diet. A significant portion of the assemblage was so fragmented that it could only be classified as mammal. Given the prevalence of marine mammal over terrestrial mammal, the marine mammal conversion factor (see Glassow and Wilcoxon 1988) was used for estimating the meat weight of the undifferentiated mammal bone. Reptile bones were so rare in the assemblage that the meat weight for reptiles was not estimated.

If changing patterns of animal resources through time are examined, it can be seen that the importance of marine mammals decreased, the importance of fish increased, and the relative contribution of shellfish decreased (Fig. 6). This pattern is consistent with Glassow's (1993) dietary reconstructions based on estimated protein yields from faunal remains from Santa Cruz Island sites (see discussion below).

There is some intersite variability in this pattern. SCRI-191, located at Christy Beach, was occupied during the Middle through Late periods. When estimated meat weight is calculated for each excavation level from one of the

Table 2
MEAT WEIGHT CONVERSION FACTORS

Taxon	Meat Yield Multiplier	Reference
shellfish	x 0.332	Glassow and Wilcoxon (1988)
fish	x 27.7	Tartaglia (1976:170)
marine mammal	x 24.2	Glassow and Wilcoxon (1988)
terr. mammal	x 10.0	Tartaglia (1976:170)
undiff. mammal[a]	x 24.2	Glassow and Wilcoxon (1988)
bird	x 15.0	Ziegler (1975)

[a] Most undifferentiated mammal in these assemblages is probably marine mammal.

units, a more complex pattern emerges (Fig. 7). In the deepest (Middle Period) levels of this unit, shellfish were the most important resource, followed by fish and marine mammals. The importance of shellfish decreases steadily through Lens D, while fish increases in importance. In the lower portion of Lens C, however, this pattern reverses, with shellfish increasing in importance and fish declining in importance throughout the remainder of the deposit.

The steady decline in importance of shellfish, followed by a sharp reversal in the relative importance of fish and shellfish, may be due to overexploitation of shellfish or temporary site abandonment, followed by later reoccupation of the site. A pattern of decreasing shell and increasing fish is consistent with the traditional view of changing prehistoric subsistence in the region, but patterns in the upper levels of this site, above Lens D, do *not* fit the traditional scenario. Overexploitation does not explain the steadily *increasing* importance of shellfish after this time. The later pattern may be due to a change in site function; these later levels are subsequent to the emergence of the shell bead manufacturing specialization at this site, and may reflect growing emphasis on craft activities, which might have led to less travel time for animal procurement and greater reliance on less mobile animals such as shellfish. Alternatively, environmental changes could have influenced the availability of marine resources.

TAXONOMIC COMPOSITION OF THE FAUNAL ASSEMBLAGE

The composition of the shellfish assemblage varies little through the Middle, Transitional, and Late periods at SCRI-191 (Stevenson 1989), being dominated by rocky intertidal species such as California mussel (*Mytilus californianus*) and black abalone (*Haliotis cracherodii*). These two species constitute approximately 90% of the shellfish in the assemblage. Although detailed analyses of shellfish are not available for the other three sites, the composition of the shellfish assemblage is similar to that reported by Walker and Snethkamp (1984) for Middle and Late period sites on San Miguel Island, California.

The taxonomic composition of the bird and mammal assemblage from these four sites is very rich, with 38 independent taxa represented. In addition to these taxa, many bones were identified to higher taxonomic levels. The marine mammal assemblage is dominated by seals, particularly Guadalupe fur seal (*Arctocephalus townsendi*) (Fig. 8, Table 3). Sea otters (*Enhydra lutris*) and several types of cetaceans are also present. The cetaceans are primarily dolphins, including common dolphin (*Delphinus delphis*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), bottlenose dolphin (*Tursiops truncata*), and short-finned pilot whale (*Globicephala macrorhynchus*). Cetaceans decrease in importance after the Middle Period.

The terrestrial mammal assemblage is dominated by deer and dog bones, although island fox, skunk, domestic cat, and mouse bones are also present (Table 3). The many mouse bones of the genus *Peromyscus* in the assemblage are probably from naturally occurring island mice

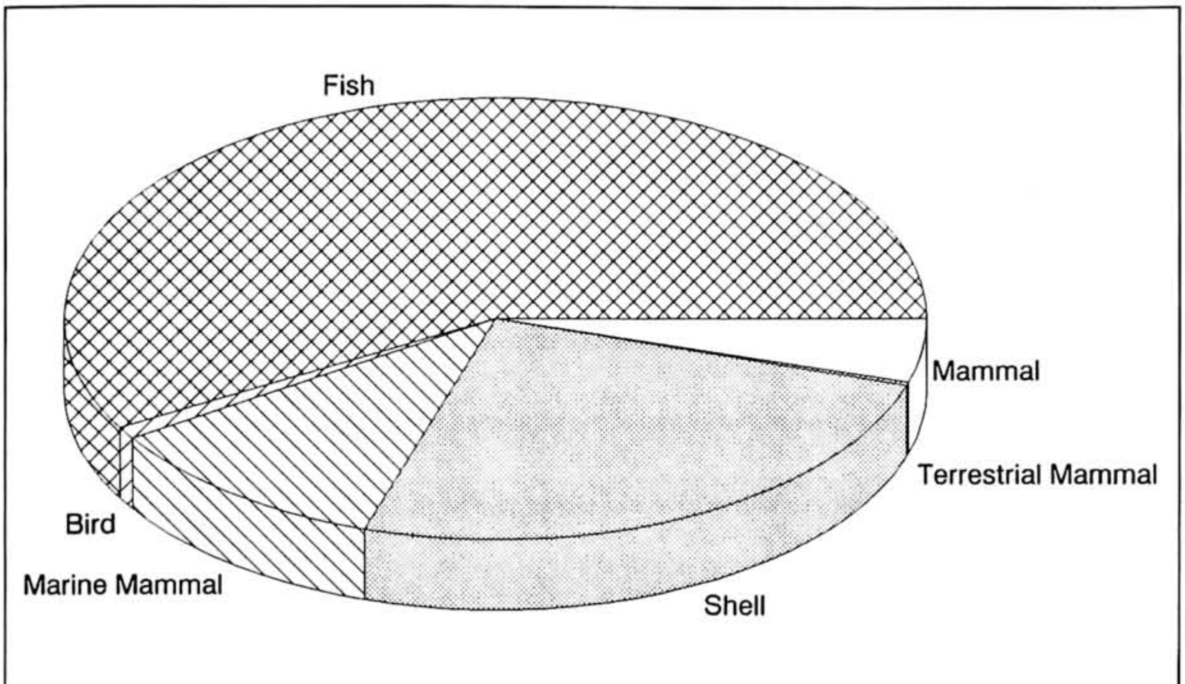

Fig. 5. Estimated meat weight for the combined archaeological assemblages from CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, and CA-SCRI-474.

that died in the ancient houses and are not considered in the dietary analysis. The dog bones are all of domesticated, coyote-sized dogs. The two domestic cat bones are from a Historic Period level. All of the deer remains are limb bones, primarily from lower limbs. It is likely that these bones were used in the manufacture of bone tools and do not represent food debris. Interestingly, the two most common terrestrial mammals, deer and dog, are not native to the island, but must have been imported from the mainland.

The bird assemblage is dominated by marine species, with cormorants being more common than all other identified birds combined (Fig. 9, Table 3). Ducks of many varieties, gulls, grebes, pelicans, raptors, and a few songbirds are present as well. Most of the bird bones were too fragmented to identify to species, however, and are classified simply as bird.

According to the meat weight estimates, fish were the most important source of food throughout the time periods considered in this analysis, and more detailed discussion of fish remains is warranted. The otoliths (ear bones) of over 80 species of Teleosts (bony fish) were identified in these assemblages (Table 4). An additional 31 fish taxa, some only identified to the family level, were identified from column samples and bulk fish remains from excavation levels (Table 5) (Johnson MS). These samples include 11 species of Elasmobranchi (cartilaginous fish), which do not have otoliths.

Otoliths may be identified to the species level in most cases. A total of 1,754 otoliths representing 82 distinct species was identified from 53 of the 75 excavation levels considered here. As the otoliths were not classified to side, it was not possible to consider MNI for this analysis; therefore, NISP was used instead. The fish assemblage from all four sites is dominated by various species of rockfish (*Sebastes* sp.) and several species of surfperch (Embiotocidae) (Table 6). The rockfish are the most numerous

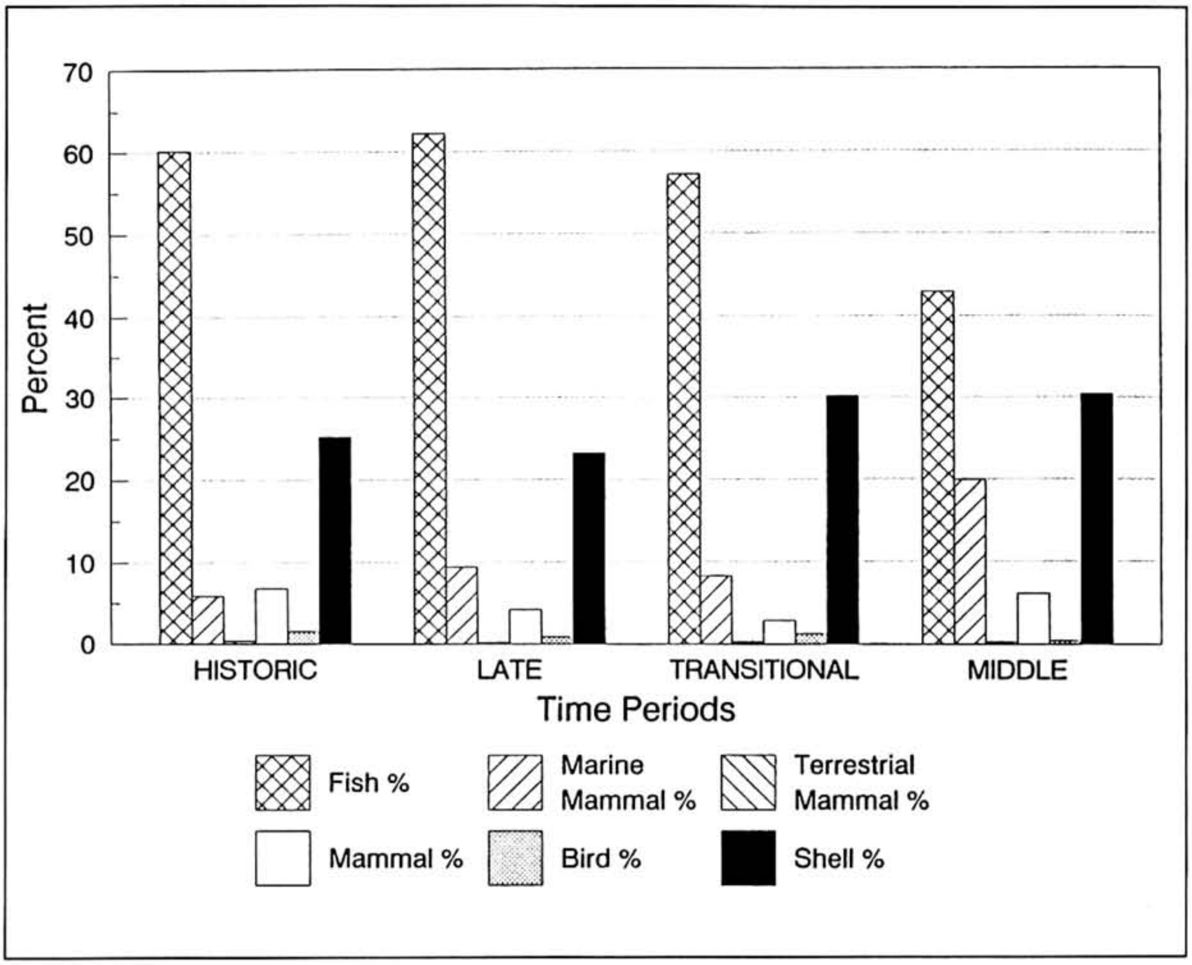

Fig. 6. Changing diet through time at CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, and CA-SCRI-474 (data combined).

genus, constituting between 50% and 94% of the identified otoliths. Surfperch range between 5% and 44% of the identified otoliths in the various analytical units. At three of the sites (excluding SCRI-192), rockfish become more important and surfperch less important through time. Rockfish are primarily rocky substrate species, whereas surfperch are primarily sandy substrate species, although the distribution of rockfish species varies by water temperature and depth.

PALEOENVIRONMENTAL DATA FROM THE FAUNAL ASSEMBLAGE

The fish assemblage provides some evidence for sea temperature change. To put these data in context, it is instructive to review other sources of information on sea temperature. In recent years, anthropologists working in the Santa Barbara Channel area have noted the correlation between changes in sea temperature and cultural changes in subsistence, technology, overall economic organization, and evidence of health from human skeletal remains. Identification of changing environmental conditions and correlations with cultural change is therefore quite important. There is a growing body of evidence that allows us to reconstruct patterns of environmental change in this region. The first category of paleoenvironmental data is Pisias's (1978, 1979) sea temperature reconstruction based on

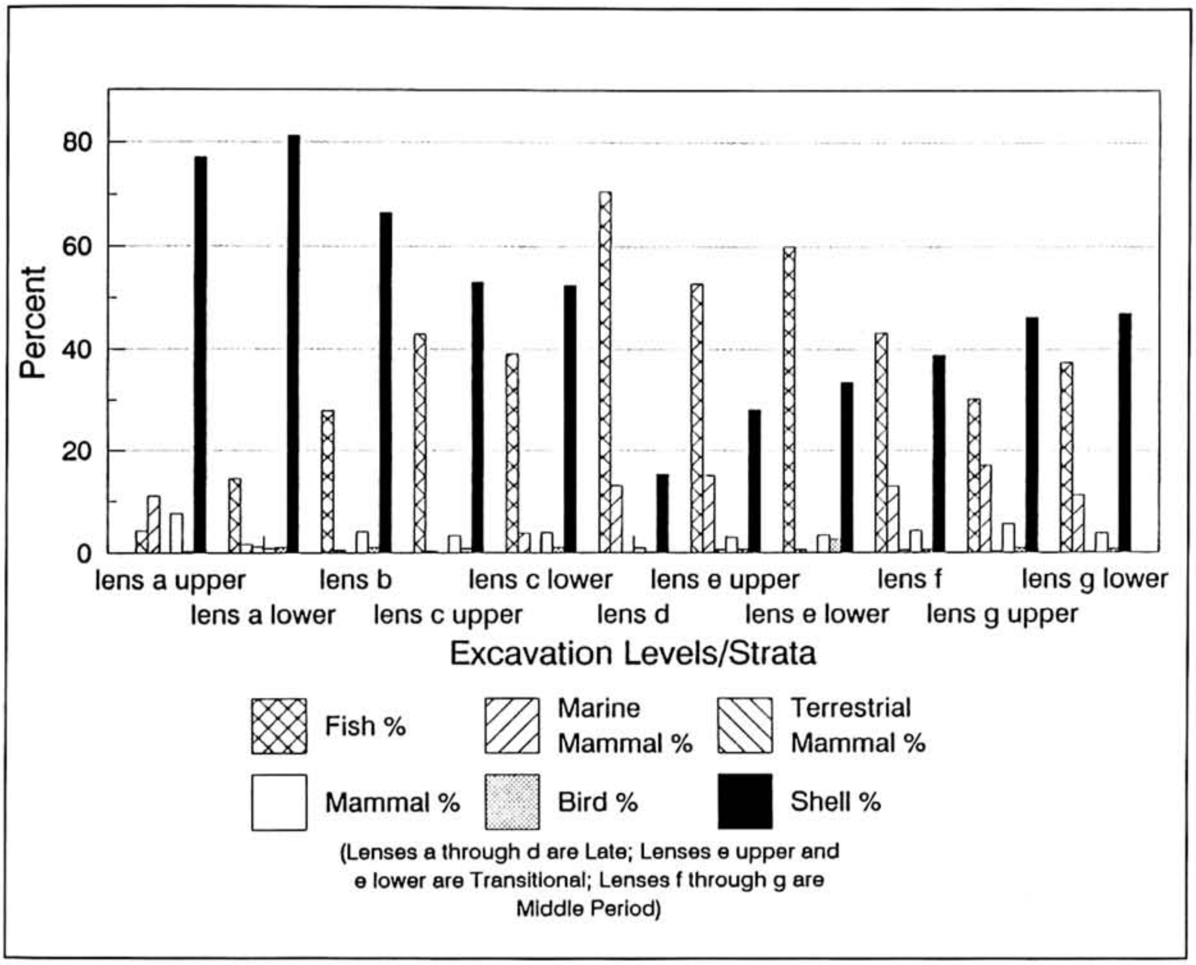

Fig. 7. Changing diet at CA-SCRI-191.

the analysis of temperature sensitive radiolaria from deep sea cores recovered from the Santa Barbara Channel. Pisias's analysis demonstrates changing sea surface temperature over an 8,000-year period, including unusually warm temperatures between approximately A.D. 1100 and 1300.

The second source of ancient sea temperature data is from Arnold and Tissot's (1993) analysis of black abalone shells recovered from middens on Santa Cruz Island. This analysis indicates that warm water conditions similar to those currently present near Baja California occurred during the Transitional Period, approximately A.D. 1150 to 1300. These shells are from the same excavations that produced the faunal data presented in this analysis. The third category of sea temperature data is Stevenson's (1989) analysis of shellfish from SCRI-191, one of the sites on the west end of Santa Cruz Island considered in this analysis. Stevenson's analysis suggests an increase in warm water shellfish species during the Transitional Period. For example, *Astrea undosa* and *Norrisia norrisi*, two gastropods, occur only rarely in these deposits but are most abundant in the Transitional Period levels. Santa Cruz Island is near the northern limit of these animals (Rehder 1981) and their increased abundance suggests warmer water during the Transitional Period.

The fish data from this analysis provide additional information on sea temperature.

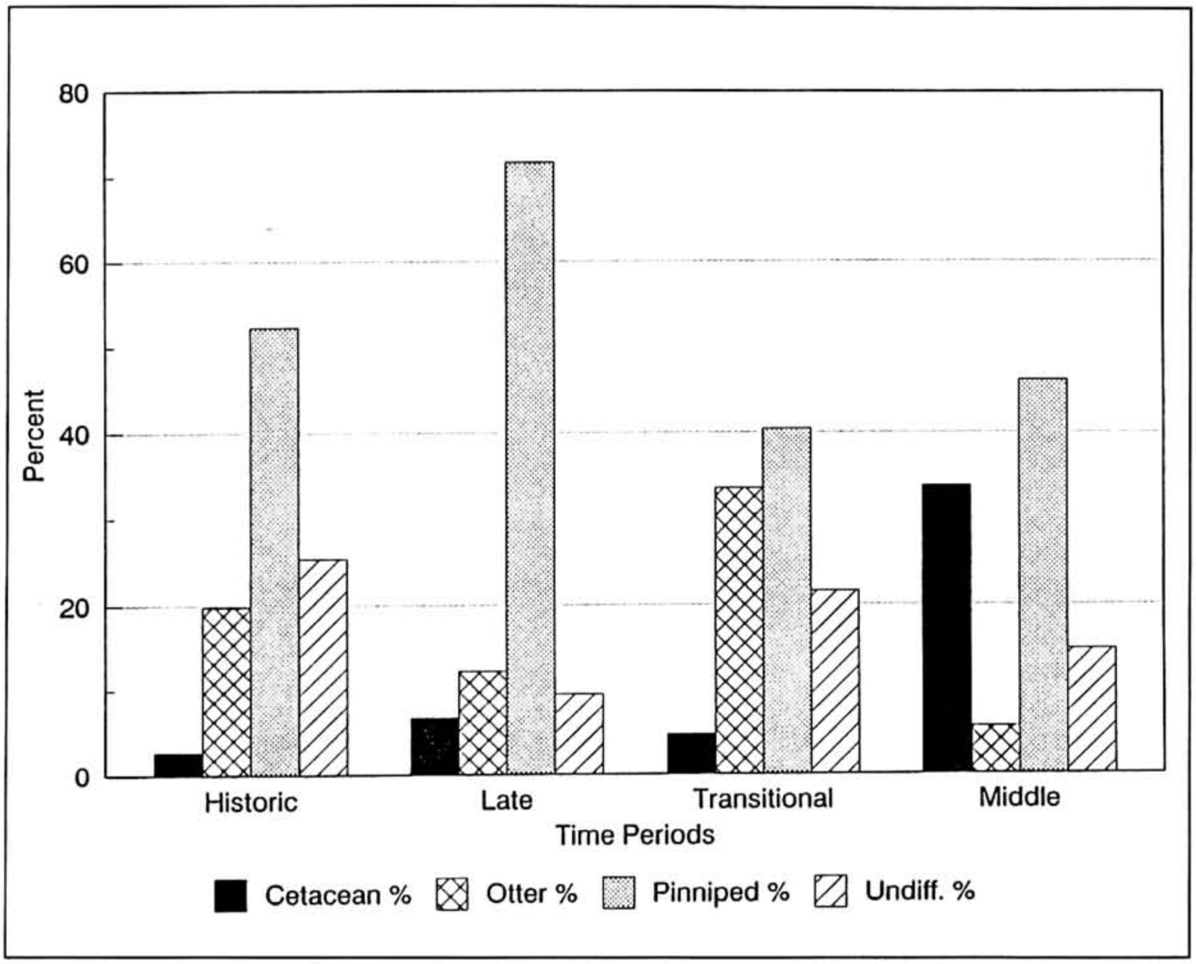

Fig. 8. Combined marine mammal bone weight by time period at CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, and CA-SCRI-474.

Using modern geographical range data from fish guides (Miller and Lea 1972; Eschmeyer et al. 1983), the fish identified from otoliths were classified as either southern, transitional, or northern species, using the Santa Barbara Channel area as the dividing line. Northern species are those whose ranges were generally north of the channel, southern species are those whose range was generally south of the channel, and transitional species are those whose range include the channel. Table 7 shows that most of the identified fish were classified as transitional, having ranges that include the Santa Barbara Channel. During the Transitional Period, the percentage of otoliths from both southern and northern species increased, suggesting changing patterns of fish distribution during this time period. Furthermore, the taxonomic diversity of the Transitional Period levels is greater than that of the other time periods (as calculated using Simpson's index of diversity [Krebs 1978]).

These data suggest that the fish population of the Santa Barbara Channel was affected by climatic change during the Transitional Period, providing further support to the existing evidence for ancient sea temperature change. While studies by Arnold and Tissot (1993), Pisias (1978), and Stevenson (1989) indicate warmer water during the Transitional Period, paleoenvironmental data from this analysis are

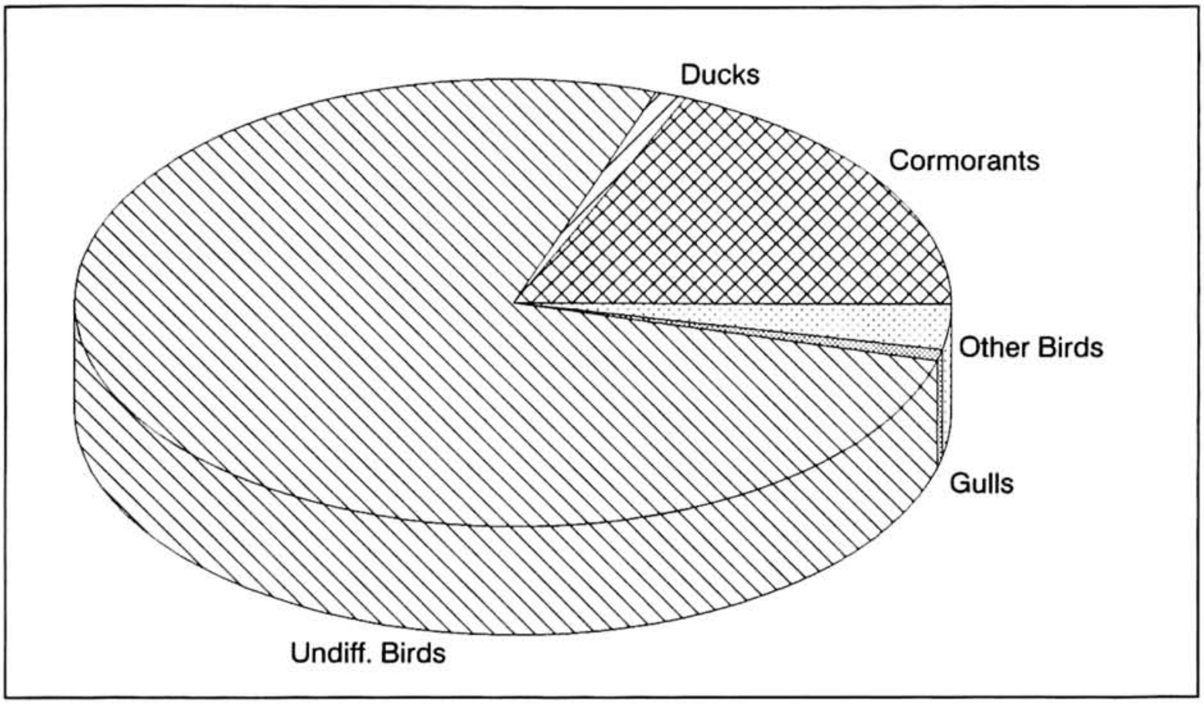

Fig. 9. Bird taxa in the combined assemblages of CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, and CA-SCRI-474.

more ambiguous in terms of sea temperature. These data demonstrate that local fish populations were not simply replaced by a warm water assemblage; instead, more complex changes in fish distribution occurred during the Transitional Period.

Other sources of paleoenvironmental data suggest that the Transitional Period was also a time of severe droughts in southern California, and perhaps on a regional or global scale as well. Larson et al. (1989) developed dendrochronological data that indicate several periods of prolonged drought during the Middle Holocene of southern California. Their data indicate that the period from A.D. 1120 to 1200 was particularly arid. These data are consistent with those of Stine (1994), which suggest several periods of global warming and desiccation, including one period from approximately A.D. 1209 to 1350. The combination of warmer sea temperature and severe drought probably had significant impacts on the subsistence and economy of hunter-gatherers in southern California.

COMPARATIVE FAUNAL DATA

While few other comprehensive faunal studies exist for the northern Channel Islands, those that have been published in recent years provide interesting comparative material. Glassow's (1993) study of faunal remains from column samples from several Santa Cruz Island sites includes samples from the Early, Middle, and Late periods, including samples from several of the sites discussed here. In his analysis, Glassow (1993) used conversion factors to estimate protein yield for fish, shellfish, and marine mammals, calculating the percentage of protein contributed by each of the three faunal categories for each column sample from each time period. In general, Glassow found that shellfish provided the most protein during the Early Period, contributing over 80% of the protein in

Table 3
NON-FISH FAUNA FROM ALL SITES

Taxon/Category	Common Name	NISP[a]	Weight (g.)
Birds			
Aechmophorus occidentalis	western grebe	1	0.50
Anas crecca	green-winged teal	1	0.17
A. platyrynchos	mallard	6	4.39
Anas sp.	undifferentiated duck	16	4.49
Anser albifrons	white-fronted goose	3	5.98
A. caerulescens	snow goose	1	8.49
Anseriformes	undifferentiated goose	1	1.66
Aves	undifferentiated bird	1,762	277.99
Aves	large bird	1	0.67
Brachyramphos hypoleucus	murrelet - xantus	1	0.02
Cepphus columba	pigeon guillemot	1	0.62
Chen hyperborea	snow goose	2	3.08
Diomedea sp.	undifferentiated albatross	3	7.94
Gavia sp.	undifferentiated loon	1	0.75
Larus californicus	California gull	7	8.13
L. glaucescens	glaucous-winged gull	1	0.97
L. heermanni	Heermann's gull	2	0.59
L. occidentalis	western gull	5	6.04
Larus sp.	undifferentiated gull	4	3.26
Melanitta fusca deglandi	white-winged scoter	2	3.49
Melanitta sp.	undifferentiated scoter	1	0.22
Mergus serrator	common merganser	1	0.81
Pandion haliaetus	osprey	2	0.81
Passeriforme	songbird	22	0.63
Pelecanus californicus	California brown pelican	1	3.49
Pelecanus sp.	undifferentiated pelican	35	33.18
Phalacrocorax auritus	double-crested cormorant	392	415.55
P. pelagicus	pelagic cormorant	4	1.93
P. penicillatus	Brandt's cormorant	27	19.55
Phalacrocorax sp.	undifferentiated cormorant	8	5.20
Podiceps nigricollis	eared grebe	1	0.37
Ptychoramphus aleuticus	Cassin's auklet	2	0.26
Zenaida macroura	mourning dove	2	0.39
	SUBTOTAL	2,319	821.62
Reptiles			
Chelonia sp.	green sea turtle	2	2.14
Clemmys marmorata	western pond turtle	1	1.42
Pituophis melanolecus	gopher snake	4	0.09
	SUBTOTAL	7	3.65

Table 3 (Continued)
NON-FISH FAUNA FROM ALL SITES

Taxon/Category	Common Name	NISP[a]	Weight (g.)
Terrestrial Mammals			
Artiodactyla	undiff. ungulate	1	1.18
Canis familiaris	dog	18	72.43
Felis catus	domestic cat	2	0.29
Odocoileus hemionus	mule deer	18	83.07
Peromyscus sp.	mouse	136	3.36
Spilogale putorius	spotted skunk	1	0.35
Urocyon littoralis	Island fox	26	9.83
mammal	undiff. terr. mammal	109	127.95
	SUBTOTAL	311	298.46
Marine Mammals			
Arctocephalus townsendi	Guadalupe fur seal	48	884.76
Callorhinus ursinus	northern fur seal	1	36.14
Cetacea	whales and dolphins	27	656.13
Cetacea (large)	large whales and dolphins	99	176.50
Delphinidae	dolphin/porpoise	31	70.19
Delphinus delphis	common dolphin	1	11.94
Enhydra lutris	sea otter	263	720.29
fur seal	undiff. fur seal	31	243.25
small fur seal	small fur seal	1	44.05
Globicephala macrorhynchus	short-finned pilot whale	1	14.36
Lagenorhynchus obliquidens	Pacific white-sided dolphin	2	35.33
Otariidae	sea lion and fur seal	689	1,937.49
Otariidae (large)	large eared seal	9	143.65
Otariidae (small)	small eared seal	36	272.96
Phoca vitulina	harbor seal	17	166.42
Phocidae	undiff. seal, earless seal	2	0.75
Pinnipedia	sea lion, all seals	59	119.27
Pinnipedia (large)	large pinniped	2	13.61
Tursiops truncata	bottlenose dolphin	2	7.63
Zalophus californianus	California sea lion	1	1.11
marine mammal	undiff. marine mammal	2,105	788.72
	SUBTOTAL	3,427	6,344.55
Undifferentiated Mammals			
Carnivora	carnivore	7	3.42
Mammalia	undiff. mammal	6,416	2,688.10
	SUBTOTAL	6,423	2,691.53
	GRAND TOTALS	12,487	10,159.80

[a] number of identified specimens.

Table 4
FISH TAXA BY TIME PERIOD (NISP[a] FOR OTOLITHS) FROM CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, AND CA-SCRI-474

Taxon	Common Name	Range[b]	Middle	Transitional	Late	Historic	Total
Amphistichus argenteus	barred surfperch	t	2	2	1	0	5
A. koelzi	calico surfperch	t	0	0	1	0	1
Anoploma fimbrina	sablefish	t	0	0	1	0	1
Atherinops affinis	topsmelt	t	1	0	0	0	1
Atractoscion nobilis	white seabass	t	2	1	1	0	4
Brachyistius frenatus	kelp surfperch	t	2	2	0	0	4
Caulotatilus princeps	ocean whitefish	t	0	1	0	0	1
Chilara taylori	spotted cusk-eel	t	0	0	2	0	2
Cymatogaster aggregata	shiner surfperch	t	0	0	1	0	1
Embiotoca jacksoni	black surfperch	t	55	26	40	6	127
E. lateralis	striped surfperch	t	3	1	0	0	4
Embiotocidae	surfperch family	-	2	1	7	0	10
Genyonemus lineatus	white croaker	t	0	0	1	0	1
Girella nigricans	opaleye	t	0	0	1	0	1
Hermosilla azurea	zebraperch	s	1	0	0	0	1
Hippoglossus stenolepis	Pacific halibut	n	0	0	0	1	1
Hyperprosopon anale	spotfin surfperch	t	1	1	3	0	5
H. argenteum	walleye surfperch	t	31	5	8	1	45
H. ellipticum	silver surfperch	t	3	2	2	0	7
Hypsurus caryi	rainbow surfperch	t	4	7	14	1	26
Merluccius productus	Pacific hake	t	1	0	0	0	1
Micrometrus minimus	dwarf surfperch	t	0	0	1	0	1
Paralabrax clathratus	kelpbass	t	0	1	0	0	1
Paralichthys californicus	California halibut	t	0	1	2	0	3
Parophrys vetulus	English sole	t	0	0	2	0	2
Phanerodon atripes	sharpnose surfperch	t	0	0	1	0	1
P. furcatus	white surfperch	t	4	2	3	0	9
Pleuronichthys ritteri	spotted turbot	t	0	0	2	0	2
Porichthys notatus	plainfin midshipman	t	2	0	0	0	2
Rhacochilus toxotes	rubberlip surfperch	t	6	1	3	1	11
R. vacca	pile surfperch	t	4	2	8	2	16
Scorpaena guttata	California scorpionfish	t	1	0	0	0	1
Sebastes alutus	Pacific Ocean perch	t	0	0	2	0	2
S. atrovirens	kelp rockfish	t	10	2	10	1	23
S. auriculatus	brown rockfish	t	2	5	13	1	21
S. babcocki	redbanded rockfish	t	0	1	5	0	6
S. carnatus	gopher rockfish	t	0	0	7	0	7

Table 4 (Continued)
FISH TAXA BY TIME PERIOD (NISP[a] FOR OTOLITHS) FROM CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, AND CA-SCRI-474

Taxon	Common Name	Range[b]	Middle	Transitional	Late	Historic	Total
S. chlorostictus	greenspotted rockfish	t	0	0	8	0	8
S. chrysomelus	black-and-yellow rockfish	t	0	0	2	0	2
S. constellatus	starry rockfish	t	3	1	7	0	11
S. crameri	darkblotched rockfish	t	1	0	14	3	18
S. dalli	calico rockfish	t	1	9	2	0	12
S. diploproa	splitnose rockfish	t	2	0	3	0	5
S. elongatus	greenstriped rockfish	t	3	4	15	0	22
S. entomelas	widow rockfish	t	5	3	15	4	27
S. eos	pink rockfish	t	0	0	4	0	4
S. flavidus	yellowtail rockfish	n	17	13	30	3	63
S. gilli	bronzespotted rockfish	t	2	0	3	0	5
S. goodei	chilipepper	t	72	9	187	15	283
S. helvomaculatus	rosethorn rockfish	t	0	1	3	0	4
S. hopkinsi	squarespot rockfish	t	1	0	4	0	5
S. jordani	shortbelly rockfish	t	0	5	13	0	18
S. levis	cowcod	t	0	1	3	3	7
S. macdonaldi	Mexican rockfish	t	4	3	19	0	26
S. maliger	quillback rockfish	n	2	0	6	0	8
S. melanops	black rockfish	n	1	0	1	0	2
S. melanostomus	blackgill rockfish	t	0	0	2	6	8
S. miniatus	vermillion rockfish	t	10	16	50	5	81
S. mystinus	blue rockfish	t	2	0	4	0	6
S. ovalis	speckled rockfish	s	3	1	5	0	9
S. paucispinis	bocaccio	t	11	9	25	2	47
S. phillipsi	chameleon rockfish	t	4	0	5	0	9
S. pinniger	canary rockfish	t	3	6	27	3	39
S. rastrelliger	grass rockfish	t	0	1	2	0	3
S. rosaceus	rosy rockfish	t	1	0	3	0	4
S. ruberrimus	yelloweye rockfish	t	5	4	11	1	21
S. rubrivinctus	flag rockfish	t	0	1	3	0	4
S. rufus	bank rockfish	t	1	0	7	7	15
S. saxicola	stripetail rockfish	t	1	0	1	0	2
S. semicinctus	halfbranded rockfish	t	0	0	2	0	2
S. serranoides	olive rockfish	t	4	1	14	1	20
S. serriceps	treefish	t	1	0	0	0	1
cf. *S. serriceps*	treefish	-	0	0	1	0	1

Table 4 (Continued)
FISH TAXA BY TIME PERIOD (NISP[a] FOR OTOLITHS) FROM CA-SCRI-191, CA-SCRI-192, CA-SCRI-330, AND CA-SCRI-474

Taxon	Common Name	Range[b]	Middle	Transitional	Late	Historic	Total
S. simulator	pinknose rockfish	s	0	0	3	0	3
cf. *S. simulator*	pinknose rockfish	t	0	0	1	0	1
S. umbrosus	honeycomb rockfish	s	1	2	3	0	6
S. vexillaris	whitebelly rockfish	t	2	0	4	1	7
S. zacentrus	sharpchin rockfish	t	0	0	0	1	1
Sebastes sp.	undifferentiated rockfish	--	106	39	355	40	540
Sebastolobus alascanus	shortspine thornyhead	t	0	0	1	0	1
Semicossyphus pulcher	California sheephead	s	1	0	1	0	2
Seriphus politus	queenfish	t	0	0	1	0	1
Sphyraena argentea	California barracuda	s	1	7	13	0	21
Thunnus alalunga	albacore	t	1	0	0	0	1
Trachurus symmetricus	jackmackerel	t	3	1	3	1	8
Zaniolepis frenata	shortspine combfish	t	0	0	1	0	1
teleostei	undifferentiated bony fish	-	0	1	1	0	2
TOTALS			412	202	1,030	110	1,754

[a] number of identified specimens.
[b] n = north; s = south; t = transitional; "-" categories were not included in the range or diversity analyses.

most of his samples. During the Middle Period, the importance of these three categories was much more variable, with shellfish most important in one sample, marine mammal most important in three samples, and fish most important in six samples. By the Late Period, fish were the most important source of protein in all of Glassow's samples. Glassow's results support the general pattern of increasing importance of fish through time, while documenting some intersite variability. The Late Period sample with the greatest amount of protein from shellfish is from SCRI-236, a site very close to SCRI-191, the site for which the current analysis showed that shellfish was the greatest source of meat during the Late Period.

Walker and Snethkamp (1984) analyzed column sample data from several sites on San Miguel Island, also located in the northern Channel Islands. Their results show trends broadly similar to Glassow's, with the importance of fish increasing and the relative importance of marine mammals decreasing during the Middle and Late periods. Early Period shellfish assemblages were more diverse than Middle and Late period assemblages, which were dominated by California mussel (*Mytilus californianus*) (Walker and Snethkamp 1984:102-106). The San Miguel Island fish assemblage is similar to that recovered from the western Santa Cruz Island sites, being dominated by rockfish and surfperch (Walker and Snethkamp 1984:149). More detailed analysis of the San Miguel Island fish assemblage by Bowser (1993a) indicates that surfperch became relatively more important than rockfish from the Middle to Late periods, a pattern opposite of that from Santa Cruz Island.

Walker and Snethkamp's (1984:144) and Guthrie's (1980) analyses of bird remains from San Miguel Island produced results similar to those of the current study of Santa Cruz Island bird remains. These studies demonstrated that

Table 5
FISH IDENTIFIED FROM NON-OTOLITH DATA

Taxon	Common Name	Habitat[a]
Elasmobranchi - Sharks and Rays		
Family Carcharhinidae		
Carcharhinidae	requiem sharks	highly mobile[b]
Prionace glauca	blue shark	far out to sea[c]
Family Lamnidae		
Lamma ditropis	salmon shark	epipelagic[d]
Family Myliobatididae		
Myliobatis californica	bat ray	BE sandy coastlines[c]
Family Platyrhinidae		
Platyrhinoidis triseriata	thornback	sandy bottoms BE[c]
Family Scyliorhinidae		
Cephaloscyllium ventriosum	swell shark	shallow water to 1,380 ft.[d]
Family Squatinidae		
Squatina californica	Pacific angel shark	shallow sand mud bottoms[c]
Family Torpedinidae		
Torpedo californica	Pacific electric ray	sandy bottoms[c]
Family Triakididae		
Galeorhinus galeus	soupfin shark	H/NSB to offshore 411 m.[c]
Mustelus sp.	smoothhounds	H/NSB OC BE
Triakis semifasciata	leopard shark	OC BE[c]
Osteichthyes - Bony Fishes		
Family Atherinidae		
Atherinops californiensis	jacksmelt	MW H/NSB OC IT SRRF KB
Leuresthes tenuis	California grunion	MW OC BE
Family Bothidae		
Citharichthys sordidus	Pacific sanddab	SB H/NSB
Family Carangidae		
Seriola lalandi	yellowtail	RRF KB[c]
Family Clinidae		
Heterostichus rostratus	giant kelpfish	MW H/NSB OC IT SRRF KB
Family Clupeidae		
Sardinops sagax	Pacific sardine	MW
Family Cottidae		
Cottidae	sculpins	BE[c]
Leptocottus armatus	Pacific staghorn sculpin	H/NSB BE
Scorpaenichthys marmoratus	cabezon	IT RRF SRRF KB
Family Engraulididae		
Engraulididae	anchovies	nearshore[b]

Table 5 (Continued)
FISH IDENTIFIED FROM NON-OTOLITH DATA

Taxon	Common Name	Habitat[a]
Family Kyphosidae		
Medialuna californiensis	halfmoon	RRF SRRF KB
Family Labridae		
Halichoeres semicinctus	rock wrasse	MW SRRF KB
Oxyjulis californica	Señorita	RRF SRRF KB
Family Molidae		
Mola mola	ocean sunfish	oceanic at surface[b]
Family Muraenidae		
Gymnothorax mordax	California moray eel	SRRF[c]
Order Pleuronectiformes		
Pleuronectiformes	flatfishes	SB[c]
Family Pleuronectidae		
Eopsetta jordani	petrale sole	SB[c]
Hypsopsetta guttulata	diamond turbot	H/NSB BE
Psettichthys melanostictus	sand sole	5 to 27 ft.[d]
Family Pomacentridae		
Chromis punctipinis	blacksmith	RRF SRRF KB
Family Sciaenidae		
Sciaenidae	drums and croakers	SB BE[c]
Family Scombridae		
Sarda chiliensis	Pacific bonito	MW RRF KB
Scomber japonicus	Pacific or chub mackerel	MW
Thunnus sp.	tunas	open water, rarely nearshore[c]
Family Scorpaenidae		
Sebastes caurinus	copper rockfish	rocky or mixed sand to 600 ft.[c]
S. rosenblatti	greenblotched rockfish	rocky substrate 200-1,300 f.[c]
Family Serranidae		
Paralabrax maculatofasciatus	spotted sand bass	BE
P. nebulifer	barred sand bass	all but IT
Serranidae	sea basses and groupers	bottom dwellers[b]
Family Stichaeidae		
Cebidichthys violaceus	monkeyface prickleback	IT to 80 ft.[d]
Family Xiphiidae or Istiophoridae		
Xiphiidae/Istiophoridae	swordfishes/billfishes	offshore[c]

[a] Habitats: bay/estuary (BE), open coast sandy beach (OC), harbor/nearshore soft bottom (H/NSB), nearshore midwater (MW), offshore soft bottom (SB), rocky intertidal (IT), shallow rock reef (SRRF), deep rock reef (RRF), and kelp bed (KB). Habitat information from Allen (1985) unless otherwise noted.

[b] Habitat information from Eschmeyer et al. (1983).

[c] Habitat information from Salls (1988).

[d] Habitat information from Miller and Lea (1972).

Table 6
ABUNDANCE OF ROCKFISH AND SURFPERCH

Site and Period	Rockfish	Surfperch
SCRI-191		
Late Period	69.38%	23.75%
Transitional Period	65.96%	29.25%
Middle Period	50.92%	44.44%
SCRI-192		
Historic Period	85.14%	12.16%
Late Period	92.13%	6.23%
SCRI-330		
Historic Period[a]	94.44%	5.5%
Late Period	89.23%	7.69%
SCRI-474		
Transitional Period[a]	92.86%	7.14%
Middle Period	74.67%	22.70%

[a] represents only one excavation level.

cormorants were the most common identified bird in the San Miguel Island archaeological deposits.

A broader regional perspective on these results, achieved by comparison to similar analyses from the mainland coast and the mainland interior, is instructive. Few sites from these zones span the transition from the Middle to Late periods and few faunal data are available. Macko's (1984) analysis of faunal remains from a column sample from CA-SBA-485, a Late Period site in the interior Santa Ynez River Valley, is one of the few published reports for that area that provides information on subsistence. Using the data from Macko's (1984:79-84) column samples, the meat weights were estimated employing the same methods as those used for the Santa Cruz Island material (Table 8). Macko's data indicate that the relative contributions to the diet were (raw weight of bone or shell in parentheses): 52.92% fish (13.5 g.), 17.46% marine mammal (5.1 g.), 13.75% mammal (9.72 g.), 4.56% bird (2.15 g.), 2.73% shellfish (112.8 g.), and 8.56% from unidentified vertebrates (6.05 g.; calculated using the terrestrial mammal conversion factor).

Another site of interest is CA-SBA-1731, on the mainland coast west of Santa Barbara. Although the report on investigations at CA-SBA-1731 (Dames and Moore 1993:188-193) stated that it was occupied during the Middle and Late periods, radiocarbon dates and densities of cultural material suggest that the most intense occupation was during the Transitional Period, approximately A.D. 1150 to 1300. The overall composition of the diet, when calculated in the same manner as the Santa Cruz Island data, indicates a more terrestrially oriented economy than the Santa Cruz Island sites (Fig. 10, Table 8). As much as 9.5% of the assemblage is from terrestrial mammals in some strata. Marine mammals are also much more important, ranging between 25% and 64% of the estimated meat weight. Shell is very rare in this site, particularly when compared to the island sites. Fish increased in importance through time at CA-SBA-1731.

The fish remains from CA-SBA-1731 provide an interesting contrast to the Santa Cruz Island assemblage (Bowser 1993b). Rockfish and surfperch were also important at CA-SBA-1731, although not as important as on the island, constituting 41.51% of the identified otoliths (Bowser 1993b:163). The relationship between rockfish and surfperch is different than that on the island. In the Santa Cruz Island samples, rockfish increase in importance while surfperch decrease in importance through time (Table 6), while at CA-SBA-1731 rockfish decrease in importance. In the CA-SBA-1731 Transitional Period levels, rockfish otoliths are more common (27.05%) than those of surfperch (8.9%), while in the Late Period levels, surfperch otoliths are more prevalent (42.86%)

Table 7
GEOGRAPHIC RANGE[a] AND TAXONOMIC DIVERSITY[b] OF FISH SPECIES

Time Period	% South	% North	% Transitional	Diversity
Historic	0.0	5.7	94.3	0.91
Late	3.8	5.6	90.7	0.90
Transitional	6.2	8.1	85.7	0.94
Middle	2.6	6.6	90.8	0.89

[a] percentage of fish that could be classified to range.
[b] Simpson's Index of Diversity (Krebs 1978).

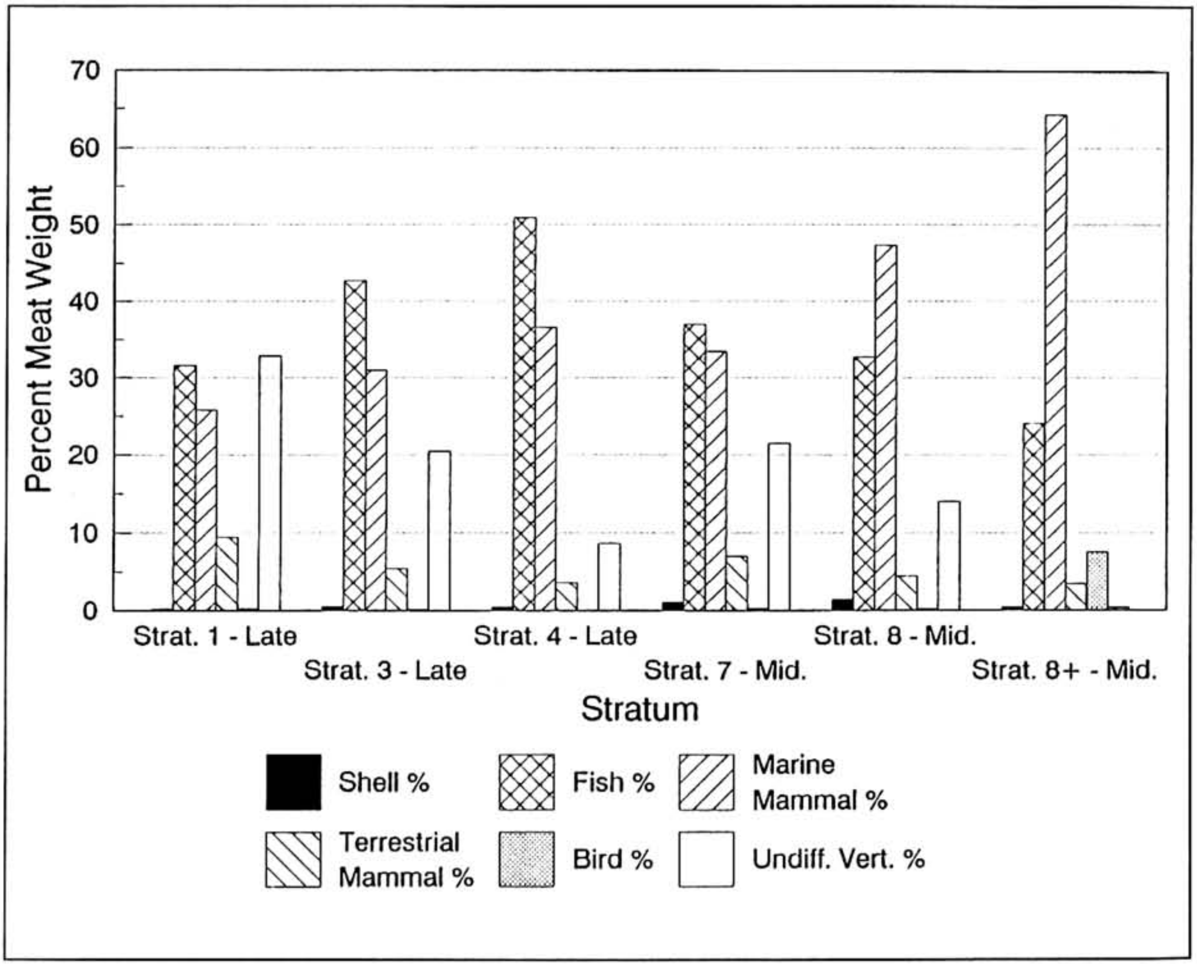

Fig. 10. Estimated meat weight by stratum at CA-SBA-1731.

Table 8
MEAT WEIGHT ESTIMATES FOR THREE ECOLOGICAL ZONES

Location	Zone	Fish	Shellfish	Marine Mammal	Terrestrial Mammal	Mammal	Bird	Undiff. Bone[d]
SCRI[a]	Island	62.21%	23.10%	9.41%	0.17%	4.20%	0.89%	N/A
SBA-1731[b]	Mainland	43.04%	0.36%	31.78%	5.69%	N/A	0.60%	19.07%
SBA-485[c]	Interior	52.92%	2.73%	17.46%	N/A	13.75%	4.56%	8.56%

[a] Late Period levels from three sites combined.
[b] Late Period levels only.
[c] Calculated from column sample data (Macko 1984:79-84); 3.962 mm. mesh screens (approximately 1/8-in.); shell meat weight calculated using conversion factor for *Chione undatella* (Erlandson 1994:59).
[d] Undifferentiated bone, estimated using terrestrial mammal conversion factor.

than those of rockfish (16.48%). Bowser (1993b) concluded that faunal exploitation at this site is related to increased availability of warm water marine resources, particularly fish.

DISCUSSION

This analysis is important for several reasons. First, it provides new faunal data from the northern Channel Islands, an area for which few quantified faunal data exist. Second, these data may be examined at the regional level to learn more about Santa Barbara area prehistory, particularly regional and temporal variability in subsistence and patterns of animal resource use. Third, it provides additional information about paleoenvironment during the critical Transitional Period, approximately A.D. 1150 to 1300, a time of cultural and environmental change in the Santa Barbara Channel region. Finally, these data have relevance for understanding cultural change during the Transitional Period.

In general, the faunal data presented here support the traditional model of decreasing importance of marine mammals and shellfish and increasing reliance on fish. According to meat weight estimates, the Middle through Historic period occupants of western Santa Cruz Island relied almost exclusively on marine resources for animal foods, with terrestrial mammals and birds playing relatively minor roles. There was some intersite variability, however, in the relative importance of various marine resources. These general patterns of faunal exploitation are consistent with those found at other sites on Santa Cruz Island (Glassow 1993) and San Miguel Island (Walker and Snethkamp 1984). In contrast, sites on the mainland coast and in the interior exhibit different patterns of faunal remains (Table 8). CA-SBA-1731, a Middle to Late period transitional site on the mainland coast, contained little shell while fish and marine mammals were important in the diet. Not surprisingly, terrestrial mammals were more important at this site than on the islands. At CA-SBA-485, a Middle to Late period site in the Santa Ynez River Valley, the order of importance in the diet was marine fish, marine mammals, terrestrial mammals, birds, and shellfish. These data demonstrate that marine resources were important in all three of the broad ecological zones of the Santa Barbara Channel area during the Late Period.

The importance of marine resources in the interior is surprising because these animal products would have been carried over the Santa Ynez Mountains. These data suggest that the Santa Ynez Mountains were not a significant barrier for transporting animal resources from the coast to the interior and may indicate regular, perhaps daily, interaction between these two areas. The faunal data from the mainland coast and the Santa Ynez River Valley are from only two sites and sample sizes are relatively small, so these results warrant further examination.

Both the island and the mainland data show a *decrease* in the importance of marine mammals through time. This could be the result of overexploitation by Native American hunters, a pattern consistent with Hildebrandt and Jones's (1992) study of marine mammal hunting.[2] The result is an emphasis, in both areas, on animals lower on the food chain, such as fish and shellfish, at some sites on the island. This is also a shift from "k-strategy" species, or animals that produce few offspring and invest a lot of energy in raising them, to "r-strategy" species, or species that produce many offspring and invest little energy in raising them. K-strategy species are not reproductively adapted to drastic changes in number caused by overexploitation by hunter-gatherers or severe environmental change.

An alternate, or additional, factor in the declining importance of marine mammals in the diet is the effect of environmental change on these animals. Pinnipeds are the most common marine mammals in the Santa Cruz Island assemblage, and studies of a recent El Niño-Southern Oscillation (ENSO) indicate that seal and sea lion populations are severely impacted by major changes in water temperature (Trillmich and Limberger 1985; Trillmich and Ono 1991). During recent warm water events, pinnipeds suffered major population declines and pup mortality. A combination of overexploitation of marine mammals by Native Californians and changing environmental conditions may have been an important stimulus in the development of fishing as a major source of animal food.

Fish and shellfish data from the islands also provide information about prehistoric environments. While these data do not indicate extreme environmental fluctuations, they support paleoenvironmental reconstructions that show sea temperature change during the period from A.D. 1150 to 1300. The paleoenvironmental data, in combination with data on animal exploitation, have a bearing on alternative models for the emergence of cultural complexity in the region. While these data do not pertain to the Early Period, the time that King (1990) asserted that chiefdoms emerged in the region, they are relevant to the period when Arnold (1992) maintained complexity developed. Arnold's (1992) model includes environmental change as one of several factors in the emergence of social complexity in the Santa Barbara Channel region, and these data indicate changes in prehistoric environment during that time. The exact nature of the changes, and their importance for human adaptation and organization, are subject to various interpretations.

It should be clear from this analysis that, rather than decreased densities of faunal remains during the Transitional Period, data from Santa Cruz Island show slightly increased density of fish remains during that period. In addition, data from CA-SBA-1731, on the mainland coast, show that the highest density of fish remains occurred during the Transitional Period. While the density of faunal remains in middens is not a direct reflection of marine productivity, it seems that fish populations were not significantly reduced by the water temperature increase that occurred during the Transitional Period. The severe drought that occurred during the Transitional Period probably caused a reduction in the availability of terrestrial resources, forcing people to turn to marine resources for food. The increased water temperature, in combination with hunting pressure, would have decreased marine mammal populations, leaving fish, and in some places shellfish, as the best sources of animal food.

CONCLUSIONS

It is argued here that the paleoenvironmental data derived from these faunal collections demonstrate environmental change during the Transitional Period. Rather than reduced marine productivity, more complex changes probably occurred. Clearly, there is much that can be learned about prehistoric diet, paleoenvironment, and culture change by studying faunal assemblages such as those discussed here. If we take a regional perspective and apply uniform methods, we can better address issues of paleoenvironmental and culture change using faunal data.

NOTES

1. The bones were identified with the aid of the reference collections in the Zooarchaeology Laboratory in the Institute of Archaeology at the University of California, Los Angeles, the Natural History Museum of Los Angeles County, and the Page Museum, and by consulting with other zooarchaeologists. For the general dietary reconstruction, I combined data from specimens positively identified to element and taxon with those from the more general categories such as marine mammal. Undifferentiated marine mammal bones were identified by the presence of large amounts of cancellous bone or very thin cortical bone. Undifferentiated terrestrial mammal bone was identified on the basis of thick cortical bone, and was very rare. Undifferentiated bird bones were often identified to element but could not be classified to taxon due to erosion or lack of diagnostic features, or were bone fragments with the characteristic surface and/or interior texture of bird bone.

2. While aspects of Hildebrandt and Jones's (1992) study are supported by the current analysis, their presentation of data from the Santa Barbara area is marred by at least one serious error. They stated (1992:388) that seals and sea lions made up roughly 35% of the vertebrate fauna at CA-SBA-142, the Glen Annie Canyon site. The page they cited is a list of shellfish taxa present at that site (Owen et al. 1964:464), and no counts or weights of marine mammal bones exist in the referenced report.

ACKNOWLEDGEMENTS

The field and laboratory processing of the Santa Cruz Island material was supported by National Science Foundation Grant BNS 88-12184, which was awarded to Jeanne Arnold. My research has been supported by the UCLA Friends of Archaeology and a UCLA Chancellor's Dissertation Year Fellowship. I thank Joyce Gerber and Jon Erlandson for access to the CA-SBA-1731 data. The late Tim Seymour created the maps, and Danny Brauer modified them for this publication. Richard Huddleston identified the otoliths. I thank Sarah Berry and Jean Hudson for comments on earlier drafts of this paper. Michael Glassow, Associate Editor for the *Journal*, and four not-so-anonymous reviewers provided many valuable comments that greatly improved the clarity and accuracy of this paper.

REFERENCES

Allen, Larry G.
1985 A Habitat Analysis of the Nearshore Marine Fishes from Southern California. Bulletin of the Southern California Academy of Sciences 84(3):133-155.

Arnold, Jeanne E.
1987 Craft Specialization in the Prehistoric Channel Islands, California. Berkeley: University of California Publications in Anthropology Volume 18.
1991 Transformation of a Regional Economy: Sociopolitical Evolution and the Production of Valuables in Southern California. Antiquity 65(249):953-962.
1992 Complex Hunter-Gatherer-Fishers of Prehistoric California: Chiefs, Specialists, and Maritime Adaptations of the Channel Islands. American Antiquity 57(1):60-84.
1993 Labor and the Rise of Complex Hunter-Gatherers. Journal of Anthropological Archaeology 12(1):75-119.

Arnold, Jeanne E., and Ann Munns
1994 Independent or Attached Specialization: The Organization of Shell Bead Production in California. Journal of Field Archaeology 21(4):473-489.

Arnold, Jeanne E., and Brian Tissot
1993 Measurement of Significant Marine Paleotemperature Variation Using Black Abalone Shells from Prehistoric Middens. Quaternary Research 39(3):390-394.

Blackburn, Thomas
1976 Ceremonial Integration and Social Interaction in Aboriginal California. In: Native Californians, A Theoretical Retrospective, Lowell Bean and Thomas Blackburn, eds., pp. 225-244. Menlo Park: Ballena Press.

Bowser, Brenda
1993a Dead Fish Tales: Analysis of Fish Remains from Two Middle Period Sites on San Miguel Island, California. In: Archaeology on the Northern Channel Islands of California, Studies of Subsis-

tence, Economics, and Social Organization, Michael Glassow, ed., pp. 55-136. Coyote Press Archives of California Prehistory No. 34.

1993b Fish Remains. In: Archaeological Investigations at CA-SBA-1731: A Transitional Middle-to-Late Period Site on the Santa Barbara Channel, by Dames and Moore, pp. 141-170. Report on file at the Central Coast Information Center, University of California, Santa Barbara.

Collins, Paul

MS Checklist of Vertebrates of Santa Cruz Island. MS in possession of the author.

Colten, Roger H.

1991 Preliminary Analysis of Faunal Remains From Four Sites on Santa Cruz Island, California. In: Proceedings of the Society for California Archaeology, Vol. 5, Martin D. Rosen, Lynne E. Christenson, and Don Laylander eds., pp. 247-267. San Diego: Society for California Archaeology.

1993 Prehistoric Subsistence, Specialization, and Economy in a Southern California Chiefdom. Ph.D. dissertation, University of California, Los Angeles.

Dames and Moore

1993 Archaeological Investigations at CA-SBA-1731: A Transitional Middle-to-Late Period Site on the Santa Barbara Channel. Report on file at the Central Coast Information Center, University of California, Santa Barbara.

Erlandson, Jon M.

1994 Early Hunter-Gatherers of the California Coast. New York: Plenum Press.

Erlandson, Jon M., and Roger H. Colten (eds.)

1991 Hunter-Gatherers of Early Holocene Coastal California. University of California, Los Angeles, Perspectives in California Archaeology 1.

Erlandson, Jon M., Roger H. Colten, and Michael A. Glassow

1988 Reassessing the Chronology of the Glen Annie Canyon Site (CA-SBA-142). Journal of California and Great Basin Anthropology 10(2):237-245.

Eschmeyer, William N., Earl S. Herald, and Katherine Hammann

1983 A Field Guide to Pacific Coast Fishes. Boston: Houghton Mifflin.

Glassow, Michael

1975 Considerations in the Evaluation of the Archaeological Significance of Sites of the Santa Barbara Channel Mainland. Paper presented at the Society for California Archaeology Fall Data Sharing Meeting, California State University, Northridge.

1980 Recent Developments in the Archaeology of the Channel Islands. In: The California Islands: Proceedings of a Multidisciplinary Symposium, Dennis M. Power, ed., pp. 79-99. Santa Barbara: Santa Barbara Museum of Natural History.

1993 Changes in Subsistence on Marine Resources Through 7,000 Years of Prehistory on Santa Cruz Island. In: Archaeology on the Northern Channel Islands of California, Studies of Subsistence, Economics, and Social Organization, Michael Glassow, ed., pp. 75-94. Coyote Press Archives of California Prehistory No. 34.

Glassow, Michael, and Larry Wilcoxon

1988 Coastal Adaptations Near Point Conception, California, with Particular Regard to Shellfish Exploitation. American Antiquity 53(1):36-51.

Grayson, Donald

1984 Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas. New York: Academic Press.

Guthrie, Daniel A.

1980 Analysis of Avifaunal and Bat Remains from Midden Sites on San Miguel Island. In: The California Islands: Proceedings of a Multidisciplinary Symposium, Dennis M. Power, ed., pp. 689-702. Santa Barbara: Santa Barbara Museum of Natural History.

Hildebrandt, William R., and Terry L. Jones

1992 Evolution of Marine Mammal Hunting: A View from the California and Oregon Coasts. Journal of Anthropological Archaeology 11(4):360-401.

Johnson, John R.

MS Observations on Fish Remains from Five Santa Cruz Island Archaeological Sites. MS in possession of the author.

1982 An Ethnohistoric Study of the Island Chumash. Master's thesis, University of California, Santa Barbara.

1988 Chumash Social Organization: An Ethnohistoric Perspective. Ph.D. dissertation, University of California, Santa Barbara.

King, Chester D.
1990 Evolution of Chumash Society: A Comparative Study of Artifacts Used for Social System Maintenance in the Santa Barbara Channel Region Before A.D. 1804. New York: Garland.

King, Linda
1969 The Medea Creek Cemetery (LAn-243): An Investigation of Social Organization From Mortuary Practices. Los Angeles: University of California, Archaeological Survey Annual Report 11:23-68.

1982 Medea Creek Cemetery: Late Inland Chumash Patterns of Social Organization, Exchange, and Warfare. Ph.D. dissertation, University of California, Los Angeles.

Krebs, Charles J.
1978 Ecology: The Experimental Analysis of Distribution and Abundance. New York: Harper and Row.

Lambert, Patricia, and Phillip Walker
1991 Physical Anthropological Evidence for the Evolution of Social Complexity in Coastal Southern California. Antiquity 65(249): 963-973.

Landberg, Leif
1965 The Chumash Indians of Southern California. Southwest Museum Papers No. 19.

Larson, Daniel, Joel Michaelson, and Phillip Walker
1989 Climatic Variability: A Compounding Factor Causing Culture Change Among Prehistoric Coastal Populations. Paper presented at the annual meetings of the Society for American Archaeology, Atlanta.

Macko, Michael
1984 Beads, Bones, Baptisms, and Sweatlodges: An Analysis of Collections from "Elijman" (CA-SBA-485), A Late Period Ynezeno Chumash Village in the Central Santa Ynez Valley, California. Master's thesis, University of California, Santa Barbara.

Martz, Patricia
1984 Social Dimensions of Chumash Mortuary Populations in the Santa Monica Mountains Region. Ph.D. dissertation, University of California, Riverside.

1992 Status Distinctions Reflected in Chumash Mortuary Populations in the Santa Monica Mountains Region. In: Essays on the Prehistory of Maritime California, Terry L. Jones, ed., pp. 145-156. Davis: Center for Archaeological Research at Davis, Publication No. 10.

Miller, Daniel J., and Robert N. Lea
1972 Guide to the Coastal Marine Fishes of California. State of California, The Resources Agency, Department of Fish and Game, Fish Bulletin 157.

Minnich, Richard
1980 Vegetation of Santa Cruz and Santa Catalina Islands. In: The California Islands: Proceedings of a Multidisciplinary Symposium, Dennis M. Power, ed., pp. 123-138. Santa Barbara: Santa Barbara Museum of Natural History.

Olson, Ronald
1930 Chumash Prehistory. University of California Publications in American Archaeology and Ethnology 28(1).

Owen, R. C., F. Curtis, and D. S. Miller
1964 The Glen Annie Canyon Site, SBa-142, An Early Horizon Coastal Site of Santa Barbara County. Los Angeles: University of California, Archaeological Survey Annual Report 6:431-520.

Pisias, Nicklas
1978 Paleoceanography of the Santa Barbara Basin During the Last 8,000 Years. Quaternary Research 10(3):366-384.

1979 Model for Paleoceanographic Reconstructions of the California Current During the Last 8,000 Years. Quaternary Research 11(3):373-386.

Rehder, Harald A.
1981 The Audubon Society Field Guide to North American Seashells. New York: Alfred A. Knopf.

Rogers, David Banks
1929 Prehistoric Man of the Santa Barbara Coast. Santa Barbara: Santa Barbara Museum of Natural History.

Salls, Roy
1988 Prehistoric Fisheries of the California Bight. Ph.D. dissertation, University of California, Los Angeles.

Stevenson, Barbie
1989 El Niño Effects on Shellfish Exploitation for the Prehistoric Chumash of Santa Cruz

Island. Senior Honors thesis, Department of Anthropology, University of California, Los Angeles.

Stine, Scott
1994 Extreme and Persistent Drought in California and Patagonia During Mediaeval Time. Nature 369(6481):546-549.

Tartaglia, Louis
1976 Prehistoric Maritime Adaptations in Southern California. Ph.D. dissertation, University of California, Los Angeles.

Timbrook, Janice
1984 Chumash Ethnobotany: A Preliminary Report. Journal of Ethnobiology 4(2): 141-169.

1993 Island Chumash Ethnobotany. In: Archaeology on the Northern Channel Islands of California, Studies of Subsistence, Economics, and Social Organization, Michael Glassow, ed., pp. 47-62. Coyote Press Archives of California Prehistory No. 34.

Trillmich, F., and D. Limberger
1985 Drastic Effects of El Niño on Galapagos Pinnipeds. Oecologia 67(1):19-22.

Trillmich, F., and K. A. Ono (eds.)
1991 Pinnipeds and El Niño. Ecological Studies 88. Heidelberg: Springer-Verlag.

Walker, Phillip
1986 Porotic Hyperostosis in a Marine-Dependent California Indian Population. American Journal of Physical Anthropology 69(3):345-354.

1989 Cranial Injuries as Evidence of Violence in Prehistoric Southern California. American Journal of Physical Anthropology 80(3):313-323.

Walker, Phillip, and Patricia Lambert
1989 Skeletal Evidence for Stress During a Period of Cultural Change in Prehistoric California. In: Advances in Paleopathology, Luigi Capasso, ed., pp. 207-212. Journal of Paleopathology, Monographic Publication No. 1. Solfanelli: Chieti, Italy.

Walker, Phillip, and Pandora Snethkamp
1984 Archaeological Investigations on San Miguel Island--1982. Prehistoric Adaptations to the Marine Environment. Report on file at the Department of Anthropology, University of California, Santa Barbara.

Ziegler, Alan C.
1973 Inference from Prehistoric Faunal Remains. Addison-Wesley Module in Anthropology 43.

1975 Recovery and Significance of Unmodified Faunal Remains. In: Field Methods in Archaeology, Thomas R. Hester, Robert F. Heizer, and John A. Graham, eds., pp. 183-206. Palo Alto: Mayfield Publishing Co.