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Prehistoric Shellfish Exploitation Around the Goleta Lagoon, California

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THE reconstruction and interpretation of prehistoric subsistence has been a focus of Santa Barbara-area archaeology for many years, and the analysis of faunal remains is an integral part of this research. Shellfish remains are an abundant and visible constituent of local sites. The role of shellfish in subsistence, and their relative contribution to the prehistoric diet, have been topics of recent literature (Erlandson 1988a; Glassow and Wilcoxon 1988). To understand the role of shellfish in the prehistoric diet, it is necessary to document the nature of shellfish remains in archaeological sites.

In recent years a large body of quantified data on shellfish from several sites in the vicinity of the Goleta Lagoon has been recovered, and it is now possible to consider the nature and causes of changes through time in shellfish remains in a broad context. This paper is a description of shellfish assemblages from 14 site components from 11 sites, and a discussion of explanations for changes through time in shellfish exploitation.

CULTURAL AND ENVIRONMENTAL CONTEXT

The sites are all located on the coastal plain near Goleta, some 13 km. west of Santa Barbara (Fig. 1). The coast has a sheltered, southern exposure there, and many streams cross the coastal plain. Six streams once fed the Goleta Lagoon, an embayment that was a focus of prehistoric human habitation.

Lohmar et al. (1980:232) observed that

> Goleta Slough occupies a coastal valley excavated below present sea level during the last glacial low-stand. It represents the final stage of sedimentary infilling of a marine embayment which spread into the valley as the seas later rose to their present level.

At its maximum extent, the ancient Goleta Lagoon was eighteen square miles in size, and may be typical of other coastal lagoons, being formed by a sequence of incision, inundation, and subsequent infilling (Lohmar et al. 1980). Alluviation and airport construction have reduced the Goleta Lagoon to a small remnant area near its mouth. More than 20 archaeological sites line the ancient slough shorelines and the banks of its tributaries (Fig. 2). These sites range in age from over 7,000 years to less than 200 years, encompassing the Early to the Late Periods in King's (1981) chronology, and from Oak Grove to Canaliño in Rogers' (1929) scheme.

PREHISTORIC SHELLFISH REMAINS IN THE GOLETA AREA

Local patterns of changing shellfish exploitation first were noted at CA-SBA-56 (Serena 1982), CA-SBA-142 (Owen et al. 1964), and CA-SBA-143 (Colten 1987), three multiple-component sites. One of the shifts documented at these sites is a change in abundance from open coast species such as *Mytilus californianus* (California mussel) and *Tivela stultorum* (Pismo clam) to estuarine species (Table 1). For example, Serena (1982) identified 21.4% *Mytilus californianus* and 14.9% *Chione* spp. from the older component of CA-SBA-56, and 9.4% and 37.7%, respectively, of these two taxa from the younger component (Tables 2 and 3).

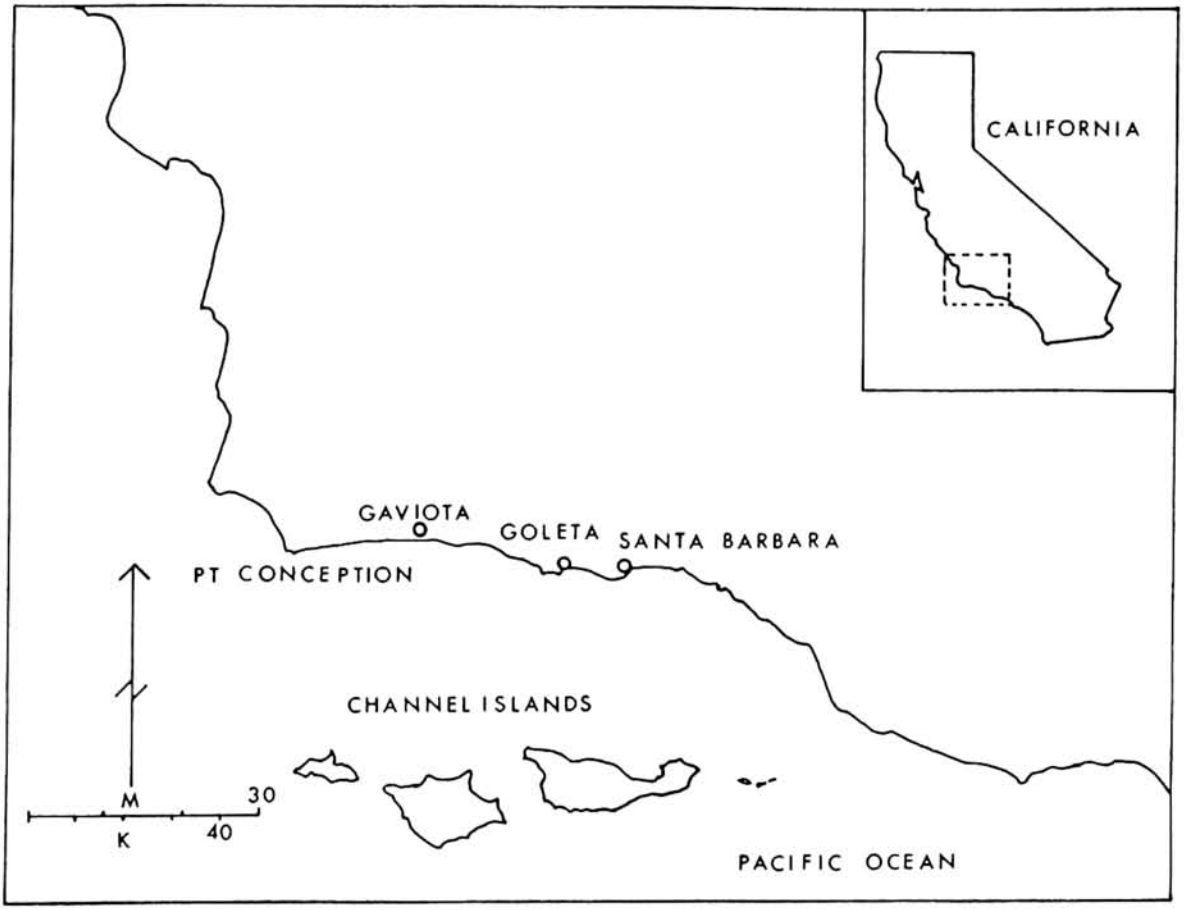

Fig. 1. Map of general research area.

Table 1
SHELLFISH HABITATS[a]

Shellfish	Common Name	Description of Habitat
Chione	California venus	In sand, on flats in bays near low-tide level, and offshore in water 60-150 ft. deep.
Mytilus	California mussel	On rocks, intertidally to 150 ft. deep.
Ostrea	Pacific oyster	On rocks near low-tide line and in beds on mud flats and gravel bars in estuaries and bays.
Protothaca	Pacific littleneck	In coarse, sandy mud, in bays and estuaries or on open coast near rocks and rubble, in lower half of intertidal zone.
Saxidomus	Washington clam	Deeply buried in sand in bays or off rocky coasts, from near low-tide line to water 150 ft. deep.
Tivela	Pismo clam	In high-energy sand flats, intertidally to water 80 ft. deep.

[a] from Rehder (1981).

A second documented change in shellfish remains from Goleta-area sites is within estuarine species, for example, from *Saxidomus nuttalli* (Washington clam) to *Chione* spp. (various Venus clams) (Table 1). For example, the lower levels of the Glen Annie Canyon site (CA-SBA-142; Owen et al. 1964: 495), contained 27.3% *Saxidomus nuttalli* and 28.7% *Chione undatella*, while the upper level contained 13.7% and 38.7% respectively of these two species (Tables 2 and 4).

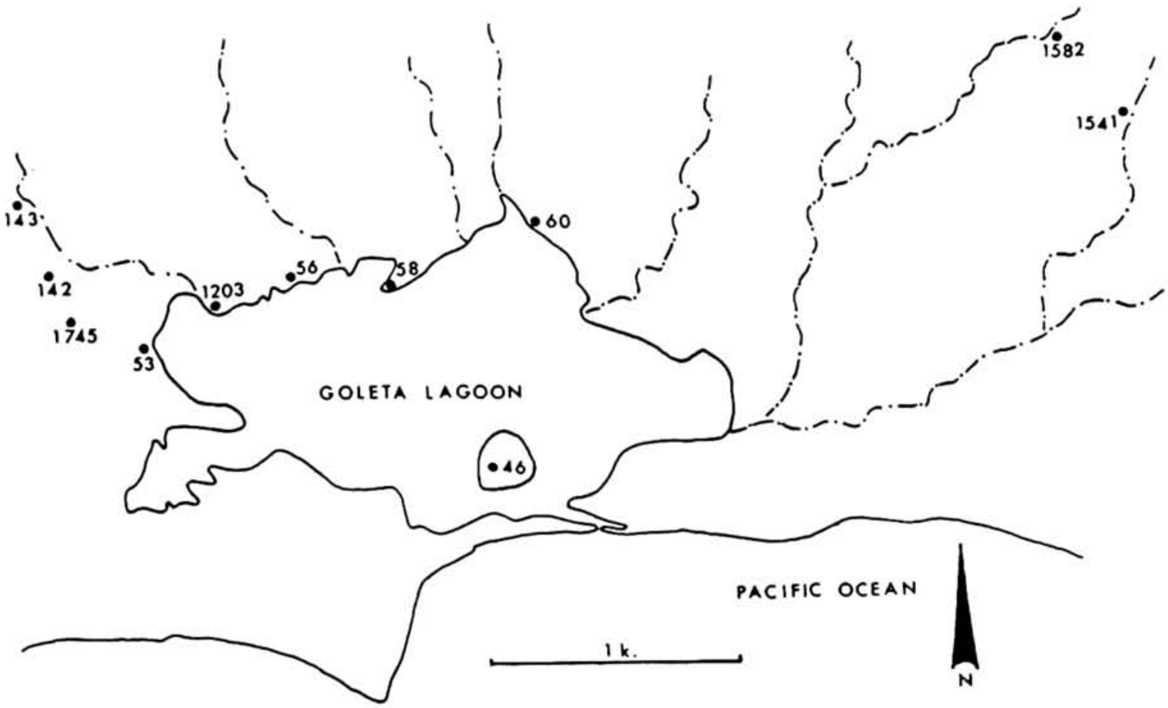

Fig. 2. Map of Goleta-area archaeological site locations mentioned in text.

Table 2
PERCENTAGES OF SELECTED SHELLFISH FROM EARLY PERIOD COMPONENTS OF SITES

	SBA-53 (Unit A)	SBA-56 (Lower)	SBA-58 (70-80 cm.)	SBA-142 (older)	SBA-143 (older)	SBA-1745
Shellfish						
Chione	39.98	14.93	51.58	29.55	7.02	30.01
Ostrea	6.76	7.33	4.64	7.16	3.16	3.29
Protothaca	1.27	6.75	2.18	3.06	4.06	0.72
Saxidomus	1.06	17.25	2.54	30.09	9.95	3.62
Estuarine total	49.07	46.26	60.93	69.86	24.19	37.64
Mytilus	19.74	21.43	2.23	20.99	58.90	12.33
Tivela	12.88	0.26	0.00	0.00	0.91	39.84
Marine total	32.62	21.69	2.23	20.99	59.81	52.17

Data Collection and Sample Sizes

Excavation type and screen sizes are listed for each site in Table 5. Shellfish remains recovered in 1/8-in. mesh were used when possible because they reflect midden constituents more accurately than materials recovered from larger screens. Shellfish taxa have differential fracture rates, and use of 1/4-in. screens can bias a sample significantly.

Data from additional sites exhibit patterns of shellfish exploitation similar to those discussed above. Early Period shellfish assemblages are quite variable, exhibiting roughly 20% to 60% marine taxa, and roughly 24% to 70% estuarine taxa (Table 2). This is not surprising since the Early Period spans some 4,000 years.

Table 3
PERCENTAGES OF SELECTED SHELLFISH FROM LATE PERIOD COMPONENTS OF SITES

	SBA-46	SBA-56 (upper level)	SBA-60	SBA-1582
Shellfish				
Chione	54.11	37.73	64.52	13.35
Ostrea	10.16	1.94	12.25	7.3
Protothaca	27.60	7.01	18.87	43.55
Saxidomus	1.54	6.06	1.2	4.95
Estuarine total	93.41	52.74	96.84	69.15
Mytilus	0.95	9.42	0.08	0.25
Tivela	0.74	0.52	1.12	1.9
Marine total	1.69	9.94	1.20	2.15

Table 4
PERCENTAGES OF SELECTED SHELLFISH FROM MIDDLE PERIOD COMPONENTS OF SITES

	SBA-142 (upper)	SBA-143 (younger)	SBA-1203	SBA-1541
Shellfish				
Chione	53.94	25.41	46.68	53.63
Ostrea	5.56	4.17	1.3	0.42
Protothaca	1.22	7.22	24.46	38.74
Saxidomus	16.68	10.13	0.74	1.01
Estuarine Total	77.4	46.93	73.18	93.8
Mytilus	3.89	40.51	0.54	0.39
Tivela	2.55	4.14	0.74	3.57
Marine total	6.44	44.65	1.28	3.96

Table 5
SITE CHRONOLOGY AND SAMPLING INFORMATION[a]

Site Number	King's Period	Rogers' Classification	Sampling Method	Screen Size
CA-SBA-46	Late	Canaliño	Excavated units	1/4 in.
CA-SBA-53	Early	Hunting	Excavated units	1/8 in.
CA-SBA-56	Early and Late	Oak Grove and Canaliño	Column samples	1/8 in.
CA-SBA-58	Early and Late	Hunting	Column samples	1/8 in.
CA-SBA-60	Late and Historic	Canaliño	Excavated units	1/4 in.
CA-SBA-142	Early and Middle	Oak Grove and Canaliño	Excavated units	1/4 in.
CA-SBA-143	Early and Middle	Oak Grove and Canaliño	Column samples	1/8 in.
CA-SBA-1203	Middle	Canaliño	Column sample	1/8 in.
CA-SBA-1541	Middle	Canaliño	Excavated units	1/4 in.[b]
CA-SBA-1582	Late	Canaliño	Excavated units	1/8 in.
CA-SBA-1745	Early	Oak Grove	Excavated units	1/8 in.

[a] Information from Rogers (1929) and King (1981).
[b] Mathematically corrected with data from column samples screened through 1/8-in. mesh.

CA-SBA-58 (Bixler et al. 1979) and the older component of CA-SBA-142 differ from the other Early Period sites by having the highest percentages of estuarine taxa, and the lowest proportions of marine taxa. The data from CA-SBA-58 may reflect sampling problems. CA-SBA-58 is the youngest of the five Early Period components considered here, it has the smallest sample size analyzed, and also has the highest percent of the sample classified as unidentified. While at first glance CA-SBA-142 may appear anomalous, when we consider change through time at this site, Glen Annie fits the general pattern. Although the Early Period component contains a higher than normal proportion of estuarine shellfish, the Middle Period component contains an even greater proportion of estuarine shellfish, which fits the general pattern of increasing estuary exploitation through time. The Middle Period component of CA-SBA-142 overlays the Early Period component, and mixing undoubtedly occurred, blurring distinctions between the components. CA-SBA-53 (Moore 1980) and the older component of CA-SBA-56 have proportions of estuarine shellfish that are average for Early Period sites.

In general, Middle Period shellfish assemblages (Table 4) contain greater proportions of estuarine shellfish and lesser proportions of marine shellfish than Early Period sites. Significantly, the two Middle Period assemblages with the highest proportions of estuarine shellfish, CA-SBA-1203 (Serena et al. 1981) and CA-SBA-1541 (Woodman 1986; Moore et al. 1988), are the youngest Middle Period sites considered here.

Two of the four Late Period sites, CA-SBA-46 (Peterson 1985) and CA-SBA-60 (McKusick 1961), exhibit the highest proportions of estuarine shellfish and the lowest proportions of marine shellfish of any of the assemblages (Table 3). The later component of CA-SBA-56, as mentioned earlier, has a greater proportion of estuarine shellfish and lower proportion of marine shellfish than the older component at that site, although the proportions are not as extreme as those from CA-SBA-46 and CA-SBA-60. This may be due in part to sampling error. The data from CA-SBA-56 are derived from single levels of a column sample, and some vertical mixing of the occupations may have occurred in this small sample.

The relationship between *Saxidomus nuttalli* and *Chione* spp. described above is also exhibited at other Goleta Lagoon sites. In general, Early Period sites have the greatest proportion of *Saxidomus nuttalli* in their assemblages, Middle Period sites have relatively less, and Late Period sites have the lowest proportion of this species. The sites along the eastern edge of the lagoon and its tributaries have low proportions of *Saxidomus nuttalli*.

Another pattern of interest is that later sites, those along the eastern shores of the lagoon and along its eastern tributaries, have the highest proportions of *Protothaca staminea*. This could be due to proximity to habitats favored by this species, or may be purely a function of time–later sites have greater proportions of estuarine shellfish. Jon Erlandson (personal communication 1983) has noted that the earliest sites cluster around the western Goleta Lagoon, and that the later sites tend to be near the eastern edge.

Two related explanations may account for this distribution. During the later prehistory of the Santa Barbara area the Chumash used plank canoes, which may have been easier to launch from areas near the mouth of the lagoon. The second possible explanations is that the western portion of the lagoon may have silted in earlier than the eastern area. This might explain why few *Protothaca* were recovered from western sites, and may reflect a general reduction in the productivity of the estuary environment in that area. Unfortunately, quantified shellfish data from sites along the southern edge of the lagoon are not available at this time.

In summary, there is a pattern of increasing proportions of estuarine taxa and decreasing marine taxa through time at prehistoric archaeological sites near the Goleta Lagoon. When site location is held constant, as it is at the multiple-component sites CA-SBA-56, CA-SBA-142, and CA-SBA-143, changes through time are clear. The proportion of *Saxidomus nuttalli* tends to decrease through time relative to *Chione* spp. *Protothaca staminea* remains are a major constituent of Middle and Late Period middens, particularly along the eastern edge of the lagoon.

EXPLANATIONS FOR SHIFTS IN SHELLFISH EXPLOITATION

For the Goleta Slough area, Serena (1982: 40-41) suggested that the change from *Mytilus californianus* to *Chione* spp. reflected a shift in procurement strategy from species with low search/collection times to species with higher search and collection times in response to increasing regional human population density.

Glassow (1975:3-4) has suggested a more general model of prehistoric maritime adaptation in the Santa Barbara Channel, ranking marine resource zones by energy expenditure required for exploitation. For example, the greater pelagic zone is an expensive, low-ranked resource zone because of the technological expense (i.e., boats) required for systematic exploitation of pelagic resources. This model is useful for examining the development of the overall marine adaptation of the Chumash, but it is difficult to apply to shellfish exploitation.

In the analysis of the shellfish remains from the Dos Pueblos High School Site, CA-SBA-143, I (Colten 1987) tested Serena's hypothesis with a general diet-breadth model of optimal foraging theory (Smith 1983). The hypothesis, tested with shellfish and vertebrate faunal remains and artifacts, was that in response to population-resource imbalances, the prehistoric inhabitants of the region expanded their diet breadth to extract greater amounts of energy from the environment. Although the shellfish data exhibited patterning similar to those from CA-SBA-56, which is consistent with a general diet-breadth model, other categories of faunal data did not support the model.

In a more general discussion, Claassen (1986:126) considered four alternative explanations to account for species ratio changes through time. These explanations are: "a) gastronomical whim, b) dietary shifts required by human overexploitation, c) technological advances that permit new harvesting techniques and consequently new prey, and d) environmental changes that extirpate some species and favor other species."

Claassen's first explanation, gastronomical whim, or human choice, is difficult to test archaeologically. Overexploitation has been cited as the cause for changes in shellfish assemblages in other parts of California (Botkin 1980), but again, it is a proposition that is difficult to test with available data. Reduction in mean size of individuals through time is often considered as evidence of overharvesting, but data of this nature are not readily available for the Goleta area. It is difficult to imagine that thousands of years of human predation would selectively eliminate only marine taxa from the local habitat, especially since both environments were exploited since the earliest local occupation.

Technological advances seem an unlikely candidate for causing changes in shellfishing patterns. The only reference to tools used by the Chumash and their predecessors in shellfish harvesting that I have found is the pry bar used for harvesting abalone (Hudson and Blackburn 1982:253-255). The last of Claassen's four explanations is environmental change, which is considered in more detail below.

CHANGING RESOURCES AND ENVIRONMENTAL CHANGE

Given the nature and timing of changes in shellfish remains in local archaeological sites, environmental change seems a likely candidate for a causal factor. I believe that as sea level rose and then stabilized, a change in available resources occurred. The basic assumption in this explanation is that prehistoric people collected shellfish in proportion to their natural abundance in the local environment (Yesner 1981), and that as sea levels rose and estuaries formed, more lagoon species were available and were collected. Certain marine habitats, particularly rocky shores, may have been submerged at this time, reducing the productivity of this habitat. As further infilling of the Goleta Lagoon occurred, there were changes in the microenvironments within the lagoon, increasing mudflats and associated molluscan fauna. These environmental changes altered significantly the available faunal resources (Lohmar et al. 1980). As the estuaries increased in size, more *Chione* spp. were available. As the lagoon filled with sediment, habitats preferred by sand-dwelling *Saxidomus nuttalli* decreased.

This type of model has been used to explain changes in prehistoric subsistence in several regions. Claassen (1986:131-134) invoked sea level changes to explain shifts in molluscan midden constituents in southeastern North America, and cited several examples of proportional harvesting of shellfish. Archaeological studies of shellfish remains from California (Gallegos 1985) and Australia (Webb 1987) support the hypothesis that shellfish are exploited in proportion to their abundance in the environment. Changes in coastlines have been invoked to explain similar shifts in shellfish remains in archaeological sites in other parts of California (Bickel 1978; Erlandson 1985; Rudolph 1985), and Braun (1972) noted that sea level change was an important variable in shellfish exploitation in prehistoric New England.

Paleogeography

Clearly, the timing of sea level rise and stabilization during the Holocene is critical to this model. It has been suggested that sea levels stabilized near their present level in southern California ca. 6,000 radiocarbon years B.P. Inman (1983:11) has described the southern California sequence as follows:

> . . . a relatively rapid rise in sea level (a meter/century and more) from 16,000 to about 6,000, punctuated by a brief standstill at about 10,000 years B.P. at which time the 10-fathom terrace was cut. Subsequent to about 6,000 years B.P. the rise has been much slower at a mean rate of about 10 cm/century.

A date of roughly 6,000 B.P. would place sea level stabilization near the end of King's (1981:47) Early Period Phase Ex, a period of significant cultural changes on the Santa Barbara coast.

Archaeological Implications

If increasing estuarine environments lead to greater exploitation of estuarine resources, there are several implications for the archaeological record. The first implication is that as sea level rose, estuaries formed in canyon mouths, and shellfish populations changed to include greater percentages of estuarine species. An increasing percentage of estuarine species in the diet and a decrease in open-coast shellfish species relative to estuarine species are clearly demonstrated by the data (Tables 2-4).

Given the broad impact of the ultimate causal factor—stabilization of sea levels—we should expect to find similar patterns of shellfish remains from sites in a larger region. The effect of sea level change in a particular location depends on a variety of environmental factors, particularly local topography. Consequently, similar directional changes in shellfish remains should be exhibited in archaeological sites in the greater Santa Barbara Channel area located near major estuary basins. Table 6 shows shellfish data from one Early Period site, three Middle Period sites and one Late Period site in Tecolote Canyon, located approximately 10 km. west of the ancient Goleta Lagoon. These sites have a decreasing percentage of marine species through time, and an increase in estuarine species.

As the Goleta Lagoon gradually filled with sediments, mudflat habitats increased and greater percentages of mudflat shellfish (e.g., *Chione* spp.) were exploited. This change is manifested in archaeological assemblages as a gradual increase in *Chione* spp., and a relative decrease in slough species, particularly *Saxidomus nuttalli*, from other microhabitats. This relationship is particularly clear at the three multiple-component sites, CA-SBA-56, CA-SBA-142, and CA-SBA-143.

Table 6
PERCENTAGES OF SELECTED SHELLFISH FROM TECOLOTE CANYON SITES[a]

	SBA-75 (Ey)	SBA-71 (M2)	SBA-72N (M3)	SBA-73N (M4)	SBA-73S (L1)
Shellfish					
Chione	0.83	5.37	9.43	19.43	12.23
Ostrea	0.02	0.68	18.14	17.61	4.72
Protothaca	0.25	8.29	20.28	28.71	54.74
Saxidomus	0.85	3.49	2.96	3.88	2.28
Estuarine total	1.95	17.83	50.81	69.63	73.97
Mytilus	8.98	74.32	35.60	19.98	8.64
Tivela	88.70	2.95	5.07	11.06	11.99
Marine total	97.68	77.27	40.67	31.04	20.63

[a] Data for SBA-75 from Erlandson et al. (1984:50, Table 6); other data from Serena (1980).

These patterns conceivably could result from an alternate cause: human overexploitation of open-coast species. If human predation had a significant impact on *Mytilus californianus* populations, as suggested for other areas of California (Botkin 1980), a decrease in the availability of this species could result in an increased percentage of estuarine species in middens. To test this alternate hypothesis, a fourth test implication, independent of shellfish, was devised.

As sea level rose and estuary environments formed, more estuarine fish species should have been available, leading to an increase in estuarine fish exploitation. Fishing is a more complex subsistence phenomenon, however, and a lack of evidence for increased estuary fishing does not necessarily contradict the model of changes in shellfish exploitation.

First, fishing requires significant advances in technology, and, perhaps, changes in social organization, while shellfishing was part of the subsistence regime from the earliest occupation of the region. Second, the estuarine fishery may not be as productive as the pelagic fishery, and the bulk of fish in the diet may come from resource zones other than estuaries, despite an increase in available estuarine fish. Third, the development of the *tomol*, or plank canoe (Hudson et al. 1978), is believed to have occurred during the Middle Period (King 1981:142). By the end of the Middle Period, and certainly by the Late Period, the pelagic and kelp bed fisheries would have been accessible, and the role of estuarine fish would be further complicated.

Data from CA-SBA-58, CA-SBA-142, CA-SBA-143, CA-SBA-1203, and CA-SBA-1541 were available to evaluate changes in fish procurement through time. No quantified fish data are available from CA-SBA-53, CA-SBA-56, CA-SBA-60, or CA-SBA-1745. The fish data from Late Period sites were not considered because technological advances, particularly the use of the plank canoe, had significant impacts on fishing by that time.

Three aspects of the fish data limit their reliability. First, the oldest known site in the vicinity of the Goleta Lagoon, CA-SBA-142, is a bioturbated multiple-component site with an overlying Middle Period component (Colten 1988; Erlandson et al. 1988). Differentiating the relative contributions of the Early and Middle Period components to the vertebrate faunal assemblage therefore is difficult.

Second, the sample sizes from CA-SBA-143 and CA-SBA-1203 are relatively small. CA-SBA-143 has less than 100 identified fish elements, and CA-SBA-1203 less than 300. The fish data from CA-SBA-58 rely on an even smaller sample size.

Third, fish are mobile and many "marine" fish spend part of their life cycle in estuaries. Fish remains should not be as reliable indicators of environmental change as shellfish.

Given the limits of the fish data, a qualitative rather than quantitative comparison was made between the sites. Of the eleven types of fish identified at CA-SBA-143

(Colten 1987:52-54), four are considered "slough species" (Johnson 1980; Bowser 1984), and all four are from the later portion of the site. None of the identified fish remains from the older portion of the site are from estuarine taxa. The fish remains from CA-SBA-1203 are mainly from estuarine species (Bowser 1984:149). Nearly 100% of the fish remains recovered from CA-SBA-1541 are from nearshore sandy-bottomed and estuary habitats (Moore et al. 1988:98).

The data suggest that the Phase Ex component of CA-SBA-143 contains no estuarine fish; the later, Phase Ey/M1 component of this site has a moderate amount of estuarine fish; and the Phase M3 component of CA-SBA-1203 contains mainly estuarine fish remains. Late Middle Period fishing occurred in a variety of habitats, and clearly was not restricted to the estuary environment.

SUMMARY AND CONCLUSIONS

The data presented here show that changes in shellfish exploitation exhibited in sites in the area of Goleta Lagoon reflect exploitation of a developing estuary environment. This change in shellfishing is correlated with stabilization of sea level. Given the broad impact of sea level change we should expect to find similar patterns of shellfish remains from sites in a wider region, at least along protected coastlines where productive estuaries have formed. Supporting data has been presented from a number of sites located at the mouth of Tecolote Canyon, demonstrating a similar pattern in this location. Data from sites located further west (Erlandson 1988b) do not fit this pattern, however, suggesting that a reliance on estuary exploitation was either restricted to large estuaries or that estuaries west of Gaviota did not exist after the early Holocene.

The analysis described here sheds light on one aspect of a complex prehistoric marine adaptation and demonstrates a relationship between paleogeography and subsistence. It is clear that changes in sea level affected coastal geography during the early Holocene in the Goleta area. Archaeological data have proved useful for reconstructing paleocoastlines in this region as well as in other parts of the California coast (Erlandson 1985; Rudolph 1985). The potential of archaeological data for paleoenvironmental reconstruction deserves further attention.

This study also shows that prehistoric people collected shellfish in proportion to their abundance in the local environment, and that as local conditions changed, diet changed. If, as Erlandson (1988a) has suggested, shellfish were collected primarily for protein, then changing environmental conditions and consequent changes in shellfish collecting would have broader implications for studies of prehistoric subsistence in coastal areas. For example, if a significant increase in shellfish populations led to an increase in available protein, other subsistence activities, particularly fishing and hunting, would have been affected. Understanding the relationship between paleogeography and prehistoric subsistence will increase our understanding of prehistoric behavior in general.

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