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# The Relative Importance of Lacustrine and Estuarine Resources to Prehistoric Hunter-Gatherer Populations: A View from Southern Santa Clara Valley, California

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*Data from excavations at five sites in southern Santa Clara Valley provide several interesting insights regarding the relative importance of lacustrine and estuarine resources to prehistoric hunter-gatherer populations. The sites are located 20 to 26 km. inland from the saltwater estuary of Elkhorn Slough, but only between 0.3 and 9.0 km. from San Felipe Lake and its adjacent marshlands. Essentially ignoring the local lacustrine-marshland resource base, early populations (ca. 4,200 to 2,500 B.P.) employed a mobile subsistence-settlement strategy that included transport of estuarine resources (largely bay mussel) to interior residential bases located far from Elkhorn Slough but relatively close to San Felipe Lake. This general adaptation continued until ca. 1,000 B.P., when a simultaneous increase in population density and territoriality appears to have restricted access to Elkhorn Slough, forcing interior populations to move their settlements closer to San Felipe Lake and intensify their use of the local lacustrine resource base.*

**O**VER the last few decades, a great deal of attention has been given to the productivity of wetland habitats and their influence on hunter-gatherer subsistence-settlement strategies. Much of this interest stems from the presence of Early Holocene artifacts along the shores of pluvial lakes throughout much of the Columbia Plateau, western Great Basin, and Mojave Desert. Due to the widespread nature of this association, Bedwell (1970) created an archaeological pattern known as the "Western Pluvial Lakes Tradition," which was thought to represent an adaptation focused on the use of plant and animal resources obtained from lakes, marshes, and associated grassland areas. The importance of Great Basin wetland areas has also been extended to the later part of the Holocene by Heizer and Napton (1970), who argued that such habitats supported a "limno-sedentary" settlement system, where the exploitation of tules, cattails,

fish, waterfowl, and other aquatic resources allowed for long-term residential stability.

Both of these perspectives have faced little challenge until relatively recently, when several large-scale, regional surveys produced data indicating that most subsistence-settlement systems made use of a more diversified set of environmental settings than previously thought. Basgall's (1993) work with Early Holocene materials from the Mojave Desert showed that most researchers have biased their samples toward lakeshore settings, focusing on Pleistocene terrace formations but showing little interest in adjacent non-lacustrine areas. By using a more comprehensive sampling strategy, Basgall (1993) argued that although lakeshore areas were visited on a regular basis, Early Holocene populations formed small, mobile groups and exploited a variety of plants and animals from a wider range of environmental settings. Kelly (1985, 1988)

and Thomas (1985) arrived at similar conclusions based on analyses of Middle and Late Holocene materials from the western Great Basin, proposing that lacustrine environments represented only a single component of a more generalized subsistence-settlement system. Furthermore, Kelly's (1990) analysis of survey data from the Carson Sink, a large basin containing an extensive wetland area (Stillwater Marsh) produced by snow melt from the Sierra Nevada, indicated that wetland areas were not extensively exploited until 1,500 B.P., when terrestrial productivity decreased due to warmer and drier conditions, increasing the relative value of local wetland areas.

With the exception of the southern San Joaquin Valley (see Hartzell 1992), similar arguments regarding the relative importance of lacustrine resources have rarely been applied to cis-montane California—no doubt due to the low frequency of pluvial lake basins which characterize much of the arid lands east of the Sierra Nevada. Excavations at CA-SCL-178, however, have sparked the interest of several researchers due to the presence of an Early Holocene component in apparent association with the northern shore of Pleistocene Lake San Benito. This relationship led Roop et al. (1981) and Moratto (1984) to hypothesize that the early inhabitants of CA-SCL-178 focused on the use of lacustrine resources, and practiced an adaptation quite similar to the Western Pluvial Lakes Tradition of the Great Basin and Plateau. Due to the productive nature of lacustrine and some coastal environments (the latter corresponding to the Paleo-Coastal Tradition), Moratto (1984:113) suggested that many of these settings may have been occupied on a near-permanent basis by people exploiting a variety of both terrestrial and wetland-marine resources.

Jones (1991) also recognized the occupational priority given to lacustrine and coastal (particularly estuarine) settings, noting that the antiquity of CA-SCL-178 and other lakeshore sites in

central California (e.g., CA-SON-977 at Laguna de Santa Rosa [Origer and Fredrickson 1980], CA-SCR-177 at Scott's Valley [Cartier 1988], and the Tracy Lake site [Heizer 1938]), is equaled by sites located in estuary habitats such as Elkhorn Slough (Dietz et al. 1988; Jones and Jones 1992; Breschini and Haversat 1995) and Bodega Bay (CA-SON-348; Jones 1992; Schwaderer 1992). As a result of these similarities, and the fact that no other environmental contexts in California exhibit a higher degree of occupational antiquity, Jones (1991) proposed that both lakes and estuaries provided concentrations of high-quality resources (e.g., shellfish, waterfowl) that were readily apparent to the earliest populations of central California. Such areas produced continually high yields for relatively small mobile groups, but were ultimately depleted by increased population densities, necessitating an increased reliance on small seeds—the latter marked by the emergence of the "Milling Stone Horizon" (see Basgall and True 1985).

The goal of this paper is to expand upon the above ideas by systematically tracking the relative importance of lacustrine and estuarine resources to the prehistoric occupants of the southern Santa Clara Valley. The first step includes a review of the geomorphic-hydrological history of Pleistocene Lake San Benito, documenting how its emergence and demise predated the earliest occupation of CA-SCL-178, and how the importance of lacustrine resources may have been overstated in the reconstruction of the local Early Holocene record. Focus then shifts to five archaeological sites excavated by Hildebrandt and Mikkelsen (1993) that produced 21 single-component assemblages dating between 4,200 B.P. and 600 B.P. These assemblages are particularly significant to the comparison of lacustrine and estuarine resource use because they lie 20 to 26 km. inland from the saltwater estuary of Elkhorn Slough, but only 0.3 to 9.0 km. from freshwater San Felipe Lake and its adjacent marshlands. A rich suite of data, including ver-

tebrate and invertebrate faunal remains, paleobotanical remains, and a variety of artifacts and features, indicates that Early Period populations (ca. 4,200 to 2,500 B.P.) essentially ignored the local lacustrine resource base. Instead, they practiced a relatively mobile subsistence-settlement strategy that included transport of estuarine resources to interior residential bases. By the Middle Period (2,500 to 850 B.P.), a steady decrease in estuarine resources at interior archaeological sites may indicate that access to the coast was reduced. It is hypothesized that a simultaneous increase in population density and greater maintenance of territorial boundaries diminished the range of foraging opportunities available, requiring an increase in local resource production. In response to this change, lacustrine resources became more significant, reaching maximal importance after 850 B.P. when settlements concentrated on the shore of San Felipe Lake.

These data provide strong support for early exploitation of estuarine resources proposed by Jones (1991), but do not substantiate an equal emphasis on the use of lacustrine resources—at least not in the southern Santa Clara Valley. In an attempt to ascertain whether these findings are anomalous (i.e., unique to the southern Santa Clara Valley), similar analyses of archaeofaunas from Buena Vista Lake, Owens Lake, and Stillwater Marsh are included in this study. These areas were selected because they contain good chronological sequences of faunal remains, as well as providing an interesting environmental gradient through California and into the western Great Basin. The results of this analysis indicate that the use of lacustrine resources probably occurred throughout the Holocene, but their intensive use was a relatively recent phenomenon at Buena Vista and Owens lakes, not unlike the findings from southern Santa Clara Valley. Data generated from Stillwater Marsh, in contrast, indicate an earlier focus on lacustrine/marsh resources, probably due to the lower quality of the surrounding terrestrial resource base.

## PLEISTOCENE LAKE SAN BENITO

The southern Santa Clara Valley is a broad plain bounded by the Santa Cruz Mountains on the west and the Diablo and Gabilan ranges on the east and south (Fig. 1). Relatively large terraces rim the western edge of the valley, ranging from 0.1 to 1.5 km. in width and 200 to 330 ft. (60 to 100 m.) in elevation. These terraces overlook the southern Santa Clara Valley lowlands, and contain four of the subject sites (CA-SCL-639, -308, -577, and -698; Fig. 1). About 15 km. north of these sites, the valley floor rises to form an imperceptible divide between the southern and northern flowing catchments that drain the valley. The northern system reaches San Francisco Bay via Coyote Creek, flowing by archaeological site CA-SCL-178, while all the southern drainages lead to the Pajaro River, which flows into Monterey Bay.

There are three major interconnected groundwater basins in the valley that currently provide the main water supply of the area. A series of artesian wells once extended from Gilroy across the valley to San Felipe Lake prior to the development of expansive irrigation systems. The wells were formed through a buildup of groundwater blocked from the Pajaro drainage by an underground rock formation, and filled San Felipe Lake and the extensive marshland habitats that once surrounded it (Lindsey 1974). Although these wells have been reduced to small springs, San Felipe Lake remains a perennial body of water today. Analysis of strata trenches excavated along its northern shore indicate that it was present throughout much of the Holocene (Hildebrandt and Mikkelsen 1993), and was a major subsistence focus to the inhabitants of CA-SCL-119, the final archaeological site of interest to this study.

Jenkins (1973) developed a hydrological history of southern Santa Clara Valley that included the development and demise of at least two lakes during the Pleistocene. Unlike the pluvial lakes

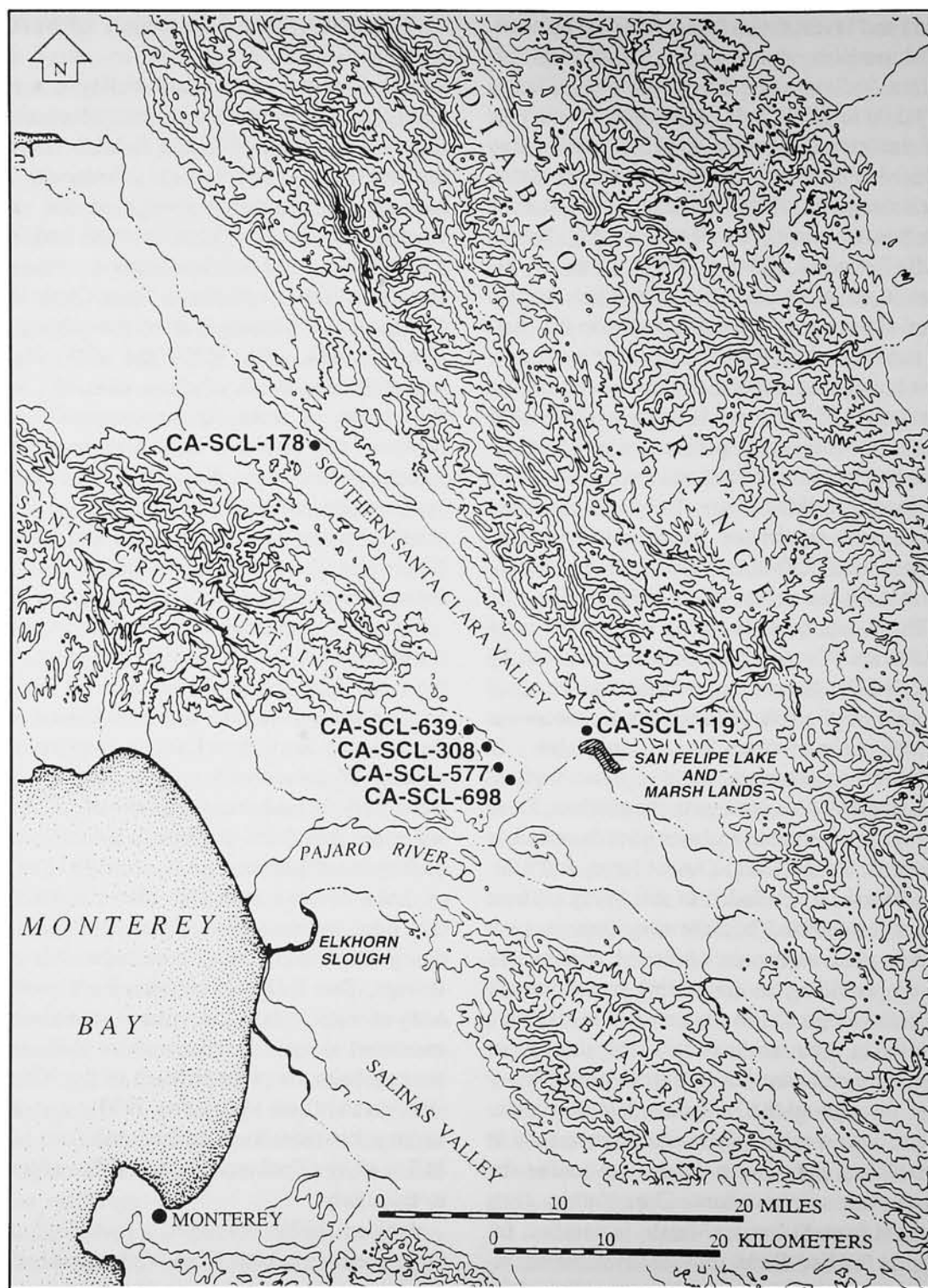


Fig. 1. Geographic distribution of project sites.



of the Great Basin, those filling the southern Santa Clara Valley were formed as a result of earthquakes near Pajaro Gap that created major landslides, damming the Pajaro River for extensive periods of time (Fig. 2). Jenkins (1973) noted that Pleistocene Lake San Benito was not a Late Pleistocene/Early Holocene phenomenon, but was created sometime during the last 100,000 years. After the Pajaro River broke through its dam at some unknown point during the Pleistocene, the valley remained open until another earthquake-derived dam was created, forming Pleistocene Lake San Juan. Although the exact age of this second lake is unknown, it postdates Lake San Benito and, therefore, had a much better chance of being chronologically associated with the occupation of CA-SCL-178. Nevertheless, its major stand occurred at the 200-ft. contour interval, roughly 30 km. south of the site.

Archaeological data from CA-SCL-178 are consistent with Jenkins' (1973) reconstructions, as they show little evidence of a lacustrine focus (Hildebrandt 1983). The lower component (Component I) at CA-SCL-178 produced four uncorrected radiocarbon dates, all corresponding to the Early Holocene ( $8,000 \pm 300$  B.P.,  $9,190 \pm 600$  B.P.,  $9,200 \pm 1,000$  B.P.,  $9,960 \pm 500$  B.P.). Because the samples were widely dispersed throughout a complex accumulation of alluvial sediments, and were overlaid by a relatively discrete stratum assigned to a much later interval (Component II; 4,500 to 3,000 B.P.), Hildebrandt (1983) was not convinced that Component I was a clean, Early Holocene depositional unit (i.e., the 4,000-year gap between the Component I radiocarbon dates and the Component II stratum were unaccounted for). As a result, it was conceded that Component I could have contained materials dating between 10,000 and 4,500 B.P. (Hildebrandt 1983).

Irrespective of its chronological placement, it is important to point out that the excavation of

69 m.<sup>3</sup> of Component I deposits yielded a tool assemblage restricted to eight handstones, three cobble tools, two possible net sinkers, a bone awl fragment, and 16 flake tools (or 0.4 items per cubic meter of deposit). Faunal remains were dominated by rabbits ( $n = 79$ ) and deer ( $n = 14$ ), but also included 11 unidentified bony fish and eight unidentified birds. Shellfish was also present, and included mussel (*Mytilus californianus*; 54%), purple clam (*Sanquinolaria nuttallii*; 23%), other bay clams (15%), and *Olivella* (8%); however, no freshwater mollusks or turtles were recovered. Both the mussel and purple clam indicate a rather extensive foraging radius, as the former were obtained from outer coast settings, while the latter may have been gathered from Elkhorn Slough (the currently known northern distribution of purple clam is Elkhorn Slough [Fitch 1953:82]). It is also possible that some of these taxa, such as the bay clams, were collected from San Francisco Bay, roughly 40 km. to the north.

Although the presence of bird, fish, and the possible net sinkers (notched and grooved stones) may evidence use of wetland resources (Coyote Creek and the seasonally marshy bottomlands of La Laguna Seca are nearby), the overall assemblage indicates that a rather mobile settlement system was used to exploit a wide diversity of habitats (including both estuaries and the outer coast), and reflects an adaptation not unlike that of the Milling Stone Horizon of southern California (see Basgall and True 1985; Erlandson 1994; McGuire and Hildebrandt 1994; Jones 1995).

#### LACUSTRINE AND ESTUARINE RESOURCES: SAN FELIPE LAKE VERSUS ELKHORN SLOUGH

Evaluation of the relative importance of lacustrine and estuarine resources can now be addressed through analysis of assemblages derived from five sites excavated by Hildebrandt and Mikkelsen (1993). As mentioned above, four of

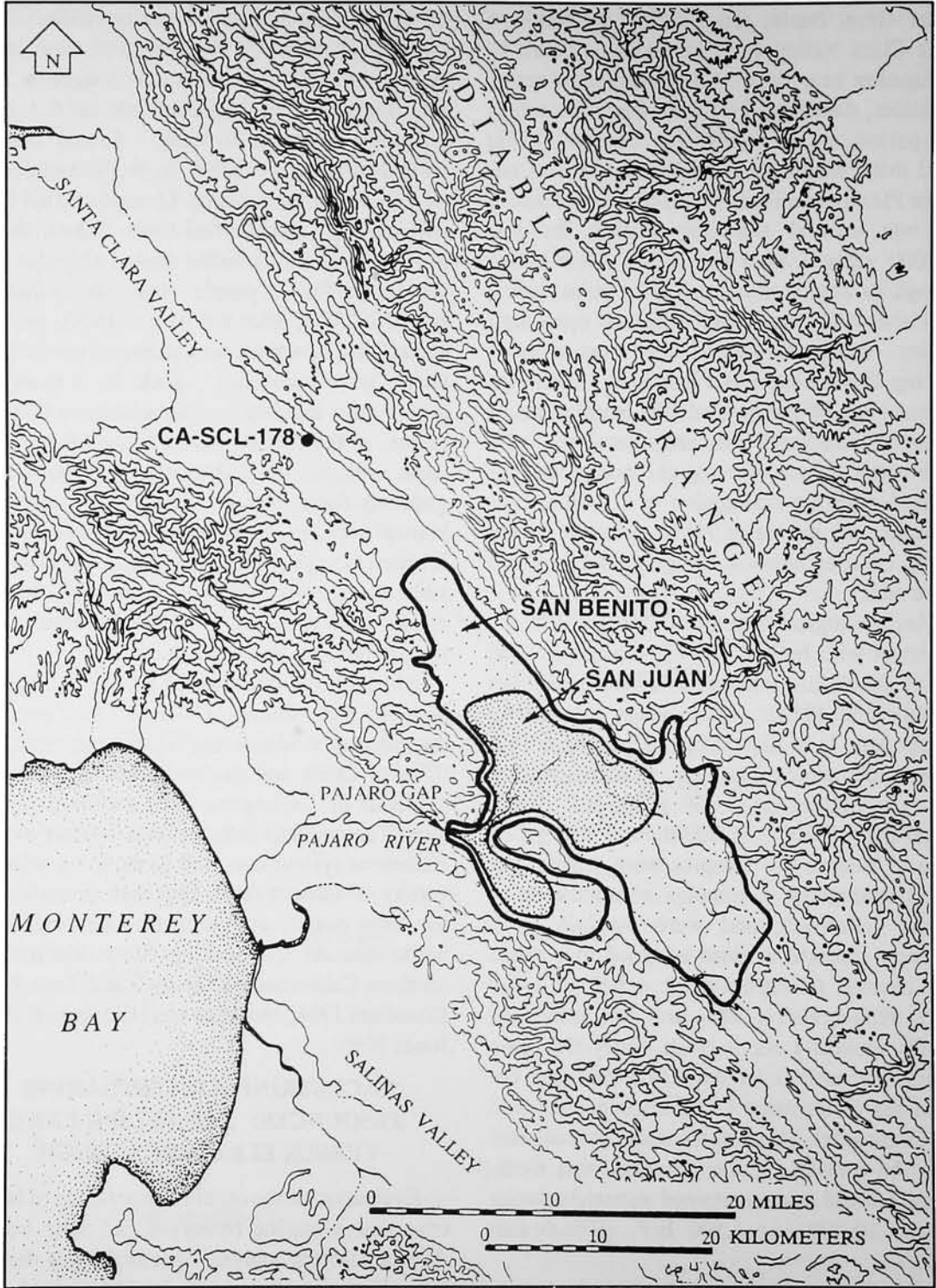


Fig. 2. High stands of Pleistocene Lakes San Juan and San Benito.

the sites are located on the western terraces of San Felipe Lake (CA-SCL-639, -308, -577, and -698), and hereinafter called the terrace sites, while the final site (CA-SCL-119) is an extensive complex of five loci located on a series of knolls near the north shore of San Felipe Lake (see Fig. 1). These sites were located during an archaeological survey by Gmoser (1992a, 1992b) of 1,880 acres on the western terraces and eastern hill-valley interface adjacent to San Felipe Lake. Because these five sites represent all of the significant archaeological deposits within these two important zones, they provide an excellent means to evaluate prehistoric land-use pattern changes in the local area.

The Hildebrandt and Mikkelsen (1993) field effort included multiple backhoe trenches and hand excavation of over 160 m.<sup>3</sup> of deposit. This work resulted in the discovery of multiple house floors/living surfaces, pit features, burials, and 21 temporally discrete component areas.

### Component Areas

Definition of components was made possible by the presence of spatially discrete strata and features that could be dated through radiocarbon assay. A small number of shell beads, projectile points, and obsidian tools/debitage was also encountered; however, these materials played only a secondary role in the chronological ordering of the components. Radiocarbon samples included 10 of bay mussel (*Mytilus edulis*), eight of freshwater mussel (*Anodonta* spp.), and six of charcoal (Table 1). The *Mytilus* and *Anodonta* assays were corrected for isotopic fractionation using <sup>13</sup>C adjusted ages, while the former were also corrected for marine reservoir effects based on a 650 ± 70 B.P. assay obtained from a modern (pre-1950) *Mytilus* shell collected from Elkhorn Slough (see Waechter 1993). All of the resulting dates (including charcoal-derived assays) were converted to age ranges using the secular variation adjustments of Pearson and Stuiver (1986).

Most of the obsidian obtained from the project sites derives from either the Casa Diablo or Napa source localities. Hydration rim values generated from this small sample of material were corrected using a factor of 6% per 1°C difference in Effective Hydration Temperature between the source locations and the study area. Calendric estimates were then derived using hydration rates developed by Origer (1982) for Napa and Hall and Jackson (1989) for Casa Diablo. Age ranges provided in Table 2 represent one standard deviation around the hydration mean obtained from a particular component area; in some cases, extreme outliers were removed from the analysis (see Hildebrandt and Mikkelsen 1993).

These data document three major periods of occupation: Early (4,500 to 2,500 B.P.), Middle (2,500 to 850 B.P.), and Late (post-850 B.P.). The Middle Period consists of a combination of material traditionally placed within the Middle and Middle-Late Transition periods (see Bennyhoff 1994) because samples corresponding to the latter interval were too small for useful comparison with the others. This problem could have been solved by either lumping Middle-Late Transition Period materials with those of the Late Period (separating Middle from Late at about 1,250 B.P.) or combining them with the Middle Period sample, placing the Middle to Late Period break at approximately 850 B.P. The latter alternative was chosen because the 850 B.P. break corresponds to the time when the western terrace sites fell into disuse and the occupation of San Felipe Lake intensified. Moreover, this division is consistent with major settlement shifts proposed for Big Sur and Monterey Bay by Jones (1995)—shifts that may have had a strong influence on developments within the current study area.

Most of the Early Period (4,500 to 2,500 B.P.) material was found at the western terrace sites, where CA-SCL-698, -308, and -577 produced four single-component areas (Table 3).



Table 1  
RADIOCARBON DATES (RCYBP)\* FOR SOUTHERN SANTA CLARA VALLEY SITES

Site/ Location	Component	Specimen Number	Material	Weight <sup>b</sup> (g.)	<sup>14</sup> C Age	<sup>13</sup> C Adjusted Age	Marine Shell Calib.	Secular Variation Corrected	Reservoir Effect Adjustment <sup>c</sup>
Elkhorn Slough CA-SCL-308/H	--	Beta-52859 <sup>d</sup>	<i>M. edulis</i>	11.7	250 ± 70	650 ± 70	-5	N/A	N/A
	A1	Beta-43071	charcoal	3.0	1,990 ± 170	N/A	N/A	1,720-2,190	N/A
	A2	Beta-43060	<i>M. edulis</i>	25.0	3,270 ± 80	3,680 ± 80	3,248	3,060-3,380	2,989-3,439
		Beta-43061	<i>M. edulis</i>	28.4	2,680 ± 70	3,110 ± 70	2,545	2,350-2,740	2,329-2,739
	A2	Beta-43062	<i>M. edulis</i>	30.8	3,290 ± 70	3,700 ± 70	3,272	3,170-3,380	3,049-3,439
	A2	Beta-54800	<i>M. edulis</i>	40.7	3,440 ± 70	3,840 ± 70	3,417	3,360-3,560	3,249-3,609
CA-SCL-577/H	A2	Beta-43063	<i>M. edulis</i>	22.5	3,840 ± 100	4,270 ± 100	3,962	3,736-4,115	3,679-4,269
CA-SCL-639/H	A1	Beta-43064	<i>M. edulis</i>	66.3	1,330 ± 70	1,690 ± 70	925	910-1,060	750-1,080
	A1	Beta-43070	charcoal	5.6	1,190 ± 80	N/A	N/A	1,053-1,261	N/A
	A2	Beta-43065	<i>M. edulis</i>	28.8	1,680 ± 90	2,080 ± 90	1,303	1,280-1,490	1,140-1,520
	A1	Beta-43068	<i>M. edulis</i>	24.9	1,310 ± 70	1,690 ± 70	925	910-1,060	750-1,080
	B1	Beta-43066	<i>M. edulis</i>	24.9	2,430 ± 70	2,830 ± 70	2,177	2,050-2,340	1,989-2,339
	B2	Beta-43067	<i>M. edulis</i>	44.4	3,750 ± 90	4,160 ± 90	3,816	3,645-3,980	3,559-4,069
CA-SCL-119/ CA-SBN-24/H	C1	Beta-43069	charcoal	5.7	1,500 ± 80	N/A	N/A	1,313-1,510	N/A
	A1	Beta-50717*	charcoal	5.0	950 ± 70	N/A	N/A	768-938	N/A
	A1	Beta-52571	<i>Anodonta</i>	36.8	550 ± 50	770 ± 50	N/A	675-734	N/A
	A1	Beta-52572	<i>Anodonta</i>	36.7	450 ± 80	680 ± 80	N/A	633-685	N/A
	C1	Beta-52569	<i>Anodonta</i>	214.8	500 ± 50	750 ± 50	N/A	671-725	N/A
	D1	Beta-52573	<i>Anodonta</i>	35.9	830 ± 60	1,060 ± 60	N/A	932-1,053	N/A
	D2	Beta-50716	charcoal	8.8	1,130 ± 80	N/A	N/A	964-1,165	N/A
	D2	Beta-52570	<i>Anodonta</i>	334.6	1,060 ± 50	1,340 ± 50	N/A	1,260-1,303	N/A
	D3	Beta-54801	<i>Anodonta</i>	35.9	1,460 ± 60	1,690 ± 60	N/A	1,538-1,702	N/A
	E1	Beta-52575	<i>Anodonta</i>	58.3	640 ± 50	840 ± 60	N/A	690-791	N/A
	E2	Beta-50715	charcoal	18.1	1,970 ± 60	N/A	N/A	1,872-2,005	N/A
	--	Beta-52574	<i>Anodonta</i>	33.6	600 ± 60	830 ± 60	N/A	685-785	N/A

\* From Pearson and Stuiver (1986).

<sup>b</sup> Prior to pretreatment.

<sup>c</sup> Date used for component definition.

<sup>d</sup> Modern sample (A.D. 1932).

• Extended count.

**Table 2**  
**DETERMINATION OF TEMPORAL COMPONENTS**  
**AT SOUTHERN SANTA CLARA VALLEY SITES**

Component Designation	Radiocarbon Assay (B.P.)	Radiocarbon Source	Hydration (B.P.)	Beads Types <sup>a</sup>	Temporal Period
CA-SCL-639/H					
A1	750-1,080, 1,053-1,261	Pit Feature 2	--	F2a	Middle
A2	1,140-1,520	shell midden	--	--	Middle
B1	--	--	1,156-1,911	--	Middle
CA-SCL-308/H					
A1	1,720-2,190	house floor (Feature 1)	849-2,479	F3a, M1d	Middle
B1	--	--	1,176-1,518	--	Middle
A2	3,049-3,439, 2,329-2,739	shell midden	--	A2a	Early
CA-SCL-577/H					
A1	--	--	1,500-1,832	--	Middle
A2	3,679-4,269	shell lens	--	--	Early
CA-SCL-698					
A1	750-1,080	shell midden	--	--	Middle
C1	1,313-1,510	Pit Feature 1	1,640-2,174	--	Middle
B1	1,989-2,339	shell midden	--	--	Middle
B2	3,559-4,069	shell midden	--	--	Early
CA-SCL-119/SBN-24/H					
C1	671-725	shell lens	--	--	Late (Phase 1)
A1	675-734, 633-685, 768-938 <sup>b</sup>	Pit Features 1 and 2	--	--	Late (Phase 1)
E1	690-791	shell midden	395-1,042	--	Late (Phase 1)
D1	932-1,053	shell midden	--	--	Middle
D2	964-1,165 <sup>b</sup> , 1,260-1,303	living surface B/H	--	--	Middle
D3	1,538-1,702	shell midden	--	--	Middle
E2	1,872-2,005 <sup>b</sup>	house floor (Feature E)	--	G6b, F2a	Middle
E3	--	--	--	--	Early to Middle
B1	--	--	1,458-4,960	G6b	Early to Middle

<sup>a</sup> From Bennyhoff and Hughes (1987).

<sup>b</sup> Charcoal samples; all others are *Anodonta*.

All four terrace sites had Middle Period (2,500 to 850 B.P.) components (nine in total), while no Late Period (post-850 B.P.) single-component areas could be isolated. It should be noted that some evidence of Late Period activity was found at the terrace sites, but consisted of a sparse, near-surface veneer of artifacts that could not be

placed in a discrete component area. These materials were limited to three hydration readings, three Desert Side-notched points, one shell bead, four glass beads, and two pieces of worked porcelain, and probably represent ephemeral uses of the sites.

Early Period materials are quite rare at the

Table 3  
SPATIOTEMPORAL DISTRIBUTION OF SINGLE-COMPONENT AREAS

	Late Period (post-850 B.P.)	Middle Period (850 to 2,500 B.P.)	Early Period (pre-2,500 B.P.)
<b>Terrace Sites</b>			
CA-SCL-639/H	--	A1, A2, B1	--
CA-SCL-308/H	--	A1, B1	A2
CA-SCL-577/H	--	A1	A2
CA-SCL-698	--	A1, C1, B1	B2
<b>San Felipe Lake</b>			
Locus A	A1	--	--
Locus B	--	--	B1*
Locus C	C1	--	--
Locus D	--	D1, D2, D3	--
Locus E	E1	E2	E3*

\* These Early/Middle Period components are considered early to facilitate diachronic comparisons.

San Felipe Lake site (CA-SCL-119), and are limited to a sparse accumulation of artifactual debris spanning the Early and Middle periods (see Table 3, Locus B). Substantial occupations do not appear to have occurred until 2,000 B.P., continuing until around 500 B.P. Four Middle Period components were defined at the site, while the Late Period (post-850 B.P.) is represented by three components. Most of these were radiocarbon dated using *Anodonta* shell that, similar to marine shell, can be contaminated by fossil carbonates within the drainage system from which they were collected. No obvious source of such material (e.g., limestone) is known within the Pacheco-Pajaro catchments. But even if contaminants were assimilated by the shellfish, the age estimates presented in Table 1 would be too old and, if corrected, would strengthen the temporal contrasts between the western terrace and San Felipe Lake components. As will be discussed in more detail below, this shift in settlement seems to reflect a more intensive use of the lacustrine resources associated with San Felipe Lake late in time.

### Faunal Remains

Because only small samples could be obtained from each component area (see Table 2), meaningful trends were identified by combining the data into more inclusive spatiotemporal units of analysis. This was accomplished by combining data from the four terrace sites, which exhibited parallel trends, and comparing them to materials from the San Felipe Lake site complex. It is also necessary to glean intrusive elements from these assemblages, as naturally occurring rodent bone can be relatively abundant. This problem is illustrated by the frequency at which these materials have been burned and/or butchered. Of the 667 rodent specimens identified, only eight (1.2%) were burned/butchered, while such was the case for 45.2% of the other identified taxa. Due to the obvious difficulties associated with distinguishing culturally versus naturally deposited rodent bone, all rodent taxa were removed from subsequent analytical discussions. Loss of these data is not considered significant due to the abundant presence of equally valuable

Table 4  
FAUNAL REMAINS\* FROM TERRACE AND SAN FELIPE LAKE SITES

Taxon	Terrace Sites				San Felipe Lake			
	Early	Middle	Late	Terrace Total	Early/Middle	Middle	Late	San Felipe Total
deer	5	14	--	19	12	32	20	64
elk	--	--	--	--	1	14	2	17
rabbits	19	34	--	53	7	22	6	35
carnivores	5	19	--	24	2	12	9	23
<b>Total</b>	29	67	--	96	22	80	37	139
waterfowl	3	1	--	4	20	54	41	115
other birds	1	11	--	12	1	1	5	7
<b>Total</b>	4	12	--	16	21	55	46	122
fish	2	3	--	5	22	526	432	980
turtle	--	2	--	2	--	8	72	80
<b>Total</b>	2	5	--	7	22	534	504	1,060
<i>Mytilus</i>	1,652.0	2,098.8	--	3,750.8	2.6	27.4	0.9	30.9
other marine	96.6	287.8	--	384.4	--	15.8	41.5	57.3
<i>Margaritifera</i>	172.3	46.1	--	218.4	1.2	1.8	2.2	5.2
<i>Anodonta</i>	1.6	--	--	1.6	63.6	1,641.2	1,762.8	3,467.6
<i>Gonidea</i>	--	--	--	--	0.7	--	0.5	1.2
<b>Total</b>	1,922.5	2,432.7	--	4,355.2	68.1	1,686.2	1,807.9	3,562.2
m. <sup>3</sup> excavated	13.08	56.06	--	--	5.45	6.0	13.11	--

\* Vertebrate values represent number of identified specimens; invertebrate values are weight in grams.

indicators of local habitat use, particularly with respect to the issue of resource intensification (e.g., birds, fish, turtles; see also Sutton 1993).

Early components along the western terrace have moderate frequencies of deer, rabbits, and carnivores, and relatively high amounts of shellfish (Table 4). Bay mussel (*Mytilus edulis*) dominates the shellfish sample (85.9% by weight), followed by *Margaritifera* (available from cool streams in or adjacent to the Santa Cruz Mountains [Pennak 1989; Thorp and Covich 1991]), and a variety of other marine species. Lacustrine-oriented resources (e.g.,

waterfowl, fish, *Anodonta*, turtle) are conspicuously rare, while diagnostic elk bone (an open prairie and marshland-adapted species) is absent.

The composition of vertebrate fauna from Middle Period contexts remains roughly similar; however, several interesting changes in the mix of taxa occur. Similar to trends identified by previous studies in the area (Hildebrandt 1983; McGuire and Hildebrandt 1994), deer increase relative to rabbits over time. Shellfish also show diachronic variability, decreasing in relative abundance while simultaneously increas-



Table 5  
FAUNAL RATIOS FOR TERRACE AND SAN FELIPE LAKE SITES

Taxon	Terrace Sites			San Felipe Lake		
	Early	Middle	Late	Early/Middle	Middle	Late
deer/elk	5	14	--	13	54	22
rabbits	19	34	--	7	22	6
deer/elk:rabbits	1:3.8	1:2.4	--	1:0.54	1:0.41	1:0.27
terrestrial	29	71	--	22	80	37
birds	4	12	--	21	55	46
terrestrial:birds	1:0.14	1:0.17	--	1:0.95	1:0.69	1:1.24
terrestrial	29	71	--	22	80	37
fish	2	3	--	22	526	432
terrestrial:fish	1:0.07	1:0.04	--	1:1.00	1:6.58	1:11.68
terrestrial	29	71 (63 <sup>a</sup> )	--	22	80	37
shellfish <sup>b</sup>	1,922.5	2,432.7 (1,069.7 <sup>a</sup> )	--	68.1	1,686.2	1,807.9
terrestrial:shellfish	1:66.3	1:34.3 (1:17.0 <sup>a</sup> )	--	1:3.1	1:21.1	1:48.9
terrestrial	29	71	--	22	80	37
turtle	--	2	--	--	8	72
terrestrial:turtle	--	1:0.03	--	--	1:0.10	1:1.95
<i>Mytilus</i>	1,652.0	2,098.8	--	--	--	--
other marine shellfish	96.6	287.8	--	--	--	--
<i>Mytilus</i> :other marine	1:0.06	1:0.14	--	--	--	--

<sup>a</sup> Values when Feature 2 at CA-SCL-639/H is excluded.

<sup>b</sup> Marine shellfish for terrace sites; *Anodonta* for San Felipe Lake.

ing in species diversity (i.e., a more even representation of taxa is observed). To better illustrate these relationships, shellfish weight was measured against the frequency of terrestrial mammal bone. This was accomplished by dividing shell weight by bone count, giving a shell weight value (in grams) per identified bone (Table 5). Early components have a value of 1:66.3 g., while the ratio drops to 1:34.3 g. in Middle Period contexts. When Feature 2 at CA-SCL-639 was removed from the calculations (a unique pit feature filled almost entirely with bay

mussel shell), the Middle Period shellfish abundance value drops to 1:17.0 g., or about 25% of the Early Period value. Shellfish diversity, in contrast, increases over time, as other marine taxa (largely clams) increase relative to bay mussel in non-Feature 2 Middle Period deposits (Early = 5.5%; Middle 21.5%), even though the overall abundance of shellfish goes down. This general change has also been observed in San Francisco Bay Area sites where the shift from mussel to clam has been attributed to human overexploitation of the former or, al-

Table 6  
FAUNAL RATIOS AND Z-SCORES FOR SAN FELIPE LAKE

Temporal Period	Terrestrial:Bird	Terrestrial:Fish	Terrestrial:Shellfish	Terrestrial:Turtle
<b>Early/Middle</b>				
ratio	1:0.95	1:1.00	1:3.10	--
z-score	-0.04	-1.01	-0.92	-0.62
<b>Middle</b>				
ratio	1:0.69	1:6.58	1:21.08	1:0.10
z-score	-0.96	+0.03	-0.14	-0.53
<b>Late</b>				
ratio	1:1.24	1:11.68	1:48.86	1:1.95
z-score	+1.00	+0.99	+1.06	+1.15
<b>Mean Ratio</b>	1:0.96	1:6.42	1:24.37	1:0.68
<b>Standard Deviation</b>	0.28	5.34	23.07	1.10

ternatively, to the destruction of mussel habitat by a progressive silting in of the bay (see Greengo 1948).

San Felipe Lake reflects a different set of relationships (Table 4). Terrestrial mammals include a higher frequency of large game relative to rabbits and carnivores, including significant quantities of elk. Lacustrine resources are also much more abundant, and show a progressive increase relative to other foods over time. To document this process of intensification, terrestrial mammal bone was again used as a baseline to measure changes in the relative abundance of each lacustrine resource group (Table 5). When computing the ratio of terrestrial game to fish, the frequency of the latter starts low in Early/Middle contexts (1:1.00), but increases to 1:6.58 and 1:11.68 during the Middle and Late periods. Likewise, shellfish (which are dominated by *Anodonta*) begin quite low in the Early Period (3.1 g. per terrestrial bone), and increase in a progressive fashion over time (Middle = 21.1 g./terrestrial bone; Late = 48.9 g./terrestrial bone). These relationships can be illustrated by standardizing intertaxonomic ratio differences through the calculation of z-scores (Table 6).

Using fish for example, the mean ratio of terrestrial game to fish for all three time periods was computed. The relative distance of the period-specific ratios from this mean is then determined by calculating the absolute difference between the two values (either positive or negative) and dividing it by the standard deviation.

Figure 3 clearly illustrates an increase in the use of lacustrine resources relative to terrestrial game over time. Freshwater fish and shellfish have a minimal presence in early contexts, reach average values during the Middle Period, and peak late in time. Many of the fish (all but suckers, squawfish, and minnows) are adapted to slow water environments, and fall under Smith's (1982) Low-Gradient Black Fish Association, which corresponds to San Felipe Lake and the lower reaches of the Pajaro River (Table 7). This is also the favored habitat of *Anodonta*, the dominant shellfish species represented. Suckers, squawfish, and minnows can enter these areas as well, but also frequent the cooler, faster moving waters of upstream tributaries.

Turtle follows a more radical track due to its absence/rarity in Early and Middle period deposits, and relative abundance thereafter. Bird, in

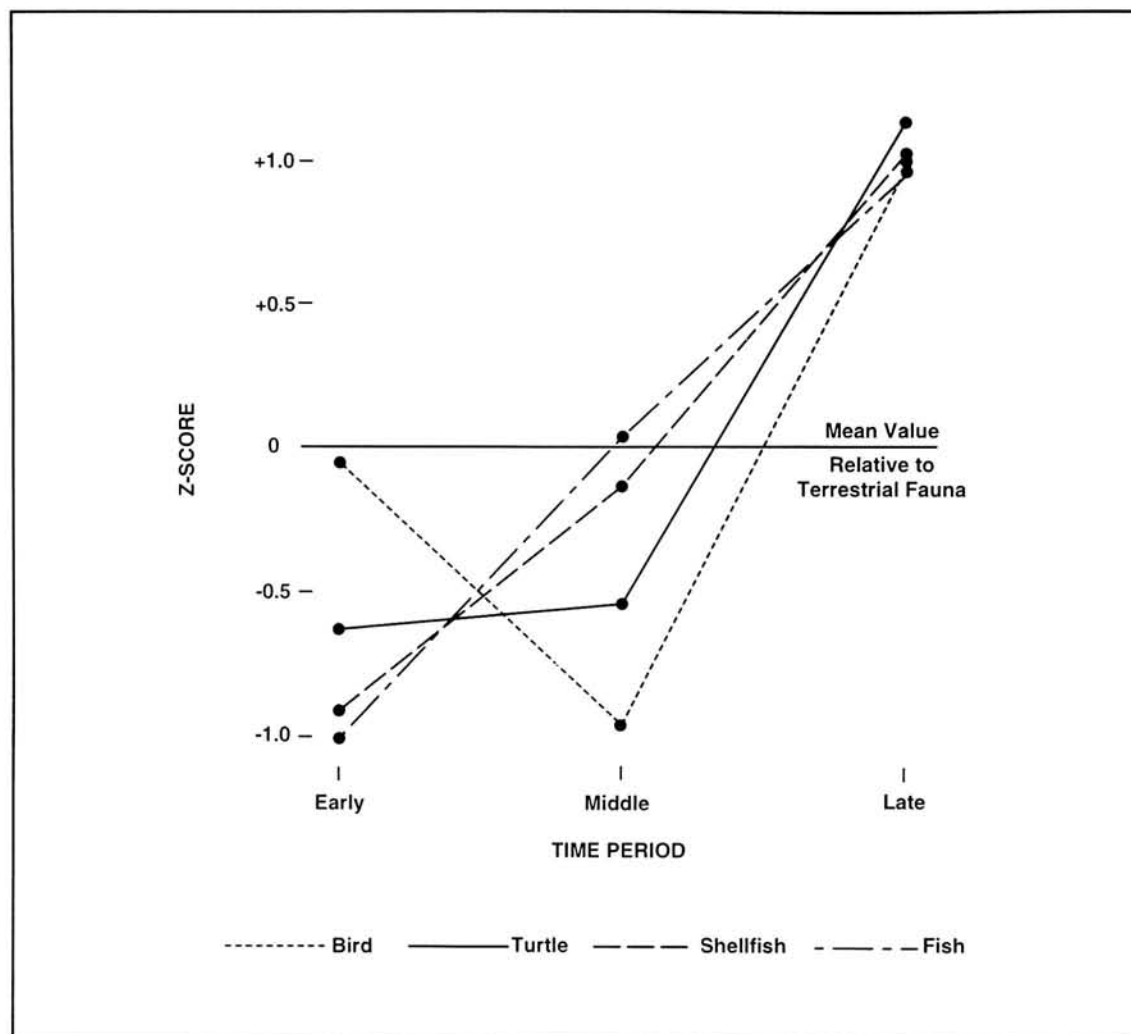


Fig. 3. San Felipe z-score data for faunal remains.

contrast, follows a more variable pattern, beginning at near-average frequencies, dropping during the Middle Period, and peaking with the others late in time. This pattern does not appear related to changes in the range of taxa exploited, as all three assemblages are dominated by about the same proportion of ducks, geese, and coots (Table 7).

When data from the terrace sites and San Felipe Lake are combined, the curves for all four lacustrine resource groups become much steeper (Table 8; Figure 4). This occurs because the terrace sites tend to have older compo-

nents with low frequencies of lacustrine remains, while the opposite is generally the case at San Felipe Lake. Combining data from the two areas also allows the addition of marine shellfish to the graph, which peaks early and drops significantly over time. This shift in emphasis from nonlocal marine foods to locally available lacustrine resources, along with more intensive occupation of the San Felipe locality, could indicate that mobility patterns were altered over time, perhaps due to increased territoriality on the part of coastal groups, restricting access to Elkhorn Slough and other important resource areas.

Table 7  
FISH AND BIRDS FROM SAN FELIPE LAKE

Taxon	Early/Middle Period	Middle Period	Late Period	Totals
ducks	7	15	10	32
geese	7	19	16	42
coots	4	15	13	32
<b>Total</b>	18	49	39	106
Sacramento perch	12	204	127	343
tule perch	--	3	4	7
Sacramento blackfish	--	17	28	45
Sacramento squawfish	--	1	1	2
Sacramento sucker	--	3	12	15
thicktail chub	1	30	33	64
hitch	--	19	16	35
minnow	5	113	81	199
minnow/sucker	4	136	130	270
<b>Total</b>	22	526	432	980

### Plant Macrofossils

Charred plant remains were recovered from 16 single-component areas, spanning all temporal periods represented at the terrace sites and San Felipe Lake. These materials are classified into two basic groups: small seeds and large seeds. Small seeds have been further divided into wetland grasses, dryland grasses, other wetland taxa, other dryland taxa, and miscellaneous small seeds; the latter corresponds to *Chenopodium* spp., which could include species that live in both wetland (e.g., *C. rubrum*) and dryland (e.g., *C. californicum*) habitats, but could not be distinguished with current analytical methods.

Grass seeds are represented by seven major taxa (Table 9), three from wetland environments and four from dryland settings. At San Felipe Lake, wetland grasses are found in near-equal frequencies relative to dryland grasses in Early (wet = 45.5%) and Middle (wet = 49.7%) period contexts, but jump to 67.5% in Late Period

deposits (Table 10). Other small seeds from San Felipe Lake include three wetland and eight dryland taxa, and produce a pattern quite similar to that of grasses. Beginning in the Early Period, wetland taxa make up only 16.7% of the assemblage, but steadily increase over time, totaling 32.3% of the Middle Period and 49.8% of the Late Period samples. In contrast to the above trends, the terrace sites show decreases in the relative frequency of wetland grasses and other wetland seeds when moving from the Early to the Middle period (75.0% to 31.9% for grass, 23.1% to 11.1% for other seeds), but lack data from the Late Period. It should be noted, however, that the density of small seeds from the terrace sites is quite low (3.5 per liter) compared to San Felipe Lake (49.2 per liter) and, when compared to the abundance of acorn remains (see below), probably represents a rather casual use of seeds obtained from locally accessible savanna and lowland habitats.

Acorn nutshell dominates the large seed samples throughout the entire sequence, fol-



Table 8  
FAUNAL RATIOS AND Z-SCORES FOR ALL SITES

Taxon/Ratio	Early	Middle	Late	Mean Ratio Per Period	Standard Deviation
deer/elk	18	68	22	--	--
rabbit	26	56	6	--	--
birds	25	67	46	--	--
fish	24	529	432	--	--
<i>Anodonta</i>	65.2	1,641.2	1,762.8	--	--
<i>Mytilus</i>	1,654.6	1,033.2	0.9	--	--
turtle	--	10	72	--	--
terrestrial:birds	1:0.49	1:0.44	1:1.24	0.72	0.45
z-score	-0.51	-0.62	+1.16	--	--
terrestrial:fish	1:0.47	1:3.50	1:11.68	5.22	5.80
z-score	-0.82	-0.30	+1.11	--	--
terrestrial: <i>Anodonta</i>	1:1.28	1:10.87	1:47.64	19.93	24.47
z-score	-0.76	-0.37	+1.13	--	--
terrestrial: <i>Mytilus</i>	1:32.44	1:7.23	1:0.02	13.23	17.02
z-score	+1.12	-0.35	-0.78	--	--
terrestrial:turtle	--	1:0.07	1:1.95	0.67	1.11
z-score	-0.60	-0.54	+1.15	--	--

lowed by lesser amounts of bay, wild cucumber, and buckeye (see Table 9). The long-term importance of this resource is not surprising judging by the presence of mortars and pestles in Early Period contexts at CA-SCL-577, -308, and -119 (see below), and the post-4,500 B.P. emergence of these artifacts at CA-SCL-178 (Hildebrandt 1983; Hildebrandt and Mikkelsen 1993). Because of their relative abundance across the sequence, acorns provide a useful standard from which to measure the relative importance of various combinations of other plant resources over time.

When acorn was compared to the "other wetland" category of small seeds (primarily

*Scirpus*), the latter shows progressive increases through time, tracking quite closely with the lacustrine fauna (Table 11). Analysis of wetland grasses, however, reveals a different trend, reaching peak relative frequencies early, dropping significantly in Middle Period contexts, and picking up again later in time. The same pattern is exhibited by dryland taxa (grasses and other small seeds), as well as *Chenopodium*.

The abundant presence of small seeds in Early Period contexts, followed by a dominance of acorn in the Middle Period and, ultimately, a diversification of plant use late in time, has also been noted by Wohlgemuth (1996). Testing a series of hypotheses generated by Basgall and

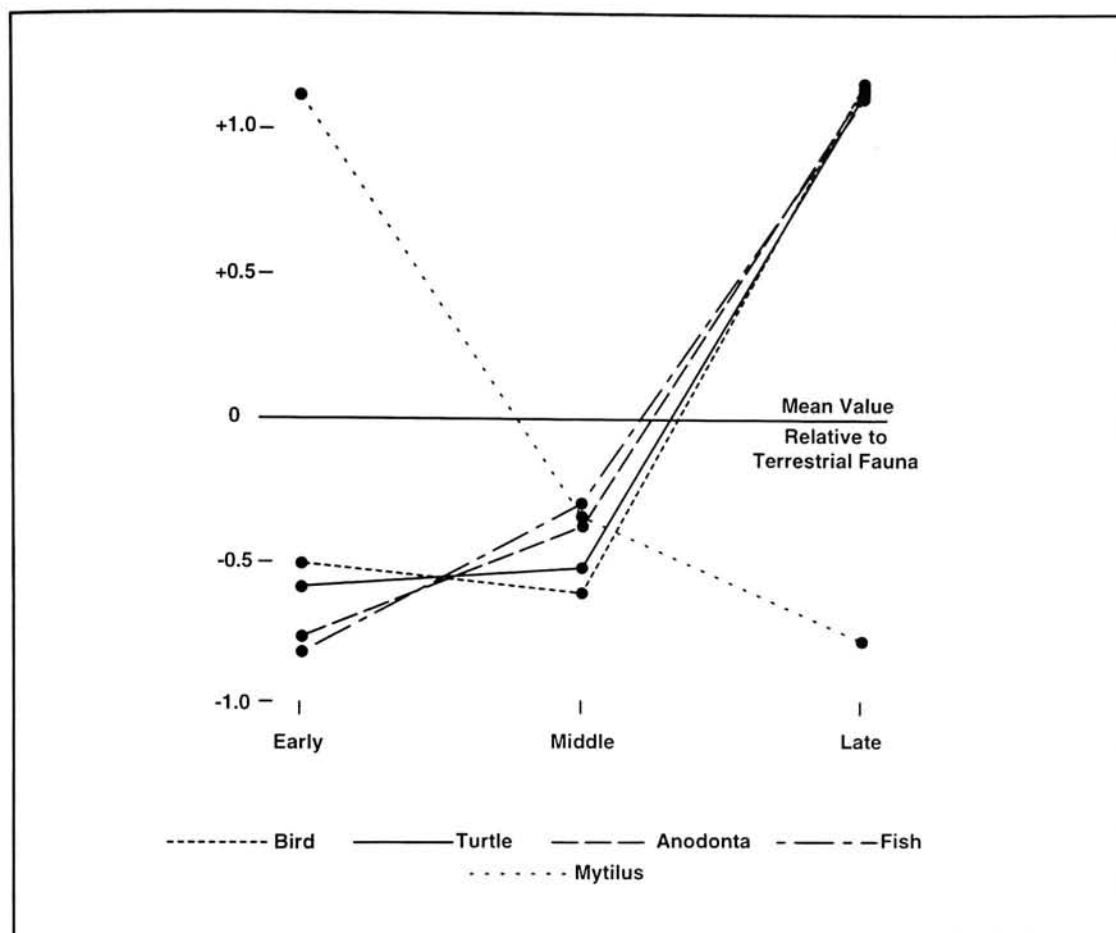


Fig. 4. Combined z-score data for faunal remains.

Bouey (1991) from the southern North Coast Ranges, Wohlgemuth (1996) argued that the initial dominance of acorn in the Middle Period reflects the first step in a multiphase intensification process. Intensive production and storage of acorns during the Middle Period surpassed the earlier importance of small seed resources, allowing populations to expand as a result of increasing sedentism (see also Testart 1982). The continued increase in population led to another phase of intensification, where subsistence strategies were developed to maximize the production of small seeds like *Chenopodium* and *Clarkia*, as well as other taxa that were previously underused (e.g., *Scirpus*). In the case of the two for-

mer taxa, both of which favor disturbed habitats, their production may have been maximized using strategies such as managed burning, or even planting such as that reported among the Numic people of north-central Nevada, who regularly broadcast *Chenopodium* seeds in areas previously burned (Steward 1938:104).

### Artifacts

Artifact assemblages from San Felipe Lake and the terrace sites demonstrate that all component areas reflect multiactivity occupations (Table 12; see also Hildebrandt and Mikkelsen 1993). All assemblages include tools associated with generalized maintenance and production

Table 9  
PLANT MACROFOSSILS FROM ALL SITES

	Terrace Sites		San Felipe Lake			
	Early	Middle	Early	Middle	Late	Total
<b>Small Seeds</b>						
<b>Wetland Grasses</b>						
<i>Deschampsia</i>	2	11	2	12	2	29
<i>Phalaris</i>	1	8	1	44	52	106
<i>Hordeum</i>	--	3	7	211	100	321
<b>Other Wetland Seeds</b>						
<i>Scirpus</i>	3	8	1	267	371	650
<i>Polygonum</i>	--	--	--	1	1	2
<b>Total</b>	6	30	11	535	526	1,108
<b>Dryland Grasses</b>						
<i>Bromus</i>	1	4	5	64	13	87
<i>Stipa</i>	--	--	1	--	--	1
<i>Festica</i>	--	3	--	8	2	13
<i>Vulpia</i>	--	40	6	198	59	303
<b>Other Dryland Seeds</b>						
<i>Calandrina</i>	7	2	1	33	14	57
<i>Montia</i>	--	2	--	4	--	6
<i>Salvia</i>	1	3	--	--	--	4
<i>Trifolium</i>	--	6	--	300	111	417
<i>Ranunculus</i>	--	--	--	4	2	6
<i>Galiun</i>	1	15	1	7	18	42
<i>Madia</i>	--	3	1	--	2	6
<i>Clarkia</i>	1	33	2	213	233	482
<b>Total</b>	11	111	17	831	454	1,424
<i>Chenopodium</i>	7	45	34	525	315	926
<b>Large Seeds</b>						
acorn	18	571	7	628	554	1,778
bay	1	22	1	42	64	130
wild cucumber	1	6	1	14	1	23
buckeye	--	--	--	17	18	35
<b>Total</b>	20	599	9	701	637	1,966

tasks, and several component areas also produced human burials, hearths, and structural remains. However, subsistence-settlement pattern changes exhibited by faunal and botanical remains are only marginally reflected by the tools, probably because these tools were used for

a generalized set of functions (i.e., plants are better indicators of habitat preference and seasonality than handstones and millingstones). Nevertheless, changes in the relative abundance of several basic tool types produced patterns that are largely consistent with the more direct mea-

Table 10  
FREQUENCY DISTRIBUTION OF WETLAND AND  
DRYLAND SMALL SEEDS FROM ALL SITES

Type	San Felipe Lake			Terrace Sites		Combined Data			Totals
	Early	Middle	Late	Early	Middle	Early	Middle	Late	
wet grass	10	267	154	3	22	13	289	154	456
dry grass	12	270	74	1	47	13	317	74	404
wet other	1	268	372	3	8	4	276	372	652
dry other	5	561	380	10	64	15	625	380	1,020
Totals	28	1,366	980	17	141	45	1,507	980	2,532

Table 11  
RATIOS OF ACORN TO SMALL SEEDS FROM ALL SITES

Type/Ratio	Early Period	Middle Period	Late Period	Mean Ratio Per Period	Standard Deviation
acorn (frequency)	25	1,199	554	--	--
acorn:wet other	1:0.16	1:0.23	1:0.67	0.35	0.28
z-score	-0.68	-0.43	+1.14	--	--
acorn:wet grass	1:0.52	1:0.24	1:0.28	0.35	0.15
z-score	+1.13	-0.73	-0.47	--	--
acorn:all dry	1:1.12	1:0.79	1:0.82	0.91	0.18
z-score	+1.17	-0.67	-0.50	--	--
acorn: <i>Chenopodium</i>	1:1.64	1:0.48	1:0.57	0.90	0.64
z-score	+1.16	-0.66	-0.52	--	--

tures of subsistence-settlement pattern change.

Both ground and battered stone tools show a progressive increase relative to projectile points, bifaces, and flake tools over time (Table 13), and may relate to more intensive use of plant resources (and perhaps shellfish processing in the case of cobble tools and anvils). Unlike at CA-SCL-178, where handstones and millingstones were essentially replaced by mortars and pestles,

both tool complexes persist through time in the Santa Clara Valley sites, producing a pattern that is largely consistent with the plant macrofossil trends (i.e., both acorns and small seeds are present throughout the sequence). Cores also increase relative to flaked stone tools over time, and may reflect a correlation between occupational intensity and the on-site manufacture of tools. In contrast to the above trends, the re-



Table 12  
FREQUENCY DISTRIBUTION OF UTILITARIAN TOOLS

	Terrace Sites			San Felipe Lake			
	Early	Middle	Total	Early	Middle	Late	Total
Flaked Stone							
projectile points	--	13	13	--	--	1	1
bifaces	11	42	53	1	5	7	13
flake tools	24	105	129	6	12	16	34
cores	8	89	97	8	4	24	36
<b>Totals</b>	43	249	292	15	21	48	84
Groundstone							
mortars	--	10	10	1	1	1	3
pestles	2	12	14	--	2	7	9
millingstones	--	3	3	--	--	--	--
handstones	2	31	33	--	1	5	6
misc. groundstone	2	16	18	--	--	1	1
<b>Totals</b>	6	72	78	1	4	14	19
Battered Stone							
cobble tools	--	4	4	--	--	5	5
anvil	--	3	3	--	1	--	1
<b>Totals</b>	--	7	7	--	1	5	6
Miscellaneous							
modified bone	11	31	42	5	17	12	34
net weight	--	1	1	--	6	--	6
<b>Totals</b>	11	32	43	5	23	12	40

maining implements (modified bone and net weights) follow a more sporadic spatiotemporal distribution.

## DISCUSSION

Early Period (4,500 to 2,500 B.P.) occupation of southern Santa Clara Valley is best documented at three of the four western terrace sites. All components appear to represent some form of residential base, probably operating within a highly mobile subsistence-settlement pattern system. A high degree of mobility is indicated by the abundant presence of bay mussel. Other commonly used subsistence resources include

deer, rabbits, acorns, a variety of grasses, and *Chenopodium*, while wetland-oriented resources, such as tule elk, waterfowl, freshwater mussel (*Anodonta*), fish, turtles, and *Scirpus* seeds appear to have been of marginal importance. Seasonality indicators reflect occupations beginning in spring and continuing through fall (i.e., spring/summer small seeds and fall acorns), while the sites appear to have been abandoned or minimally used in winter due to the lack of migratory waterfowl. This general pattern of winter abandonment is consistent with data from the Monterey coast, where winter indicators, such as northern fur seals and a variety of migratory wa-

Table 13  
RATIOS OF SELECTED UTILITARIAN TOOLS

Tool Type	Early Period	Middle Period	Late Period	Mean Ratio Per Period	Standard Deviation
flaked:ground	1:0.17	1:0.43	1:0.58	0.39	0.21
z-score	-1.05	+0.19	+0.90	--	--
flaked:battered	--	1:0.05	1:0.21	0.09	0.11
z-score	-0.82	-0.36	+1.09	--	--
flaked:cores	1:0.38	1:0.53	1:1.00	0.64	0.32
z-score	-0.81	-0.34	+1.12	--	--

terfowl, are usually abundant in Early and Middle period sites (Dietz et. al 1988; Hildebrandt and Mikkelsen 1993; Breschini and Haversat 1995).

Declining quantities of bay mussel in Middle Period (2,500 to 850 B.P.) components probably reflect reduced access to the coast during this interval. Perhaps in response to these changes, exploitation of local wetland resources appears to have intensified. At San Felipe Lake, a variety of wetland resources (e.g., elk, fish, waterfowl, *Anodonta*) were added to a diet previously dominated by a more dryland assemblage of rabbits, deer, and a variety of carnivores. The addition of probable winter indicators (i.e., ducks and geese) suggests year-round settlement of the area, further corroborating a decrease in overall mobility.

Residential mobility appears to have been a thing of the past by the Late Period (post-850 B.P.). Bay mussel essentially drops from the record, and occupational intensity shifts from the terrace sites to San Felipe Lake. Even though drought conditions have been documented across much of California between 950 and 650 B.P. (see Stine 1994), exploitation of wetland resources reached a peak during this interval, as the frequency of waterfowl, *Anodonta*, freshwater fish, turtle, and *Scirpus* seeds all increased relative to mammals and acorns. This expansion

in the use of wetland resources is also paralleled by an increase in the relative frequency of ground and battered stone tools, also suggesting more intensive use of local plant products. Although single-component areas postdating 500 B.P. have not been discovered, the Late Period adaptation outlined here is consistent with Spanish accounts from the late 1700s, where a series of lowland villages were observed along the shores of relatively large bodies of water. Furthermore, Milliken's (1993) study of Spanish mission register data indicates that the study area was occupied by a tribal group (the Unijaima) that was politically independent from the people who occupied the shores of Monterey Bay.

#### INTERREGIONAL VIEW OF LACUSTRINE ADAPTATIONS

Although the above patterns support the notion that intensive lacustrine resource use did not occur until late in the Holocene in southern Santa Clara Valley, the broader implications of these findings remain open to question. Heizer and Napton (1970) proposed that the rich resource base of the Humboldt Sink wetlands (e.g., tules, cattails, fish, waterfowl) allowed for the relatively early development of a "limno-sedentary" subsistence-settlement system. Madsen (1988) generally agreed with this perspective, arguing that such a lacustrine focus could

have been an outcome of the extreme seasonal variability in the productivity of Great Basin terrestrial habitats. This was particularly the case during the crucial period between late winter and early spring (an interval characterized by the near absence of terrestrial foods) when people had to collect and store significant amounts of resources and/or had easy access to wetland areas where resources were available on a year-round basis (including both carbohydrates [tubers] and proteins from fish, birds, and mammals). The latter strategy was favored in cases where storable resources were widely dispersed over great horizontal and vertical distances, because of the considerable transport costs associated with moving them to a single location (e.g., it may have been necessary to move pine nuts a distance of over 50 km.). Because only wetland areas produce high-quality resources during almost every season of the year (see also Simms [1988] for a discussion of resource ranking), and could be obtained with relatively low transport costs, Madsen (1988) concluded that a lacustrine subsistence focus was a reasonable solution to the spatiotemporal mix of resources available.

As noted above, Kelly (1990) presented a contrasting view, arguing that lacustrine resources were of secondary value relative to terrestrial resources, and that a wetland focus should only occur during periods of terrestrial resource depletion. Support for this argument was derived from survey data obtained from Carson Sink, indicating that intensive use of Stillwater Marsh did not occur until 1,500 B.P., when warm and dry conditions lowered terrestrial productivity.

If the productivity of terrestrial environments does influence the initiation of intensive lacustrine adaptations (*sensu* Kelly 1990), then the timing and intensity of lacustrine resource use should be inversely related to the productivity of adjacent terrestrial habitats. Although this is a rather simple notion that incorrectly assumes that

all lacustrine environments are equally productive, an interregional comparison of subsistence data from this perspective provides some compelling results. The comparative data base is derived from a series of sites near Owens Lake (Basgall and McGuire 1988; Delacorte and McGuire 1993; Gilreath 1995), Stillwater Marsh (Raven and Elston 1988), and Buena Vista Lake (Hartzell 1992).

Buena Vista Lake is located in the southern San Joaquin Valley, where precipitation averages about six inches per year, creating a terrestrial environment characterized by a combination of open grassland and desert saltbush. Usable faunal data from the area are available from CA-KER-116 and CA-KER-180 (Table 14; Hartzell 1992). The former site was originally excavated by Fredrickson and Grossman (1977), and produced a very small Early Holocene (8,600 to 7,400 B.P.) faunal assemblage that included rabbits, waterfowl, fish, and some turtle. Due to the limited number of items recovered, it is difficult to know the extent to which lacustrine resources figured into the overall subsistence-settlement system, but they were clearly used. Substantial faunal assemblages were absent from deposits dating between 7,400 and 4,000 B.P., a hiatus attributed to Mid-Holocene desiccation of the lake (Hartzell 1992). Nevertheless, when the Late Holocene assemblages of fish, birds, and turtles were compared to terrestrial game, and converted to z-scores using the same method applied to the southern Santa Clara Valley sample (shellfish were present but not quantified), several interesting patterns emerged (Table 14). Similar to southern Santa Clara Valley, fish and turtles are found in low relative frequencies during the Early and Middle periods, and reach peak proportions late in time. Birds, in contrast, have low frequencies early in time, but peak during the Middle and Late periods. The earlier emphasis on birds probably reflects a greater abundance of these animals in the local area (i.e., the presence of a larger body of water

Table 14  
BUENA VISTA LAKE FAUNAL RATIOS<sup>a</sup>

Taxon/Ratio	Early Period (4,000 to 2,000 B.P.) <sup>b</sup>	Middle Period (1,500 to 1,150 B.P.) <sup>b</sup>	Late Period (post-500 B.P.) <sup>c</sup>	Mean Ratio Per Period	Standard Deviation
terrestrial	36	107	8	--	--
bird	22	123	9	--	--
terrestrial:bird	1:0.61	1:1.15	1:1.12	--	--
z-score	-1.17	+0.63	+0.53	0.96	0.30
terrestrial	36	107	8	--	--
fish	44	257	76	--	--
terrestrial:fish	1:1.22	1:2.4	1:9.5	--	--
z-score	-0.70	-0.44	+1.15	4.37	4.48
terrestrial	36	107	8	--	--
turtle	21	57	2,021	--	--
terrestrial:turtle	1:0.58	1:0.53	1:252.62	--	--
z-score	-0.58	-0.58	+1.15	84.6	145.53

<sup>a</sup> From Hartzell (1992).

<sup>b</sup> Minimum number of individuals.

<sup>c</sup> Number of identified specimens.

within the Pacific Flyway) and a lower availability of large land mammals due to the relative aridity of the area (pronghorn and elk represent only 9.3% of the mammalian assemblage, while elk and deer account for 37.0% of the southern Santa Clara Valley collection).

Ten sites contribute data to the Owens Lake sample: CA-INY-30 (Basgall and McGuire 1988); CA-INY-3807 and -3812 (Delacorte and McGuire 1993); and CA-INY-1428, -1430, -1434, -1444, -1447, -1451, and -1452 (Gilreath 1995). All are located within 3.0 km. of the lake and its adjacent marshlands. Although rainfall values are similar to those at Buena Vista Lake, local environmental diversity is much higher. Lacustrine, riparian, and desert scrub resource zones are found relatively close to each site, and upland habitats containing concentrations of oak and pinyon are also available along the Sierra Nevada escarpment. Faunal remains were obtained from three temporal intervals: Newberry (3,100 to 1,350 B.P.), Haiwee (1,350

to 650 B.P.), and Marana (post-650 B.P.; see Table 15). Following what is now a recognizable pattern, the frequency of lacustrine taxa increases relative to terrestrial game over time. Fish are found at maximum lows in Newberry deposits, reach average frequencies in Haiwee contexts, and peak late in time, while shellfish remain low until after 650 B.P., when they also reach maximum frequencies. Bird remains follow a more complicated pattern, beginning relatively low in Newberry contexts, dropping in Haiwee components but, like the others, reaching a peak late in time.

Stillwater Marsh is located in the Carson Desert where sand dunes, alkaline plains, and a sparse cover of greasewood, saltbrush, and bud-sage dominate the terrestrial landscape. Good faunal assemblages are available from three periods of occupation, but formal component areas were not defined by the authors (Raven and Elston 1988). For the purposes of this discussion, the sites are chronologically ordered as follows:

Table 15  
OWENS LAKE FAUNAL RATIOS<sup>a</sup>

Taxon/Ratio	Newberry Period (3,500 to 1,250 B.P.) <sup>b</sup>	Haiwee Period (1,250 to 650 B.P.) <sup>b</sup>	Marana Period (post-650 B.P.) <sup>b</sup>	Mean Ratio Per Period	Standard Deviation
terrestrial	280	220	339	--	--
bird	153	61	590	--	--
terrestrial:bird	1:0.55	1:0.28	1:1.74	0.86	0.78
z-score	-0.40	-0.74	+1.13	--	--
terrestrial	280	220	339	--	--
fish	5	11	25	--	--
terrestrial:fish	1:0.02	1:0.05	1:0.07	0.05	0.03
z-score	-1.00	0.00	+0.67	--	--
terrestrial	256	19	307	--	--
shellfish	13.7	0.9	417.5	--	--
terrestrial:shellfish	1:0.05	1:0.5	1:1.36	0.49	0.76
z-score	-0.58	-0.58	+1.14	--	--

<sup>a</sup> From Basgall and McGuire (1988), Delacorte and McGuire (1993), and Gilreath (1995).

<sup>b</sup> Counts represent number of identified specimens; shellfish values are weight in grams. Shellfish ratios are from CA-INY-30 only (Basgall and McGuire 1988).

26CH1052—Elko Period (3,300 to 1,250 B.P.); 26CH1048, -1068, and -1055—Rosegate Period (1,250 to 650 B.P.); and 26CH1173—Desert Period (post-650 B.P.). In direct contrast to all other localities, lacustrine resources were intensively used early in the sequence, dropping in relative frequency over time (Table 16). Muskrat, bird, and fish are found in maximum relative frequencies during the Elko Period, drop to near-average frequencies in the Rosegate Period, and continue to drop thereafter. Shellfish frequencies also begin quite high, but drop to minimum amounts in both the Rosegate and Desert components. These general trends led Raven and Elston (1988) to question the ideas of Kelly (1985, 1988), as they clearly run counter to inferences drawn from his survey data. It is important to note, however, that Raven and Elston (1988: 384) also attributed the decrease in lacustrine resources to a change in the location of the marsh (i.e., it shifted away from the sites, de-

creasing the local availability of wetland resources). Irrespective of these environmental considerations, it is important to recognize that the Elko Period assemblage produced much higher relative frequencies of wetland taxa than found in any other spatiotemporal component thus far discussed. Given the desert environment that surrounds the Stillwater Marsh sites, where terrestrial faunae are meager at best (pronghorn, deer, and sheep represent only 4.8% of the mammalian assemblage), it is not surprising that lacustrine resources were relatively important early in the sequence.

## CONCLUSIONS

When viewed from the wider contexts of Buena Vista Lake, Owens Lake, and Stillwater Marsh, the late development of an intensive lacustrine adaptation in southern Santa Clara Valley is easy to understand. Although lacustrine resources were no doubt used to some ex-

Table 16  
STILLWATER MARSH FAUNAL RATIOS<sup>a</sup>

Taxon/Ratio	Elko Period (3,300 to 1,250 B.P.) <sup>b</sup>	Haiwee Period (1,350 to 650 B.P.) <sup>b</sup>	Desert Period (post-500 B.P.) <sup>b</sup>	Mean Ratio Per Period	Standard Deviation
terrestrial	10	83	8	--	--
muskkrat	9	52	--	--	--
terrestrial:muskkrat	1:0.90	1:0.63	1:0.0	0.51	0.46
z-score	+0.85	+0.26	-1.11	--	--
terrestrial	10	83	8	--	--
bird	182	784	18	--	--
terrestrial:bird	1:18.2	1:9.45	1:2.25	10.0	8.0
z-score	+1.02	-0.07	-0.97	--	--
terrestrial	10	83	8	--	--
fish	2,810	8,276	23	--	--
terrestrial:fish	1:281.00	1:99.71	1:2.88	127.86	141.18
z-score	+1.08	-0.20	-0.89	--	--
terrestrial	10	83	8	--	--
shellfish	15,324	120.7	8.4	--	--
terrestrial:shellfish	1:1,532.40	1:1.45	1:1.05	511.63	884.01
z-score	+1.15	-0.58	-0.58	--	--

<sup>a</sup> From Raven and Elston (1988).

<sup>b</sup> Counts represent number of identified specimens.; shellfish values are weight in grams.

tent throughout prehistory (particularly during winter among nonstoring peoples), the timing of their intensive use appears to be highly situational, and largely dependent upon the availability of alternative resources (see also Hildebrandt and Levulett 1997).

One important alternative to the people of the southern Santa Clara Valley was Elkhorn Slough, where sites were occupied on its shores as early as 7,000 B.P. (Dietz et al. 1988; Jones and Jones 1992; Breschini and Haversat 1995). The resources of Elkhorn Slough were transported over 20 km. to the interior until the Late Holocene, when access to the coast appears to have been restricted and interior peoples began to intensify the use of the local, lacustrine resource base (Hildebrandt 1983; Hildebrandt and

Mikkelsen 1993). The early use of Elkhorn Slough, particularly given the relatively high value of adjacent terrestrial alternatives, clearly indicates that Jones (1991) was correct in proposing that estuaries produced concentrations of high-quality resources readily apparent to the earliest inhabitants of central California. Lacustrine settings, in contrast, exhibit much more variability across space and time, in many cases reflecting both short- and long-term changes in local climate. Lakes of the Mojave Desert, for example, were never as productive as those in the Klamath Basin with respect to fish and waterfowl (see Basgall 1993). Moreover, when many areas of the central Great Basin were abandoned between 7,000 and 6,000 B.P. (Grayson 1993), occupation of both protected and



outer coast settings along the central and southern coasts of California proliferated (Jones 1992).

It is also interesting to ponder the functional equivalence of lakes and estuaries in light of the seasonality considerations forwarded by Madsen (1988). Although not as extreme as in the Great Basin, late winter and early spring are also periods of resource depletion in California, necessitating the use of stored foods and/or resources obtained from those rare locations still producing in the winter. It seems that the presence of waterfowl, shellfish, and fish make estuaries and lakes excellent places to live during the winter months, a phenomenon that appears to have been the case at Elkhorn Slough and San Felipe Lake. But given a choice, early peoples appear to have preferred Elkhorn Slough, probably due to its larger size, abundance of resources (including marine mammals), and better access to collecting areas. With respect to the latter point, it is useful to consider the contrast between the regular exposure of shellfish during low (sometimes minus) winter tides, and a lakeshore inundated for months by heavy winter rains.

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