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Small Mammal Procurement in Coastal Contexts: A California Perspective

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Faunal remains from two sites spanning the Middle and Late Holocene (8,000-300 BP) in central California show a decline in small mammal, primarily rabbit, procurement through time, despite growing human populations and intensification of a number of other resources. Models derived from optimal foraging theory and a broader subsistence approach are used to investigate the role rabbits played within the context of human population increase, emerging long-distance and intensified local exchange, and developing socio-political complexity. The models suggest that the best explanation of the identified faunal pattern is a change in patch choice with a concurrent shift to sea otter pelts as exchange items. Models based on optimal foraging theory need to consider the non-dietary value of certain resources to better understand faunal assemblages from archaeological sites.

Current trends in the analysis of small mammal remains from archaeological contexts include environmental and demographic reconstruction (Stiner et al. 1999, 2000), changes in mobility (Bar-Yosef and Belfer-Cohen 1989), and small mammal contributions to subsistence (e.g., Grayson 1991). Ethnohistoric data indicate that in some contexts small mammal pelts, particularly from leporids (rabbits and hares), have played an important role in interregional exchange (Shaffer and Gardner 1995).

In coastal contexts, where subsistence emphasis is often placed on marine resources, changes in small mammal procurement present an interpretive challenge. This paper focuses on leporid abundances and their relation to the abundances of other taxa in two midden assemblages spanning Middle and Late Holocene cultural developments in coastal California (Figure 1). The prehistoric Chumash lived on both the mainland and the northern Channel Islands of California. These islands were never colonized by large terrestrial mammals, nor are they home to leporids; this discussion pertains only to the coastal mainland. The pattern of leporid procurement is examined from a diet-focused approach using optimal foraging theory and a general subsistence model. In this paper, 'subsistence' refers to the exploitation of resources for diet, hides, raw material, and trade goods, whereas 'diet' is limited to the portion of subsistence practices concerning what people eat. The decrease in rabbit bones through time at the sites is attributed to changes in patch choice, scheduling conflicts, and substitution of sea otter pelts for rabbit skins.

THE CENTRAL CALIFORNIA COAST IN PREHISTORY

The Terminal Pleistocene, ca. 11,000 BP, witnessed the first human occupation of the central California coast on the northern Channel Islands (Erlandson 1994). A general trend in population increase, aggregation and emerging sedentism, intensification, and political centralization is visible (Glassow and Wilcoxon 1988; King 1990; Lambert and Walker 1991; Kennett 1998). People living along the southern central California coast during the Early Holocene (10,000 - 7,000 BP) subsisted primarily on protein-rich shellfish and a variety of terrestrial resources, including deer and small mammals. McGuire and Hildebrandt (1994) have argued that rabbits were an important part of early Holocene diets in southern and central California. In addition, grass seeds were heavily exploited (Erlandson 1991, 1994), and manos and metates dominate assemblages from this period and testify to their dietary importance.

The greater number of sites known from the Middle Holocene (7,000-3,000 BP) suggests higher population densities (Erlandson 1997a, 1997b). This interval is characterized by a gradual increase in fishing (Glassow 1997) with a decrease in terrestrial mammal remains in coastal middens. Contracting-stem dart points and mortars and pestles appear between 5,000-4,000 BP. Although it has been suggested that the first mortars and pestles were used for processing tubers in esturine contexts (Glassow 1997), it is generally argued that their widespread use signifies an increase in acorn use (Basgall 1987; Glassow and Wilcoxon 1988; Glassow 1996). Concurrently, some areas of coastal California show an increase in evidence for long distance exchange (Jones 1996).

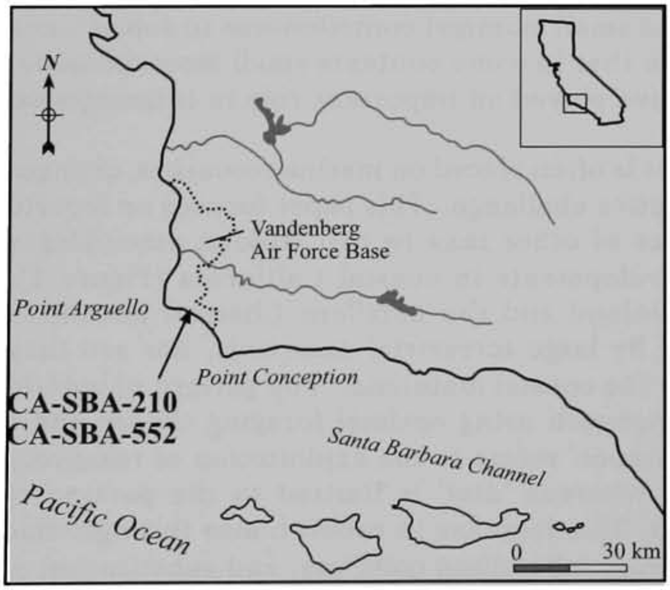

Figure 1. Location of sites discussed in text.

During the Late Holocene (3,000-200 BP), subsistence remained focused on marine resources and acorns. Development of the plank canoe (~1,500 BP; Hudson et al. 1978) and more open-water fishing technologies (Glassow 1977) allowed hunters to target a wider range of fish and sea mammals. In addition, the introduction of the bow and arrow (~1,500 BP) coincides with increased inter-village and inter-tribal warfare (Lambert 1994). After 640 BP, this trend culminates with the emergence of complex sociopolitical and economic systems, including craft specialization and widespread exchange (Arnold 1987, 1991, 1992). At contact, the Chumash had a mixed economy with a variety of food stuffs. Of these, marine resources, acorns, and large terrestrial game were the most heavily exploited. Fishing was a focus among coastal groups: kelp bed fish were caught throughout the year and more pelagic species seasonally (Landberg 1965).

In summary, the cultural sequence on the southern central coast of California shows a trend towards greater population density, increased sedentism, and a focus on marine resources and acorns as subsistence staples. The significance of leporids within this context is the focus of this analysis.

ETHNOHISTORIC EVIDENCE FOR LEPORID PROCUREMENT ON THE CENTRAL CALIFORNIA COAST

Rabbit hunting along the California coast has received relatively little attention, although ethnohistoric accounts document its existence and some of its complexity. Despite earlier European contact, much of the ethnohistoric information on the Chumash comes from members of the Portolá expedition and early Franciscan missionaries of the 18th century. In contrast to the well researched and documented rabbit drives in the Great Basin and the American Southwest (Shaffer and Gardner 1995), rabbit hunting along the coast appears to have taken place on a smaller scale. Unfortunately, these accounts do not differentiate between jackrabbits (*Lepus* spp.) and brush rabbits (*Sylvilagus bachmani*), so it is unclear which taxon was targeted. Little information on Chumash groups north of Point Conception is available (Glassow 1996), but it is possible to gain some insights from the better documented groups in the Santa Barbara Channel area.

Individual rabbit hunting included snaring, shooting, and trapping (Hudson and Blackburn 1982). Throwing sticks were used to stun or kill rabbits and other small animals. Deadfall traps were documented in the 1880s as a figure-four trap with a suspended stone to fall on the game (Hudson and Blackburn 1982). Other kinds of traps are documented for a variety of small animals. Rabbits were also shot with arrows (Woodman et al. 1991) and possibly snared by spring-pole snares (Hudson and Blackburn 1982).

Rabbit drives may have taken place as either large- or small-scale activities. Small rabbit nets with a fine mesh were used by old men who fixed the net in a path where rabbits were to be driven (Hudson and Blackburn 1982). This would be an effective technique to capture several animals at once with relatively little time and energy investment. It could be done on a small scale: a group of bushes with known rabbit nests could be disturbed to drive the animals into the net.

Large rabbit drives were also known among the Chumash. These consisted of people strategically setting a large cordage net into which rabbits were driven so that they could be snared and clubbed. Some nets may have been up to 100 feet long (Hudson and Blackburn 1982:70). The evidence of larger-scale rabbit drives is supported further by ethnohistoric documentation of vegetation burning among coastal Chumash groups (see Timbrook et al. 1982). In describing burning practices, several references are made to the capture of rabbits as an additional advantage. In José Longino Maritínez's journal from the expedition conducted as part of the botanical survey of the Spanish empire in America (1791/92), generating new grass shoots and catching rabbits are described as the main purposes for burning among the indigenous peoples of the Santa Barbara coast (in Timbrook et al. 1982). Similar information is available from locations in the interior (Woodman et al. 1991). The ethnographer J. P. Harrington mentions an Inseño woman hunting rabbits by burning near Mt. Pinos and also refers to the former existence of Chumash rabbit-drive officials (Harrington 1942). This implies that communal rabbit drives were conducted.

Descriptions of the intricate and complex exchange system recorded at the time of contact also include some limited information on rabbits. Interior groups traded rabbit and fox furs, the former likely in the form of blankets, with coastal and island groups (Landberg 1965). Among the Shoshoni, one adult rabbit blanket required 100 skins to produce, whereas a child's blanket used 40 skins (Wheat 1967). If the interior groups were indeed specializing in rabbit furs as a trade item, they would have needed a concerted effort to capture and process the number of required animals. Rabbit drives demand organization and cooperation. Several people, at times entire villages, would be needed to trap, club, and process the animals. This also suggests that questions of ownership must be answered in advance (Shaffer and Gardner 1995).

Since most materials associated with rabbit drives are perishable, they are practically impossible to identify prehistorically (Shaffer and Gardner 1995). Furthermore, ethnohistoric information for driving among the Chumash is scant: there is little information about the season or organization of the drives. Information presented above indicates that the potential role played by these small mammals in Chumash society cannot be conceived in only nutritional terms. They also had economic importance in trade, especially when taken in great numbers through drives. For this reason it is interesting to examine small mammal procurement prehistorically along the central California coast in light of two models: optimal foraging theory with its emphasis on diet, and a general subsistence model that takes the value of pelts into account.

MODELS OF SMALL MAMMAL PROCUREMENT

Optimal Foraging Theory

Optimal Foraging Theory is based on the assumption that rational decisions of individuals under a set of specified conditions will maximize the net rate of energy gain in foraging activities (e.g., Stephens and Krebs 1986; Hill et al. 1987). Optimal Foraging Theory involves two fundamental models. In the diet breadth model, optimal foragers select the combination of food types that maximizes their net energy intake per unit of foraging time (Kaplan and Hill 1992; Winterhalder and Smith 2000). Resources are ranked depending on their return rate per unit of extraction time (e.g., Broughton 1994, 1997; Smith 1991). Since a forager will not forego a higher-ranked resource for a lower-ranked resource, the use of low-ranked resources also implies use of high-ranked resources to the extent they are available.

One problem with the diet breadth model is the assumption that the probability of encountering a resource is independent of any previous encounters with it or a different resource (see Cannon 2003). The patch choice model addresses the distribution of resources in space, focusing on groups of resources found in a certain area (e.g., Smith 1991; Broughton 1994). The relationship between patch choice and diet breadth models is close. Patches are ranked using similar resource criteria, according to the net rate of energy intake per unit of foraging time. Travel time to and from patches is taken into consideration in the ranking, in addition to amount and kinds of resources available within a patch. In contrast to the diet breadth model, patches may contain an assemblage of several exploitable resources. For this reason, resources considered of low rank, but that are abundant in a high ranking patch, may be more prevalent in the diet.

Long-term changes in dietary adaptations are usually characterized in terms of the relative contributions of high-ranked resources; e.g., shifts from terrestrial to maritime adaptations. Higher-ranked resources provide the base line for diet and set the framework for people's spatial and temporal organization. Low-ranked resources, however, may also be informative in understanding changes in foraging strategies. Under what conditions can the contribution of a low-ranked resource change? When can a low-ranked resource take on greater dietary importance, and when can it be excluded from the foraging strategy?

The ranking of leporids in coastal contexts is not easily defined. The common expectation, especially in coastal California, is that rabbits are a relatively marginal subsistence resource in comparison to the large numbers of available marine resources (sea mammals, fish, shellfish). This is supported by the apparent decrease in terrestrial fauna and increased focus on marine resources during the Middle and Late Holocene. However, some have suggested that small mammals, especially rabbits, are not necessarily low-ranked. McGuire and Hildebrandt (1994) argue that rabbit procurement is more similar to collecting than hunting. Some procurement techniques, such as driving, result in low pursuit costs and may place rabbits higher on a ranking scale. Since most artifacts associated with rabbit drives are perishable, the procurement method of these animals must be inferred from the faunal remains (see Madsen and Schmitt 1998; Grayson and Cannon 1999; Cannon 2003). Furthermore, small game may be more sensitive indicators of basic changes in prehistoric foraging activities, due to their life history and potential disparities in their ranking as resources (Winterhalder and Smith 2000:58).

Changes in Resource Use

Diet Breadth Model. Intuitively, changes in resource abundance should constitute a major catalyst for changes in resource use. However, one of the primary assumptions of the diet breadth model is that abundance should *not* influence whether a resource is included in the optimal diet. Rather, it depends entirely on the abundance of all the more highly ranked resources relative to their energetic yield (Stephens and Krebs 1986; Smith 1991; Nagaoka 2002). For this reason, one would expect the relative importance of a resource to increase only when higher-ranking resources become less productive in energetic yield. A further assumption of the model is that even as general resource abundance declines, diet breadth increases to compensate.

If rabbits are considered a low-ranked resource, the diet breadth model states that an increase should only occur in extreme situations; i.e., the disappearance or great decrease of a higher-ranked resource. Rabbits may decline in importance if higher-ranked resources become more abundant or new resources are added to the foraging strategy. The low-ranked resource would still be exploited, but its relative dietary contribution would decrease. In contrast, if rabbits are a high-ranked resource, their relative abundance (closely linked with pursuit costs) is the primary determinant of their ranking.

Patch Choice Model. Since it addresses the distribution of resources in space, focusing on groups of resources found in a certain area, the patch choice model is only analogous to the diet breadth model in some ways. A decrease in overall resource abundance may result in the inclusion of a patch originally excluded. In times of stress, a forager will exploit a wide range of patches, and by extension, a wide range of resources. In a situation where resources in patches are differentially depleted, a patch may decrease in ranking or be completely excluded from the foraging itinerary (Charnov 1976; Bettinger 1991; Nagaoka 2002). Along the same lines, a patch with an increase in a certain resource may rise in ranking. A change in patch ranking may affect the kinds of resources exploited and change their dietary importance. For changes among individual resources, the patch model is more multi-factorial. It is possible that (regardless of its abundance) a resource may decline or increase in its ranking due to changes in patch choice. In this scenario, leporid exploitation is dependent on the other resources found within the same patch, since the patch is evaluated by the combination of available resources. A change in patch choice away from rabbit habitats would result in the decrease of rabbits as a subsistence resource.

A General Subsistence Model

Resources hold value for prehistoric people in more ways than one. Animals in particular may provide raw material such as bone, sinews, and hides in addition to meat. People may value a particular resource for more than its nutritional contributions. This argument is based on the problem of defining the currency for optimization models (Winterhalder and Smith 2000) and has often been brought against the application of optimal foraging theory to archaeological contexts (e.g., Jochim 1983; Mithen 1989). Other aspects of resource use figure into the realistic choices made by foragers and must be taken into account.

Regardless of the ranking of leporids in an optimal foraging scheme, the potential importance of pelts as exchange items must be acknowledged in order to understand their role in California coastal contexts. If leporids are considered a low-ranked resource, this discussion is particularly relevant. Resources that are not high on the optimal foraging scale may be exploited for non-dietary reasons, such as for their exchange value. Their presence in midden deposits may be misinterpreted as evidence for a broad spectrum diet due to resource scarcity. In this situation, one would expect the low-ranked resource to be dependent on its "general subsistence value." The resource would decrease if other raw materials or technologies were introduced. With increased exchange and/or increased population densities, the resource should increase in quantity. Based on archaeological assemblages, this may be (mis-) interpreted as a change in diet.

Archaeological Implications

The preceding models can be tested in archaeological contexts with long chronological sequences and relatively large samples. The relative abundance of leporids may be traced through time in relation to other resources and environmental and cultural change. Table 1 presents the possibilities for changes in rabbit and hare abundance in the archaeological record based on the models. These expectations require additional information on the cultural and environmental situation of the group to identify the role leporids may have played. The analysis of leporid remains from two sites on the central coast of California is an ideal case study for evaluating these models.

SMALL MAMMALS ON PREHISTORIC SOUTH VANDENBERG

The archaeological sites considered here are located on the south side of Vandenberg Air Force Base on the central coast of California (Figure 1) and were excavated by Michael Glassow (1990, 1996). Situated on the perennial Agua Vina Creek 6 km east of Point Arguello, the sites are on raised marine terraces overlooking the coastline, and enjoy a primarily southern exposure. The area is bounded on the north by Tranquillon Ridge, the western end of the Santa Ynez Mountains. Due to its southern exposure, this location enjoys milder weather than is generally the case north of Point Conception (Glassow 1996:86). Agua Vina Creek supplies perennial fresh water and the coastal plain is relatively wide (0.5-1 km). The modern plant community is typically dominated by coastal sage scrub and other low chaparral shrubs, and hosts an abundance of mule deer (*Odocoileus hemionus*), blacktailed jackrabbit (*Lepus californicus*), and brush rabbit (*Sylvilagus bachmani*) (Glassow 1996). Marine resources in the form of pinnepeds (seals and sea lions), fish, and shellfish, abound.

The midden deposits at the two sites, CA-SBA-210 and CA-SBA-552, are unique in coastal California. They reach depths of over 5 m and span the Middle and Late Holocene, from approximately 7,800 BP to historic contact (ca. AD 1769). Few sites anywhere in California contain deposits this deep (Glassow 1996:86). Not all of the depth is attributable to cultural deposition processes. During the course of occupation, sheetwash erosion from the slopes to the north most likely introduced significant amounts of sediment to the northern half of the area where both sites are located (Glassow 1990). Based on the length and density of deposits and lack of clear information on seasonal occupation, the sites are considered to have been residential bases throughout prehistory, culminating in the village encountered protohistorically (Glassow 1990, 1996).

CA-SBA-210

CA-SBA-210 is thought to be the location of *Nocto*, a historically recorded Purisimeño Chumash village visited by the Portolá Expedition of 1769-70 (Glassow 1996:86). It consisted of 10 houses and 60 to 70 residents (King 1984:23-24), and was the only village of the period of initial European contact on south Vandenberg (Glassow 1990, 1996). The earliest date of occupation is 4650 ± 250 RCYBP.

Table 1
MODEL IMPLICATIONS

	Optimal Foraging Theory	General Subsistence Model
Decline in Use of Resource	A. Change in Patch Choice: Resource not as abundant in new high ranked patches B. Disappearance of resource (e.g. environmental change, overexploitation)	Technological Change: Resource is replaced by new raw materials or technology
Increase in Use of Resource	A. Increase in Population Density: greater diet breadth to cover demands; intensification of resource procurement	A. Increase in Population Density: increased demand for raw materials provided by resource
	B. Disappearance/Decrease of higher ranked resources; If high ranked resource: Greater abundance, lower pursuit costs	B. Increase in Exchange: products of resource in greater demand; possible specialization on resource as trade item

This analysis focuses on the small mammal remains from two units. Unit 3 measured 1.5 m by 1.5 m and reached a maximum depth of 420 cm. A total of 9.45 m^3 of midden was excavated. Unit 8 lay just to the southeast, and also measured 1.5 m by 1.5 m, but reached a maximum depth of 560 cm. A total of 12.6 m^3 of deposit was excavated from this unit. Both units were excavated in 20 cm levels and screened through 6 mm mesh screens.

Unit 3 yielded 6,824 bone fragments, 929 (14%) of which were identified as small mammal. Bone density in the midden deposit averaged 324 fragments per level (798.12/m^3). Unit 8 yielded 12,053 bone fragments, 3,689 (30%) of which were identifiable as small mammal. Bone density was higher than in Unit 3, with an average of 430 fragments per level (956.5/m^3).

CA-SBA-552

The small mammal remains from CA-SBA-552, Unit 9 were also analyzed. This site is located due east of CA-SBA-210, on the opposite bank of Agua Vina Creek. Although currently covered by grassland, the area was most likely covered in sage scrub prehistorically (Glassow 1990). The scrub-covered hills of Tranquillon Ridge rise abruptly at the northern end of the site.

Unit 9 also measured 1.5 m by 1.5 m, but reached a maximum depth of 520 cm. The unit was excavated in 20 cm levels and screened through 6 mm screens. A total of 11.48 m^3 was excavated. It should be noted that the deposit sloped into sterile soil in the lowest level, which therefore constituted only half a unit of cultural deposit. Unit 9 yielded 12,020 bone fragments, 6,209 (52%) of which were identified as small mammal. Bone density in this unit was high compared to SBA-210, with an average of 471 fragments per level (1,047/m^3).

Chronology

Four radiocarbon dates were obtained from CA-SBA-210, Unit 8 (Glassow 1996: 86). No dates were taken from above the 180-200 cm level, but glass beads and certain shell bead types indicate approximate temporal placement (Glassow 1990, 1996). Based on the vertical distribution of time-sensitive artifacts and radiocarbon dates, CA-SBA-210 had a significant occupation in the Early Period (8,000-2,500 BP), portions of the Middle Period (2,500-800 BP), and at least portions of the Late Period (800-300 BP), including the post-contact era (Glassow 1990, 1996).

CA-SBA-552, Unit 9 also spans a long chapter of prehistory, from close to the beginning of human occupation in the Vandenberg area to missionization. The chronology at CA-SBA-552 overlaps only partially with CA-SBA-210. Generally, there is evidence of earlier occupation at CA-SBA-552 and more evidence of Late Period occupation at CA-SBA-210 (Glassow 1990, 1996). Five radiocarbon dates were obtained from Unit 9 (Glassow 1996: 88). All of the dates pertain to the early phase of the Early Period, Phase Ex (8,000-5,000 BP) in King's (1990) chronology. The lower 3.5 m of midden deposit date prior to ca. 6,700 BP, the oldest date at 7990 ± 350 RCYBP. Both manos and metates were abundant in the lower levels, but not the upper levels of Unit 9. The upper levels of the unit are dated by shell beads and point types. The amount of artifactual material from the Late Period levels, however, is very small.

Site Disturbance

Both sites show evidence of rodent burrowing. Numerous krotovina were recorded during the excavation and it is likely that the majority of ground squirrel (*Spermophylus beecheyi*) and pocket gopher (*Thomomys bottae*) bones found in the midden are of natural origin (Glassow 1990; see Erlandson 1994 for a detailed discussion of gopher activity in California middens). However, the vertical distribution of faunal remains and artifacts does not show evidence of size sorting through burrowing activity (see Glassow 1990). It is therefore not likely, when taken in large chronological sections, that mixing plays an important role in diachronic changes in leporid abundance.

Due to the lack of more precise chronological control and some mixing by burrowing animals, changes in small mammal exploitation patterns can be addressed only in terms of large periods of time. Table 2 summarizes the unit components and is based on data presented by Glassow (1990).

Ecological Parameters

The identified small mammal remains are categorized into leporids, ground squirrels, and gophers. Leporids are the main focus of this analysis. Since the leporids in this region do not typically burrow (see below), the remains encountered are likely attributable to cultural, as opposed to natural or intrusive, activities.

Leporids are divided into two groups, rabbits and hares. The defining difference is the fact that the young of hares are precocial (born with fur and developed hearing and eyesight), whereas rabbits are born altical, naked and blind (Jameson and Peeters 1988). Both are sensitive to the quality and availability of plant food and they reproduce in relation to the richness of resources (Jameson and Peeters 1988). In addition, the

Table 2
UNIT COMPONENTS
(after Glassow 1990)

Site	Early Period	Middle Period	Late Period
CA-SBA-210, Unit 3	280-420 cm	60-280 cm	0-60 cm
CA-SBA-210, Unit 8	300-560 cm	60-300 cm	0-60 cm
	Phase Ex Early	Terminal Early/ Middle Period	Late Period
CA-SBA-552, Unit 9	120-540 cm	60-120 cm	0-60 cm

reproductive patterns of *Lepus californicus* and *Sylvilagus bachmani* and *audubonii* are cyclical (ca. 10 years). The cause of this cyclical pattern is not clear (Jameson and Peeters 1988). Both rabbits and hares are largely crepuscular (active in twilight) and neither store food. In addition, females are larger than males and the three species represented in the midden deposits have one annual molt in autumn (Orr 1940).

Lepus californicus. The black tailed jackrabbit is a distinctive long-legged hare with very long ears and a black or partially black and gray tail. Its average total length is 49-55 cm and it weighs 1,500-2,000 grams. It is distributed throughout much of the western US and into central Mexico and Baja California, preferring semi-open and open areas. It feeds on a large variety of herbs and grasses, and numerous hares may live in a relatively small area (van Gelder 1982). Jackrabbits have a flight adaptation particularly suited to open areas. When pursued by predators, jackrabbits can leap up to 17 feet (6.8m) in one jump and can hop up to 40 mph (64 kmph). In such cases, they often make every 4th or 5th leap especially high to get a view of their pursuers over the brush.

Black tailed jackrabbits rest during the day in shallow depressions under bushes or shrubs. Also known as forms, these areas are approximately 35 by 40 cm and 5 cm deep. In areas where they are abundant, jackrabbits usually leave well-marked trails. Jackrabbits may breed at almost any time of the year and bear 3 to 4 young (up to 7) in one litter. The gestation period is 4-5 weeks, and jackrabbits may reproduce up to 10 months out of the year with an average of 4 litters (Zeiner et al. 1990).

A remarkable characteristic of *Lepus californicus* is its widespread distribution. Neither temperature, altitude, nor rainfall appears to be critical in their geographic range, although those factors may determine the distributions of subspecies (Orr 1940). The area where black tailed jackrabbits are encountered seems to be determined by the openness of vegetation. The preferred area must be open enough for flight, but include enough vegetation to provide shelter during daily resting periods. Dense areas of chaparral or forested areas are unsuitable (Orr 1940:80). A further limitation observed by Orr (1940) is the morphology of the feeding area. *Lepus californicus* prefers feeding in shallow depressions rather than prominent places, so as not to be visible from great distances. For this reason, hillsides, hilltops, or even moderate rises are invariably avoided (Orr 1940: 89).

Of the leporids, jackrabbits were the largest meat and fur package available to occupants at Agua Vina Creek. Although they are easily tracked by their distinctive trails, their speed, behavior, and feeding requirements limit the potential density and potential return rates of hunting *Lepus californicus* for the inhabitants of Agua Vina Creek.

***Sylvilagus* spp.** Two species of rabbits are potentially represented in the faunal assemblage from both sites: brush rabbit (*Sylvilagus bachmani*) and Audubon or desert cottontail (*Sylvilagus audubonii*). These species share several attributes. They are crepuscular, breed from January to June, and have an average of 3 litters per year with 3-4 young per litter. Although the research area is within the range of desert cottontails, the majority of these animals live in the interior valleys and southeastern deserts of California (Orr 1940). Brush rabbits, however, are often found in coastal areas and are likely the primary species represented in the collection.

***Sylvilagus bachmani*.** The brush rabbit is a small, short-legged rabbit with moderately pointed ears. It averages 30-36 cm in length and weighs 560-840 g. Today it lives throughout the western two-thirds of California, from the western slopes of the Sierra Nevada to the coast, and from Oregon to Baja California. It is often found in chaparral, since it favors dense brush.

Unlike jackrabbits, brush rabbits react to predators by hiding in the brush. Due to their body structure, brush rabbits cannot reach high speeds and must remain in close proximity to cover. Therefore, they rarely forage further than 9 m from dense cover.

Brush rabbits use simple forms for resting and they make nests for breeding. In patches of chaparral, brush rabbits make well-defined runways at the edges of the brush. The outer entrance to the runway is tunnel-like, and 1-2 feet from the outer entrance is a special form that serves as a look-out post (Orr 1940).

The brush rabbit would likely have been the most accessible leporid for hunters in the Agua Vina Creek area. They were probably quite numerous and easy targets for hunters of all experience levels. Furthermore, the distinct entrances to their forms would have provided hunters an easily identifiable spot for traps or snares.

***Sylvilagus audubonii*.** The desert cottontail is a large, long-legged rabbit with short fur. Its total length averages at 37-40 cm and it weighs between 750 and 1250 grams. In California, it is most commonly found in grasslands, open forests, and desert shrub habitats in the southern two-thirds of the state. In very open areas it is known to burrow, but generally it finds shelter in thickets and shrubs, rock piles, fallen trees, vines, and brush (Zeiner et al. 1990). Like the brush rabbit, the cottontail feeds on a variety of grasses and does not stray far from cover to forage.

Density Estimates

Various methods are employed to estimate the density of small mammal populations in a given area (Forys and Humphrey 1997). Although studies on small mammals in coastal areas or comparable plant communities exist, they are focused on rodents and do not include information on leporids (e.g. Fellers 1994; Heske et al. 1997). This makes it difficult to assess the potential modern animal densities at the site location as a proxy for prehistoric conditions. Population density analyses from other regions are only available for *Lepus californicus* and *Sylvilagus audubonii*.

A study in north-central Colorado (shortgrass steppe) conducted spotlight counts along a 32 km route in January, April, July, and October (Lindquist et al. 1995). The authors found that both jackrabbit and cottontail densities peaked in July at 20.47/km^2 and 11.99/km^2 respectively. The lowest densities were noted in January at 0.88/km^2 and 2.64/km^2 respectively. Although this region is not directly comparable to the chaparral and coastal sage scrub characteristic of the Vandenberg area, the study highlights the potential variation in density within just one year. It is safe to assume that this variation is even greater over time due to known population cycles (Knick and Dyer 1997; see also Giuliano et al. 1993; Porth et al. 1994; Boutin 1995; Hik 1995; Gillis 1998).

Methods

Faunal collections from both sites were sorted into size categories of mammals (small, medium, large), bird, and fish. Mammals were further divided into terrestrial and sea mammals (Glassow 1990). A total of 10,827 fragments of small mammal bones was analyzed from both sites, of which 26% were identifiable to species (Table 3).

Identifications were conducted by the author at the University of California, Santa Barbara, using comparative collections available in the Department of Anthropology and from the Santa Barbara Museum of Natural History. Where possible, fragments were identified to species, element, portion of element, side and age, and were evaluated for evidence of burning. Butchery marks were only observed on one unidentifiable fragment and one jackrabbit metapodial. Gnaw marks or modification for tool use were not observed.

Due to apparent mixing within levels through rodent burrowing (Glassow 1990), MNI (minimum number of individuals) and MNE (minimum number of elements) values were calculated by period instead of level. MNE calculations were only made for the phases with ample sample sizes and were focused on Sylvilagus sp.

With the assumption that bone weight is a better proxy for meat weight than fragment counts, interpretations are primarily based on bone weight. Density measurements (the average number of fragments per 20 cm level of a 1.5 by 1.5m unit) were calculated and showed a strong discrepancy between SBA-210 Unit 3 and the two other units. Therefore, the relative percentage of the identified small mammal bones was calculated by period (species weight over total faunal weight) to facilitate comparison between units, sites, and phases. Table 4 presents the results of the analysis.

Taphonomy

The faunal remains analyzed in this study were fragmented but generally well preserved. Several factors may influence the constitution of faunal assemblages (Lyman 1994). In particular, density-mediated bone destruction and recovery methods may bias the representativeness of an assemblage and limit the conclusions drawn from its analysis.

Six millimeter screening. Small mammal remains are generally biased by the use of 6 mm (1/4 inch) screens. A recent experimental study (Shaffer 1992) tested the consistency of representation of small mammal remains by sieving modern comparative samples through 6 mm screens multiple times. The study found that small mammals weighing less than 140g were not consistently represented in the screens. Taxa weighing 71-340g showed consistent recovery of only six elements (pelves, scapulae, femora, humeri, skulls, and mandibles). The third and largest group (340-3,100g) were fairly well represented using 6

Table 3
SUMMARY OF ANALYZED DATA (FRAGMENTS)

Site	Total Number of Fragments	Fragments Identified to Species (%)	Total Fragments Burned (%)	Fragments Identified to Species Burned (%)
SBA-210, Unit 3	929	24	14	12
SBA-210, Unit 8	3689	22	18	19
SBA-552, Unit 9	6209	33	2	3

Table 4
SUMMARY OF IDENTIFIABLE BONE

		Early Period				Middle Period				Late Period			
Site	Taxon	Count	Burn (%)	MNI	Weight (g)	Count	Burn (%)	MNI	Weight (g)	Count	Burn (%)	MNI	Weight (g)
SBA-210, Unit 3	*Lepus californicus*	1	0	1	0.1	3	66	1	1.86	0	0	0	0
	Sylvilagus sp.	6	50	1	1.52	92	9	10	20.85	66	14	10	15.92
	Spermophilus beecheyi	16	0	2	5.72	22	14	3	9.52	7	14	1	1.64
	Thomomys bottae	2	0	1	0.1	6	0	1	1.03	3	0	1	0.3
SBA-210, Unit 8	*Lepus californicus*	24	21	2	1.51	15	53	1	7.94	0	0	0	0
	Sylvilagus sp.	365	20	36	83.0	146	13	13	25.33	44	7	5	7.16
	Spermophilus beecheyi	95	21	7	20.51	63	30	5	8.76	6	17	1	1.38
	Thomomys bottae	34	6	6	4.82	19	0	5	1.83	3	0	1	0.33
SBA-552, Unit 9	*Lepus californicus*	195	7	8	125.84	3	0	1	1.78	0	0	0	0
	Sylvilagus sp.	776	3	57	216.66	8	0	2	2.33	8	13	3	2.62
	Spermophilus beecheyi	751	3	55	211.72	12	17	2	3.29	4	0	2	0.75
	Thomomys bottae	297	0	64	61.19	9	0	2	1.07	4	0	2	0.9

mm screens, although many of the smaller elements (e.g., patellae, podials, sternae) are not consistently recovered (Shaffer 1992). The study concluded that with the use of 6 mm screens only similar sized taxa can safely be compared.

Shaffer's (1992) study has implications for the Californian assemblages. The study used only complete, fully fused bones. Even in this ideal situation, gopher and ground squirrel are likely underrepresented. With the amount of fragmentation evident in the assemblages, these taxa are certainly underrepresented due to the collection technique. Rabbits and hares fall on the larger end of the spectrum analyzed by Shaffer (1992). Although many smaller elements may not have been collected and fragmentation further biases the sample, these taxa should be fairly well represented in the assemblage.

Structural bone densities. Structural densities of bone are variable, largely depending on the biomechanics of the animal. They are important for assemblage formation because they influence preservation: denser portions of bones are more likely to be preserved intact. A recent study by Pavao and Stahl (1999) measured structural densities of elements of a range of leporids. Although the sample was small, the authors found significant differences in density values between leporids and marmots, which had hitherto been used as a proxy for other small mammals (Pavao and Stahl 1999). Table 5 summarizes the leporid data for each unit and period. The last column is a volume density rank adopted from Pavao and Stahl's (1999) volume density (VDsa) values. Spearman's rho, a rank-order correlation coeffiecient, was calculated for each period and unit. Table 6 presents a comparison between element frequencies and VD rank to determine if element survivorship was dependent on bone density. Rho values near +1.0 suggest bone density strongly influences survivorship, whereas values near ± 0 show that no relationship between the variables exists. The probability indicates that four out of nine unit-periods show a moderately strong to strong correlation between bone density and survivorship. These unit-periods also have the largest sample sizes and it is likely that the other four cases are not statistically significant due to their small sample sizes.

The application of skeletal density assays to small mammals can provide a rough estimate of destruction within an assemblage (Pavao and Stahl 1999). They can act as an indicator for density-mediated destruction of other represented taxa of similar size. In conjunction with recovery biases through the use of 6 mm screens, it is likely that all small fauna in the assemblages are underrepresented. Since these biases are present in all periods and units, general trends in the leporid data should be informative of changes in subsistence and economic pursuits.

OVERALL RESULTS

CA-SBA-210

The greatest number of small mammal fragments came from Unit 8 (n=3,689); 22% of these were identifiable to species (of which 19% were burned) (Table 3). Unit 3 only contained 929 fragments of small mammal bone, and 24% were identifiable to species (12% of which were burned). In both units and through all periods, the small mammal assemblage was dominated by *Sylvilagus* spp. and *Spermophylus beecheyi* (Table 4). It is not clear to what extent ground squirrel remains are cultural rather than natural deposits. Of the bones identified to ground squirrel in Unit 3 and Unit 8, 9% and 24% respectively were burned. This is a much higher percentage than was found for the bones of pocket gophers (*Thomomys bottae*), with 0% and 3% respectively, and suggests that a substantial proportion of ground squirrel found in the deposit may be of cultural origin.

CA-SBA-552

Unit 9 produced 6209 fragments of small mammal bone (Table 3). It was possible to identify 33% of these to species, of which only

Table 5

SYLVILAGUS SP. ELEMENTS AND DENSITY RANK

Element	SBA-552, Unit 9 Early Period	SBA-552, Unit 9 Middle Period	SBA-552, Unit 9 Late Period	SBA-210, Unit 8 Early Period	SBA-210, Unit 8 Middle Period	SBA-210, Unit 8 Late Period	SBA-210, Unit 3 Early Period	SBA-210, Unit 3 Middle Period	SBA-210, Unit 3 Late Period	VD Rank
Astragulus	16	0	0	6	1	0	1	0	1	13
Calcaneus	56	0	0	20	12	4	0	6	2	7
Mandible.(prox)	7	2	4	11	6	0	1	3	0	11
Mandible (dist)	81	2	0	69	26	2	0	16	15	1
Femur (p)	52	1	0	19	5	1	0	1	2	9
Femur (d)	25	0	0	8	6	2	0	0	6	2
Humerus (p)	17	0	0	8	5	1	0	2	1	4
Humerus (d)	40	1	1	18	13	5	1	8	6	8
Radius (p)	41	0	0	8	4	2	0	4	3	15
Radius (d)	21	0	0	3	2	1	0	2	3	16
Sacrum	3	0	0	1	0	0	0	1	0	10
Scapula (p)	67	1	1	16	8	3	0	13	6	12
Scapula (d)	0	0	0	0	0	0	1	0	0	17
Tibia (p)	32	0	0	20	10	2	1	3	2	3
Tibia (d)	59	1	0	27	8	5	0	4	3	5
Ulna (p)	55	2	0	18	9	2	0	3	3	14
Ulna (d)	3	0	0	2	1	1	0	0	0	18
Pelvis	109	0	0	29	7	3	0	6	3	6
Total	**684**	**10**	**6**	**283**	**123**	**35**	**5**	**72**	**56**	

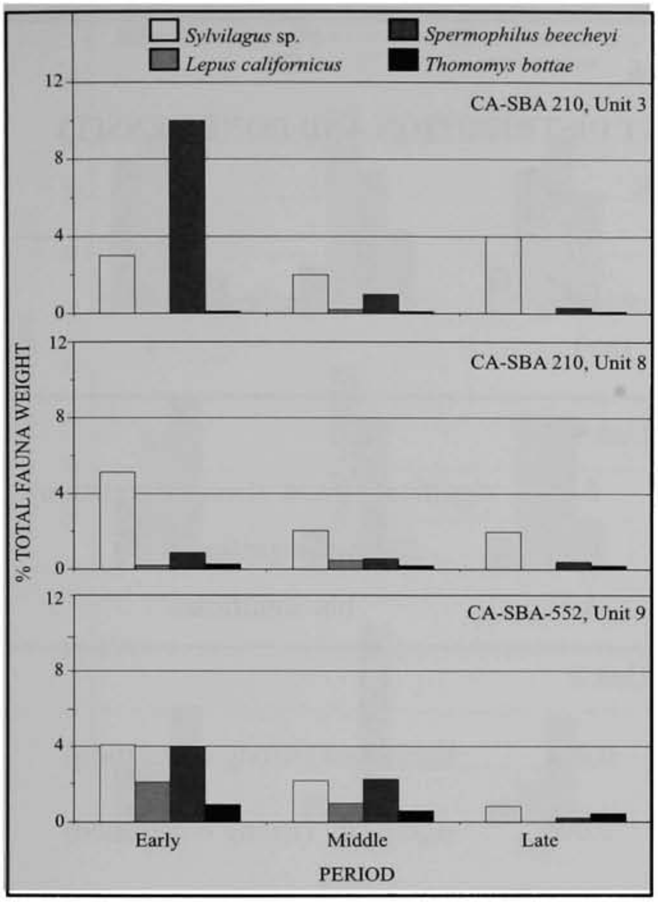

Figure 2. Relative abundance of small mammals by time period.

3% was burned. *Sylvilagus* spp. and *Spermophylus beecheyi* dominate the assemblage as a whole, although in the earliest period at the site, *Thomomys bottae* is highly represented (Table 4). Burning frequencies are much lower than at the other site for all species. It is therefore difficult to argue for the cultural deposition of ground squirrel in this case, and ground squirrel and pocket gopher seem to be intrusive.

The analysis shows (Figures 2 and 3) that the leporid remains are dominated by *Sylvilagus* spp. Jackrabbits are present in the faunal record but remain marginal in frequency and weight. A strong decrease in small mammals relative to other fauna is demonstrated. In terms of weight ratios, the small mammals decrease from 14-27% in the Early Period to 7-8% later in time (Figures 4 and 5). *Sylvilagus* sp. clearly decreases in abundance through time, except in SBA-210 Unit 3. This is likely a product of the small sample size in this unit.

The data in Figure 4 were taken from Glassow (1990) and consist largely of counts and weights of general faunal categories (terrestrial and sea mammal, fish, bird) in addition to the small terrestrial mammal data. The weight of each faunal category was divided by the total faunal weight. This facilitates comparison between categories and time periods. As demonstrated above, fish remains are certainly underrepresented due to collection techniques (see also Glassow 1996:124). Nonetheless, an increase in fish remains in the Middle and Late periods is discernable. This is in keeping with patterns found throughout coastal California (Glassow and Wilcoxon 1988; King 1990; Glassow 1990, 1996; Erlandson 1997a). The

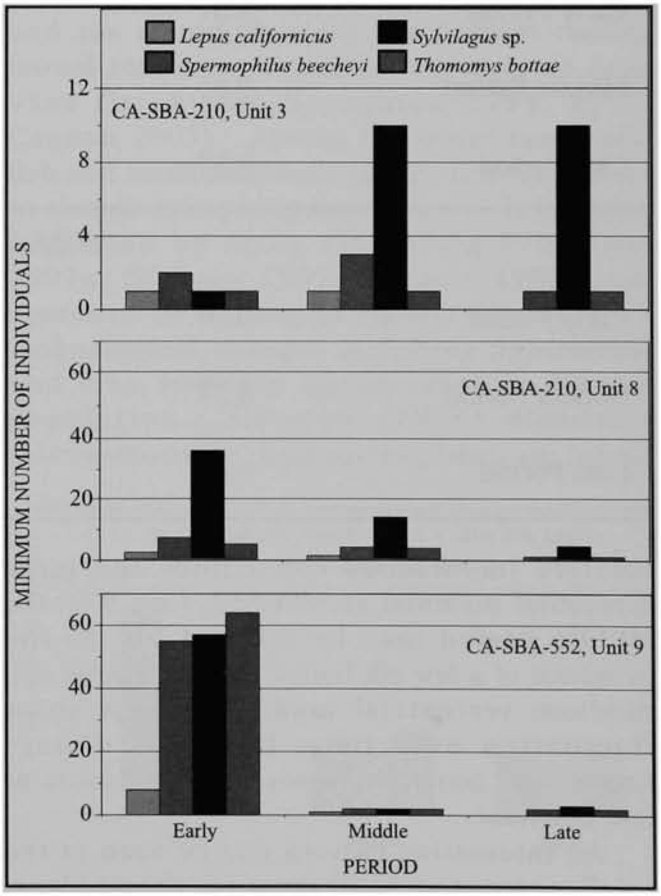

Figure 3. Minimum Number of Individuals (MNI) of small mammals by time period.

Table 6

CORRELATION COEFFICIENT OF ELEMENT DISTRIBUTION AND BONE DENSITY RANK

	Spearman's Rho	Probability (p>)	Significance
		SBA-552, Unit 9	
Early Period	0.46	0.05	significant (mod. strong correlation)
Middle Period	0.14	0.59	not significant
Late Period	0.07	0.77	not significant
		SBA-210, Unit 8	
Early Period	0.67	0.002	significant (strong correlation)
Middle Period	0.61	0.006	significant (strong correlation)
Late Period	0.37	0.13	not significant
		SBA-210, Unit 3	
Early Period	0.18	0.48	not significant
Middle Period	0.37	0.13	not significant
Late Period	0.42	0.09	significant (mod. strong correlation)

relative importance of medium and large terrestrial mammal at SBA-552, Unit 9 in the Middle Period may be inflated due to the presence of a few elk bones. Sea and large and medium terrestrial mammals show some fluctuation over time, but their dietary importance generally seems to remain more or less constant.

An interesting pattern can be seen in the smaller resources represented in the middens. Small mammals, fish, and birds each show different patterns. As mentioned above, fish are certainly underrepresented, but an increase over time is discernable. Birds remain constant at 5-10% of the total faunal weight (with some increase in the Late Period). In contrast, small mammal remains decrease sharply from the Early to Middle Period and then are constant later in time (Figures 2 and 5). Among the small mammals, the distribution of rabbits generally follows the same pattern, supported by both weight ratios and MNI values (Figures 2 and 3). SBA-210, Unit 3 is somewhat of an anomaly, likely due to the small sample from the Early Period

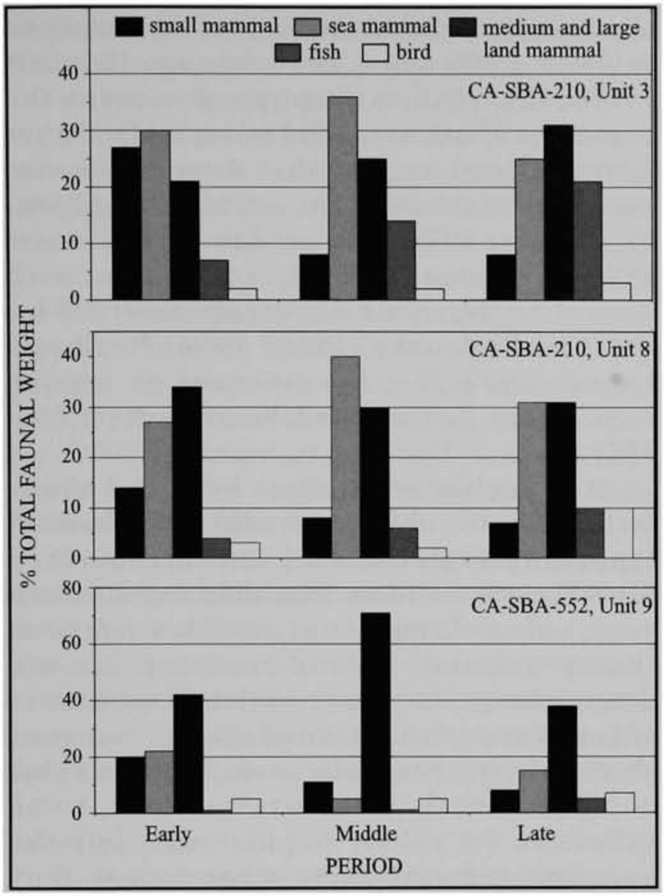

Figure 4. Relative percentage of total faunal assemblage by time period.

levels (see also Glassow 1990). The MNE values for *Sylvilagus* spp. in each phase show expected distributions of crania and fore and hind limbs (1:2:2), suggesting the animals were processed and consumed at the site.

DISCUSSION AND CONCLUSIONS

The subsistence strategy for occupants at Agua Vina Creek changed through time, albeit not as dramatically as in other parts of California (Glassow and Wilcoxon 1988; Glassow 1997; Erlandson 1997a, 1997b; Jones and Waugh 1997; Kennett 1998). Sea mammals show relatively little change through time as a category, although variation in species has been noted, particularly a slight increase in sea otters (*Enhydra lutris*) (Williams 1997). Medium and large terrestrial mammals are also found in similar abundance through time. Differences in subsistence practices are primarily encountered with regard to the smaller resources. Fishing increases, as evidenced by both faunal and artifactual material (Glassow 1990), and small mammals decrease substantially after the Early Period.

This is obviously not a complete reconstruction of dietary practices since it focuses solely on some faunal remains. Plants and shellfish undoubtedly played a crucial role. Based on column sample data from SBA-210, Glassow (1990:12.32) reports on the relation of shellfish to mammals (terrestrial and sea mammals, but not small mammals) and fish. His analysis shows that based on percentages of weight, very little changed through time: mussel dominates the assemblage in all periods and is constant at ± 90% of the total meat weight.

When viewed in light of resource ranking, it is safe to assume that large terrestrial fauna and sea mammals were the highest-ranked faunal resources available to people at Agua Vina Creek (see Broughton 1994, 1997; Cannon 2003). Among the other resources, fish and small mammals are the only resources to change in importance over time. It has been suggested by many (including Erlandson 1997a; Glassow 1997; Kennett 1998) that increase in fishing is tightly linked with technological changes in fishing implements and may indicate an increase in human population. Glassow (1996) discusses fluctuations in human population levels

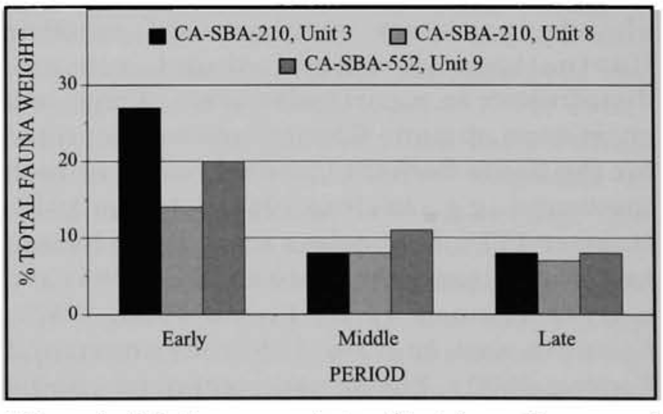

Figure 5. Relative percentage of total small mammal weight by time period.

throughout the Vandenberg region during its 8,000-year occupation. The Late Period in particular shows an increase in human population, paralleling developments in other parts of California (Glassow 1996:135-139).

In the optimal foraging model discussed above, the role of species abundance was emphasized: the exploitation of a resource depends not on its own abundance but on the absolute abundance of higher ranked resources (Pyke et al. 1977; Stephens and Krebs 1986; Smith 1991; Bettinger 1991; Nagaoka 2002). When comparing regions on either side of Point Conception, Glassow and Wilcoxon write that "while shellfish may have had a relatively low rank in both regions, there were no higher-ranking resources north of Point Conception abundant enough to depress its importance to the subsistence" (1988:47). The effort expended per kilogram of protein in rabbits, with capture and processing time included, is roughly comparable to shellfish (Glassow and Wilcoxon 1988:43). Based on the diet breadth model, therefore, rabbit exploitation should parallel shellfish exploitation through time. So why do rabbits become less abundant through time? As argued above, three factors may play a role in the decrease of a resource: disappearance/ decrease in relative abundance, economic substitution by other resources, or a change in patch choice.

Disappearance or Significant Decrease

Overexploitation and environmental change are two mechanisms causing fluctuations in animal abundance and distribution in a particular area. Long- and short-term climatic fluctuations are identified for the Santa Barbara Channel region in both terrestrial (e.g., Axelrod 1967; Johnson 1977; Heusser 1978; Michaelson et al. 1987; Larson and Michaelson 1989; Cole and Liu 1994) and marine records (e.g., Pisias 1978, 1979; Kennett and Ingram 1995; Kennett and Kennett 2000). The climatic record for coastal California indicates an amelioration during the Early Period, with the warmest and most climatically variable intervals of the Holocene between 4,500 and 3,300 years ago (Kennett 1998:245). Pollen diagrams document the expansion of oak woodland and scrubland after 7,800 BP, and suggest that drier conditions were well established between 6,000 and 2,000 BP (Heusser 1978; Cole and Liu 1994; Kennett 1998). Fluctuations in precipitation, with several dry intervals, have been recorded for the Late Holocene (Stine 1994; Raab and Larson 1997:323; for evidence in marine records see Kennett and Kennett 2000:383-385).

It is unclear what affect long- and short-term climatic changes would have had on leporid populations; however, modern distributions indicate that they can live in a variety of conditions. Orr (1940) has suggested that precipitation and temperature are determinants of the distribution of subspecies of *Lepus* spp. rather than of their presence or absence in any particular area. It is likely that environmental fluctuations had some influence on rabbit populations, but the question remains as to what extent they shaped the pattern exhibited in the faunal assemblage from the two sites. Furthermore, changes in climatic conditions continued well after the Early Period (i.e., after 2,500 BP). If long-term environmental fluctuations were the main determinant of rabbit availability and (by extension) assemblage patterns, one would expect later climatic fluctuations to have had as great an impact as earlier ones. Despite climatic fluctuations in the Middle and Late Period, however, the pattern in the assemblage remains constant. Additionally, the analysis grouped levels into large analytical units, so a direct comparison with short-term environmental fluctuations is impossible. The pattern found in the assemblage is therefore most likely due to aggregated human predation choices as opposed to environmentally-induced circumscription.

Overexploitation depletes resources within an area and leads to their significant decrease in abundance or disappearance. It is difficult to assess prehistoric rabbit population densities in terms of natural fluctuations. With increasing human populations, could it have been possible to depress rabbit populations to a point where alternative resources would become more viable? The ecology of rabbits indicates that they are reproductively robust. Fluctuations in animal abundance tend to be short term, so even if rabbits were periodically heavily hunted, populations were likely to bounce back very quickly. It is questionable that such short-term, periodic overexploitation events would be visible archaeologically and doubtful that this provides an explanation for the pattern visible in this data set.

Overexploitation and environmental change often influence and circumscribe the resources available to foragers. In this case, however, they may have had immediate effects on rabbit populations, but it is doubtful that a decrease in or disappearance of rabbits caused the pattern visible in the small mammal data.

Substitution

As postulated by the general subsistence model, technological change is another potential explanation for a decline in the use of a resource: it is substituted by new raw materials and/or technology. Changes in fishing practices in the Vandenberg and Santa Barbara Channel regions during the Middle and Late periods have been linked to the use of circular shell fishhooks by ca. 2,500 - 2,000 years ago (Glassow 1996:134). Furthermore, Glassow (1996:138) wonders if Late Period fishing increases at the Vandenberg sites might result from the use of beach seines. In the case of leporids, technological change in procurement strategies is difficult to assess. None of the numerous artifacts found at the sites provide insight into small mammal procurement (see Glassow 1996:121pp). However, if the occupants at Agua Vina Creek during the Early Period were primarily interested in rabbit furs, the increase in sea otters in the Middle Period (Williams 1997) may indicate a shift to a different source of fur. Rabbits may have become less desirable and therefore less often hunted.

At historic contact, sea otter cloaks were status items primarily worn by chiefs (Landberg 1965). Although sea otter pelts, along with rabbit and fox furs, are also described among non-chiefs, the few references preclude information on the social context of their use (Landberg 1965; Heizer and Whipple 1971). The use of sea otter cloaks as status items may be a late development. Fluctuations in sea otter populations may have limited the number of available skins, or European commercial interest in and pursuit of the soft furs may have changed their value among the Chumash. In any event, the decrease in use of a resource because of substitution may have been one factor in the change in rabbit exploitation patterns at the beginning of the Middle Period.

Change in Patch Choice

One would also expect a decline in use of a resource if there had been a shift in procurement strategy to focus on different patches. A single resource may not be as readily available in a newly high-ranked patch, limiting the return for their capture and processing. As mentioned above, the Early Period in central and southern California witnessed a shift from a broadly-based diet to a more marine-focused economy (King 1990; Glassow 1997; Jones and Waugh 1997; Erlandson 1997a, 1997b). This is evident in the deposits at Vandenberg. Furthermore, the shift from grass seed to acorn processing is evidenced by the decline of manos and metates and the emergence and increased use of mortars and pestles (Glassow 1996, 1997; Erlandson 1997a, 1997b). The Early Period deposits at SBA-552 had large quantities of manos and metates, documenting the importance of grass seed processing (Glassow 1990, 1996:123). Mortar and pestle fragments were uncovered from Middle and Late Period deposits at both sites (Glassow 1990, 1996:123). Rabbits are plentiful in grassland, sage scrub, and chaparral habitats, but seldom in oak woodlands (Orr 1940). The shift to more intensive acorn procurement may be interpreted as a shift in patch choice. With increased acorn exploitation, more time would have been spent in woodland areas and fewer rabbits would have been encountered.

Although Glassow (1990, 1996) argued that these sites were primarily residential bases throughout prehistory, activities carried out at the sites changed through time. Since oak woodlands do not occur locally, this change in strategy may indicate a functional change in the position of SBA-210 and SBA-552. Alternatively, only a part of the group may have ventured into the woodland areas, as is supported by the general lack of data on seasonally limited occupation at the sites (see Glassow 1990, 1996:118). Division of labor based on gender and age is recorded ethnohistorically for the Chumash, and it is possible that primarily women and older men collected acorns while younger men remained at the sites to continue procuring sea mammals and fish.

This scenario has further implications for rabbit hunting among the prehistoric people of Agua Vina Creek. Acorns are a highly seasonal resource, ripening in the late autumn. It is at this time of the year that rabbits undergo their seasonal molt and their fresh new coats for winter appear. In other words, rabbits would also be most desirable during autumn if hunters were interested in pelts in addition to meat. The pattern observed in the faunal remains may be the product of a scheduling conflict. The need for storable resources led to a focus on acorns, which in turn conflicted with the ideal time for rabbit hunting. The resulting lack of quality rabbit skins may in turn have heightened the demand for an alternative raw material. Increases in sea otter hunting may well have resulted from attempts to fill the new void.

This analysis suggests that a change in patch choice is the best explanatory model for the decrease in rabbit remains at the beginning of the Middle Period. The implications of a scheduling conflict suggest that the change in subsistence strategy may have resulted in the need for a raw material substitution, as argued by the general subsistence model. Small mammal exploitation on the southern central California coast highlights changes in subsistence strategies during the Middle Holocene and beyond noted by many (especially highlighted in Erlandson and Glassow 1997). In the case of south Vandenberg, exploitation patterns of leporids point to changes in patch choice with the emergence of acorn exploitation and potentially greater focus on sea otter pelts as a source of fur. In other words, the pattern suggests a combination of dietary and general subsistence decisions made by foragers. Regardless of the position a resource holds in an optimal dietary ranking system, the general subsistence value of a resource must be taken into consideration. Multiple currencies need to be considered in optimal foraging models if we are to uncover the cultural information encoded in archaeofaunal assemblages.

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