A GEOARCHAEOLOGICAL ANALYSIS

OF THE

PREHISTORIC SACRAMENTO-SAN JOAQUIN DELTA,

CALIFORNIA

Substantive Research Paper

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I. INTRODUCTION

This paper explores the evolving relationships between landforms, ecology, and human lifeways during the Holocene period in the Sacramento-San Joaquin Delta of California. The central California delta system developed from terminal Pleistocene through Holocene time (approximately 10,000 years b.p. - present). It evolved rapidly from a high energy riverine environment to a broad wetland complex under conditions of post-glacial rising sea levels. This landscape evolution may have commenced during or subsequent to human colonization of this region; it certainly continued to evolve throughout a period of archaeologically documented habitation. The Sacramento-San Joaquin Delta has evolved into a complex of deltaic and estuarine geologic features consisting of: 1) sediment that has been transported by river channels and deposited into a standing body of water 2) transgression of marine sediments onto these continental deposits and 3) a balance of prograding peat deposits and transgressing intertidal mud. Deltas and estuaries developed worldwide during the Holocene period and their evolution is specifically significant as a context of and stimulus for aboriginal adaptations (see Beaton 1985).

Given that little is known of the human adaptation patterns to this relatively rapid geomorphic and ecologic landscape evolution, this analysis will focus on existing data which primarily dates to the middle to late Holocene (5000 years b.p. to present), while limited details of previous conditions will be suggested. This paper specifically investigates how changing environmental parameters during the Holocene might influence subsistence behavior and settlement patterns of the native population in the Sacramento-San Joaquin Delta with a focus on fluctuations in the following: 1)sealevel, 2)hydrologic systems and 3)plant and animal communities.

The area under consideration is bounded to the west by the Sacramento River, to the south and southeast by the San Joaquin River, North Fork of the Mokelumne River and

Dry Creek, to the east by the Sierran foothills, and to the north by the 38°22'30" parallel (Figure 1). This territory presently ranges in elevation from sealevel (or below in the case of subsiding peat islands) to ~100 feet near the base of the foothills and is included on the U.S.G.S. 7.5 minute quadrangles of Courtland, Isleton, Bruceville, Galt, Elk Grove, and at the periphery, Thornton. Thus the area of this study includes approximately 25% of the total Delta, in particular, the lower reaches of the major river systems: Sacramento and Mokelumne Rivers with their associated riparian forests and surrounding marshland. The delta area is defined here by Atwater (1980) as the area east of the confluence of the Sacramento and San Joaquin Rivers covered by autumnal high tide and the land/waterways immediately adjacent ca. 1850. Also a part of this study is a Delta-margin area composed of lesser tributaries such as the Cosumnes River including its associated natural levees and seasonal floodplains as well as open grassland and oak woodland communities.

The composition, location, and proportion of these Delta and Delta-margin environments have changed dramatically during the last 10,000 years and may have continued to change substantially until as late as 2000-3,000 years b.p. Therefore, when interpreting archaeological indicators of cultural change in the Delta, it is necessary to consider the evolving landscape as a significant variable in changing human adaptations through time. Data are presented which provide some insight into complex human adaptational processes which complement the archaeological record, although the scarcity of extensive environmental investigations at Delta archaeological sites does not allow testing of hypotheses in a precise manner. Furthermore, the Sacramento-San Joaquin Delta regional history consists of a set of geomorphic events quite unique from that of other Holocene environments of California, thus complicating temporal comparison to other regions. Nevertheless, some general relationships between landscape and human adaptation can be presented.

Results of this study indicate that: 1) Regarding all archaeological sites, (dated or

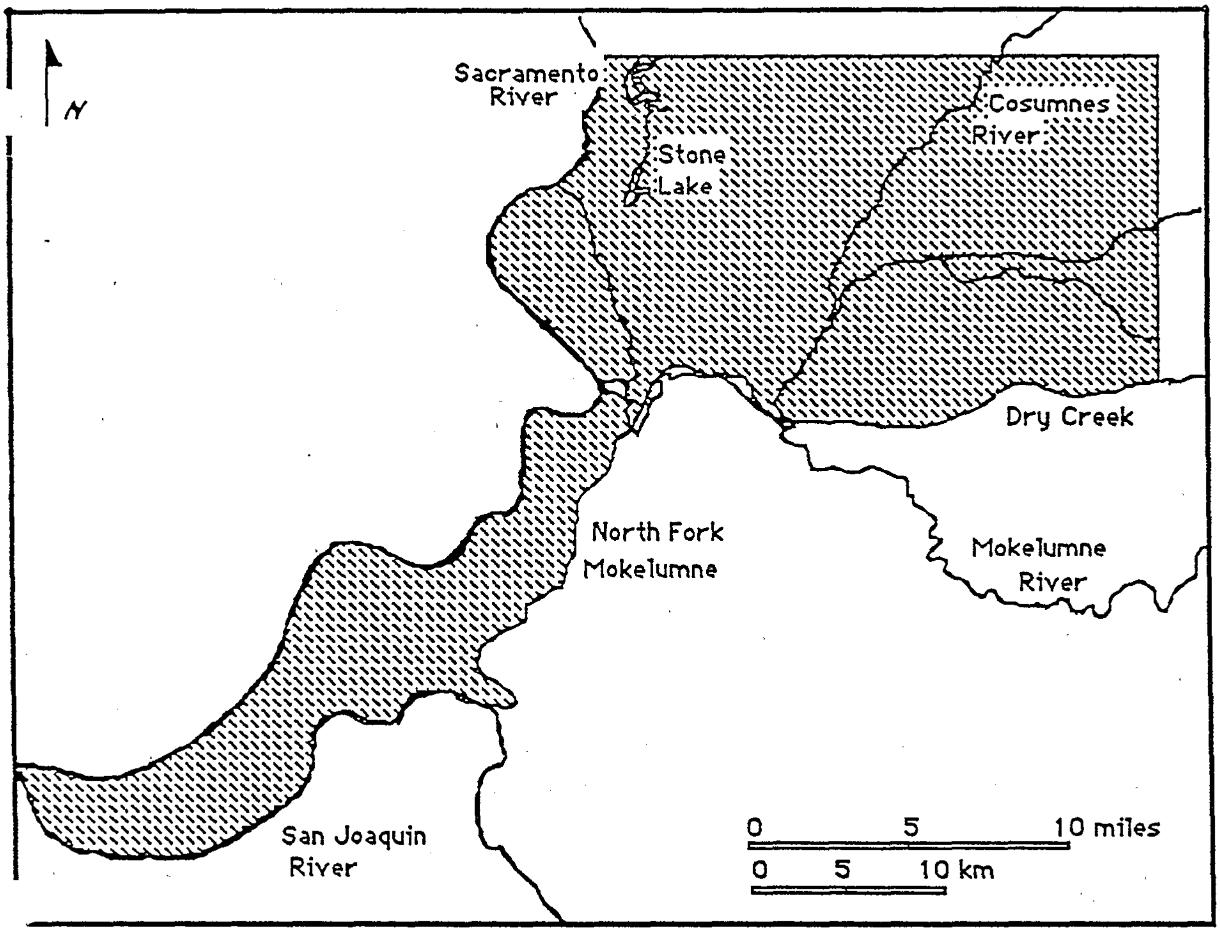

FIGURE 1: SACRAMENTO-SAN JOAQUIN DELTA (study area shaded)

undated) levee sites are not the most abundant site type, however, they are among the largest in area. The variability in site locations presented here contradicts most ethnographic observation in the Delta and Delta-margin; a more inclusive perspective on settlement patterns in this study area is supplied here (see Section IV); 2) Much of the known settlement pattern consists of Late Horizon (i.e. latest Holocene) sites. This is due to both a presumed greater population density in this period and the burial of any existing archaeological sites on early to mid-Holocene environments by marine transgressive or fluvial sediments. Where information is available on middle and late Holocene sites, this study reconstructs subsistence behavior and paleoenvironment to the degree which was possible; 3) This information then provides the basis for consideration of resource use and exploitation strategies employed by the people of the Delta in a changing landscape.

II. DELTA EVOLUTION

A. Sealevel

The Sacramento-San Joaquin Delta landform evolved dramatically during the last 10,000 years. Delta landforms have changed further since the early 19th century due to levee construction, agricultural reclamation, deforestation and hydraulic mining. Natural tidal marshes of the Delta decreased from 135 km^2 circa 1850 (Gilbert 1917:75,78) to 20 km^2 in 1970 (Atwater and Hedel 1976). These factors necessitate reconstruction of the Delta paleoenvironment as a context for archaeological study.

Prior to development of the Delta, 15,000-10,000 years ago, the dominant feature of Central California geomorphology was the converging Sacramento and San Joaquin River systems which flowed through the "Golden Gate" area and met the Pacific Ocean nearly 50 km west of San Francisco (Atwater and Hedel 1976:7). Throughout the Pleistocene, these river systems experienced cycles of incision and backfilling with each major climatic fluctuation (Shlemon 1971, Atwater and Belknap 1980). At 15,000 years b.p., global, eustatic sea level stood about 120m below its present level (Chappell 1981) due to the water volume locked in Pleistocene continental and alpine glaciers. From 15,000-10,000 b.p., sealevel rose 70m (Bloom 1971 and Flint 1971 as cited in Bickel 1978) (see Figure 2). This translates to a 20 km to 25 km marine transgression eastward along the continental shelf. Assuming constant rate of transgression, any early Holocene central coastal inhabitants, of whom there is no trace, would have experienced significant pressures to move eastward within a generational time frame (Bickel 1978) i.e. 0.5 km/100 years or 5m/year. Thus, at the terminal Pleistocene, the proposed arrival time of man into the Pacific Northwest, the proto-Delta area was dominated by incised channels, sand and gravel alluvial fans emanating from the Sierras, fields of Pleistocene eolian dunes attributable to glaciation, and less expansive alluvial floodplains (Atwater 1982). The estuarine delta did not exist at this time. Not until 11,000-10,000 years b.p. did sealevel begin to cross over the bedrock basement of San Francisco Bay (Figure 3). This basement lies 65-70m below present sealevel (Bickel 1978:11). Radiocarbon dates obtained from sediment cores show an extremely rapid filling of the bay between 11,000 and 8,000 b.p. During this period, sealevel apparently rose in the Delta an average of 2 cm/year; given this rate, shoreline transgression would approximate 30 m/year (Atwater and Hedel 1976).

As a consequence of rapid sealevel rise, plant colonizers could not keep pace with submergence rate in the Central Valley, hence it was an unsuitable period for wetland plant community development. After 8000 years b.p., the rate of sealevel rise decreased by a magnitude of 10 to an average of 0.1 cm - 0.2 cm/year (Atwater and Hedel 1976) i.e. a 2.4 m/year linear advancement, its rate having slowed since glaciers were significantly reduced. This allowed marsh plants to trap sediment and promote marsh development (Atwater and Hedel 1976) in the western portion of the Delta. Core data show time lags up to a few thousand years from the time of slowed sealevel rise to marsh development; mud flat sediments usually underlie marsh deposits. This suggests that time was needed for

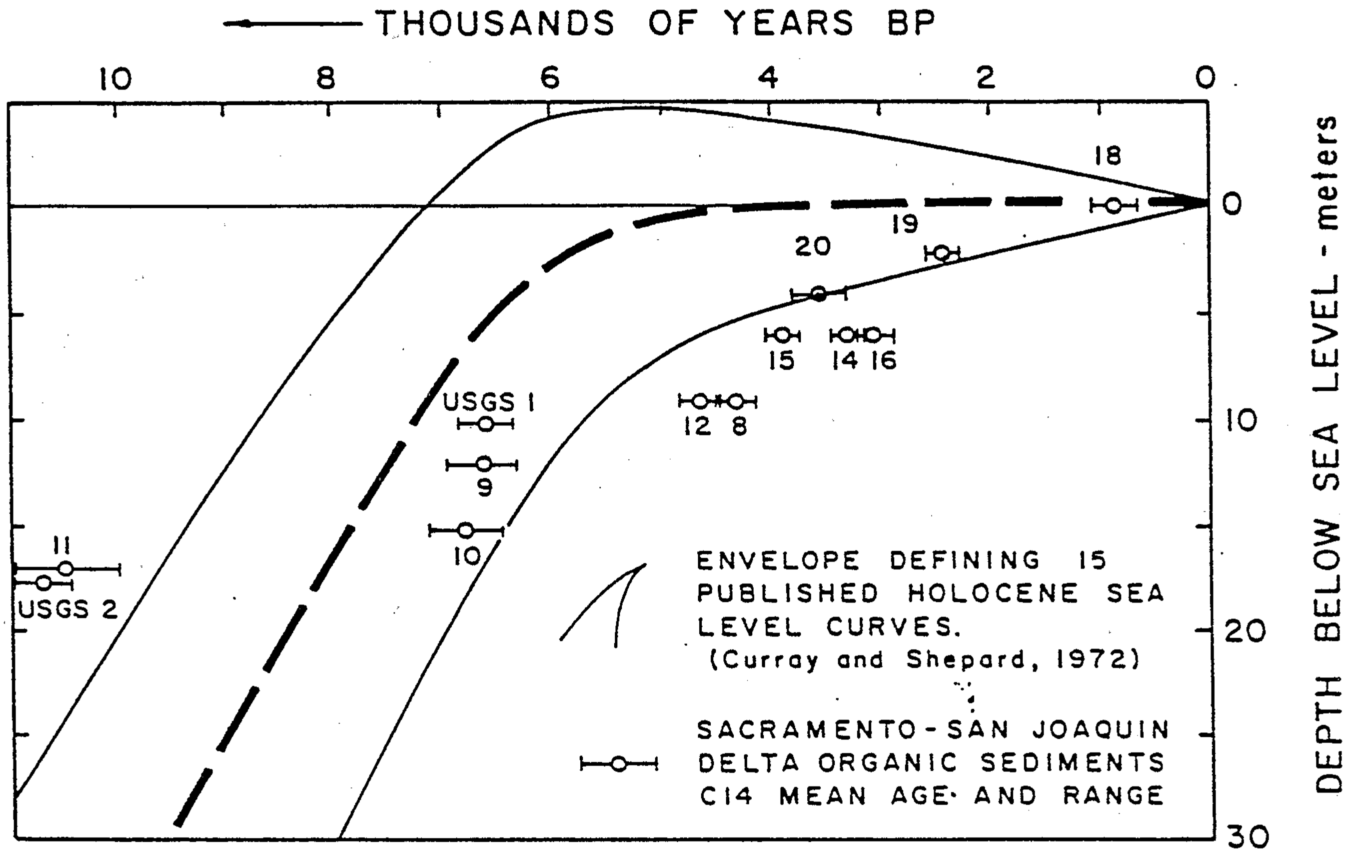

FIGURE 2: Radiocarbon age and depth of Sacramento-San Joaquin Delta sediments compared with a "calibration envelope" of world-wide Holocene sea level curves. Samples taken from central Delta. (Figure taken from Shlemon and Begg 1975)

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PLATE 1

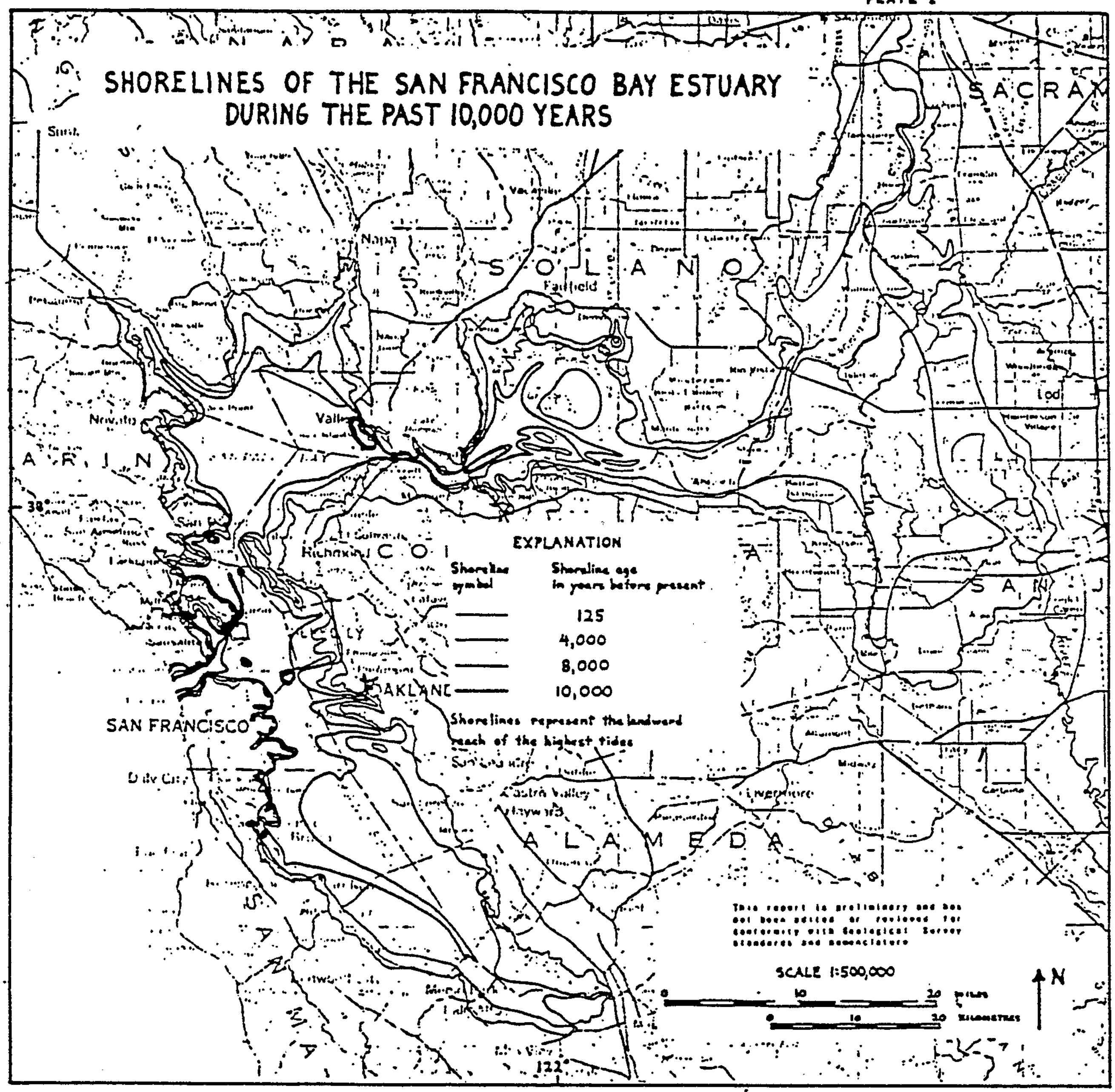

FIGURE 3: HOLOCENE PALEOSHORELINES IN THE SACRAMENTO-SAN JOAQUIN DELTA REGION

Taken from: Atwater and Hedel 1976

sediment accumulation to develop shallow flats suitable for marsh vegetation (Atwater and Hedel 1976).

Marine transgression, a gradual landward progression of shoreline, occurred in the Delta (generally from west to east). Time lag must be considered when reconstructing central Delta versus Delta-margin environments. For instance, basal peat on Sherman Island has a radiocarbon date of 6805 ± 350 years b.p. (Shlemon and Begg 1975) at 15.2m below present sea level, whereas peat did not develop until approximately 3575 ± 260 years b.p. (Atwater 1982) at Terminous Tract , some 12 miles east of Sherman Island (Figure 4), due to this time lag. During the mid-Holocene Delta development, an accumulation of aquatic plant roots, rhizomes and surficial litter maintained the vertical growth of marsh vegetation as sea level gradually encroached (Atwater and Belknap 1980). As the intertidal environment spread eastward, mud and peat eventually overlapped the glacial-age alluvial fan deposits of the Mokelumne River fan . The continuing rise of relative sealevel during the last 6000 years is attributable to regional down-warping as a result of marine loading or possibly tectonic subsidence. Nevertheless, Delta development continued beyond the mid-Holocene. Given time lags and dated core data, it is suggested here that the eastern Delta margin stabilized (stabilization considered here as development of wetland plant communities) at 2000-3000 years b.p. The Delta developmental sequence is geographically complex and so, presumably, are the associated human subsistence systems. Each geographic location has a somewhat different chronostratigraphic history and dating profile, hence necessitating site-specific reconstructions relative to the overall pattern of Delta evolution.

B. Hydrologic Systems

Associated with rising sealevel and affecting Delta development, is the process of rising base levels for the river systems draining the Sierras. The natural levee and

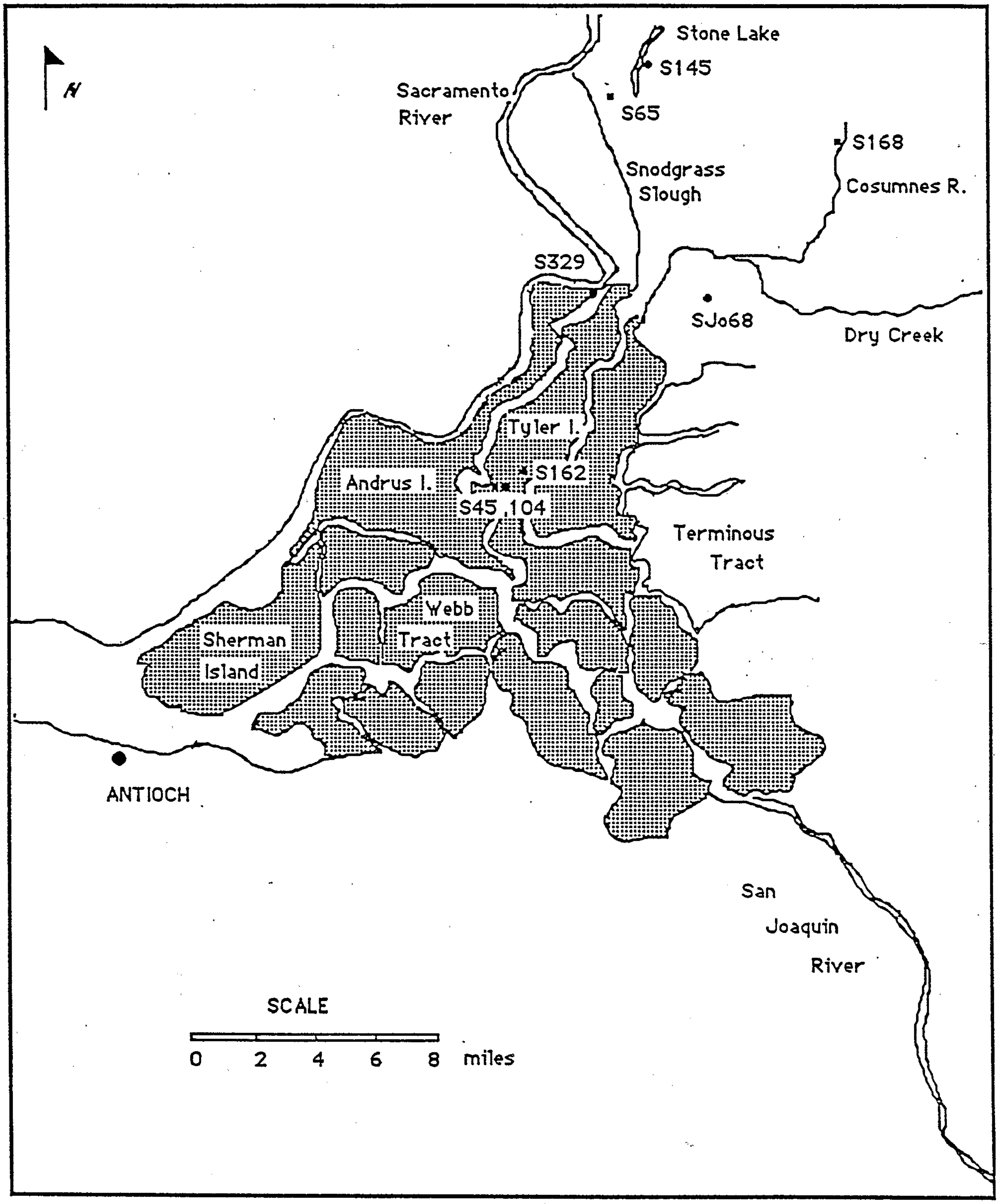

FIGURE 4: SACRAMENTO-SAN JOAQUIN DELTA GEOGRAPHY AND ARCHAEOLOGICAL SITE LOCATIONS

floodplain geomorphologies were developed to their present degree due to the encroachment of seawater into the river valleys and the change in the sedimentary depositional environment (Atwater and Belknap 1980). Maturation of these two features, levee and floodplain, would have occurred simultaneously since they are hydrologically related. "During major floods, most water from the Sacramento River entered the Delta via alluvial flood basins because the Sacramento's channel north of the Delta was too small to accommodate even moderate floods" (Atwater and Belknap 1980: 96). Since the Sacramento River delivered nearly triple the annual flow to the Delta compared to the San Joaquin River, distributaries along the Sacramento River developed to a greater extent (ibid). The rapid flow of river channel water abutting the more sluggish flow of overland floodwater in the flood basins is interpreted as one of the mechanisms which enhanced natural levee development (Brice 1977). The central area of this study, the Delta at the Cosumnes/Mokelumne confluence, lies in a sector between the Sacramento and San Joaquin Rivers, a region of considerable hydrologic complexity. Flood-flow conditions occurred annually in late winter and early spring until historic modifications of the levee and channel systems.

Since natural levees and floodplains are some of the more common locations for late Holocene archaeological sites, it is important to understand how the evolution of these environments fit with patterns of aboriginal occupation and economy. The rates of sediment deposition associated with raised base levels should not be underestimated when predicting early to mid-Holocene settlement patterns and environmental change. Near the city of Sacramento, 8 feet of sedimentary basin material was deposited in the last 3000 years (Atwater 1982). Stratigraphic relations of some archaeological sites (e.g. SJo 68 and Sac 168 [Ragir 1972]) provide evidence that sedimentation rates are considerable in other distributaries as well.

Vegetation

Once sealevel rise had stabilized somewhat on the eastern edge of the Delta, a wetland community was able to develop. This community experienced variable salinity conditions resulting from river discharge as a function of climate, seasonality and daily tidal fluctuation. The following description of vegetative communities is based on the palynological work of West (1977) and early historic observations as cited in Thompson (1961). The aboriginal uses of these resources are discussed in Section III. The geographic distribution of plant communities in the late Holocene was quite different than that of today and many efforts have been made to reconstruct it. Consideration of plant community development consequent to landform evolution is an important factor in understanding changing human adaptations. The compilation of traveler's accounts and old maps by Schulz (1981) is used here (Figure 5). The protohistoric Delta and Delta-margin area included four biotic zones: tule marsh, riparian forest, oak woodland and grassland. The Delta, mainly comprised of intertidal marsh, was dominated by the tules (Scirpus sp.) but also contained cattail (Typha sp.), sedge (Carex sp.), rushes (Juncus sp.), reeds (Phragmites sp.) and other shallow water plants. Other species present in ponds, lakes or oxbows included pondweed (Potamogeton sp.), yellow pond lily (Nuphar polysepalum), knotweed (Polygonum sp.) and wapato (Sagittaria latifolia). This floral composition of the Delta is expected to have existed over the last 5,000 years (in stable regions), although the prehistoric proportions of these species are unknown in precise terms.

A riparian forest community lined the Sacramento River, including its channel through the Delta, and the lowest reach of the Mokelumne below its confluence with the Cosumnes (Figure 5). The riparian forest community, as known historically, may have matured in conjunction with maturation of the natural levee system. The natural levees hosted a multi-storied community which consisted of a deciduous canopy including

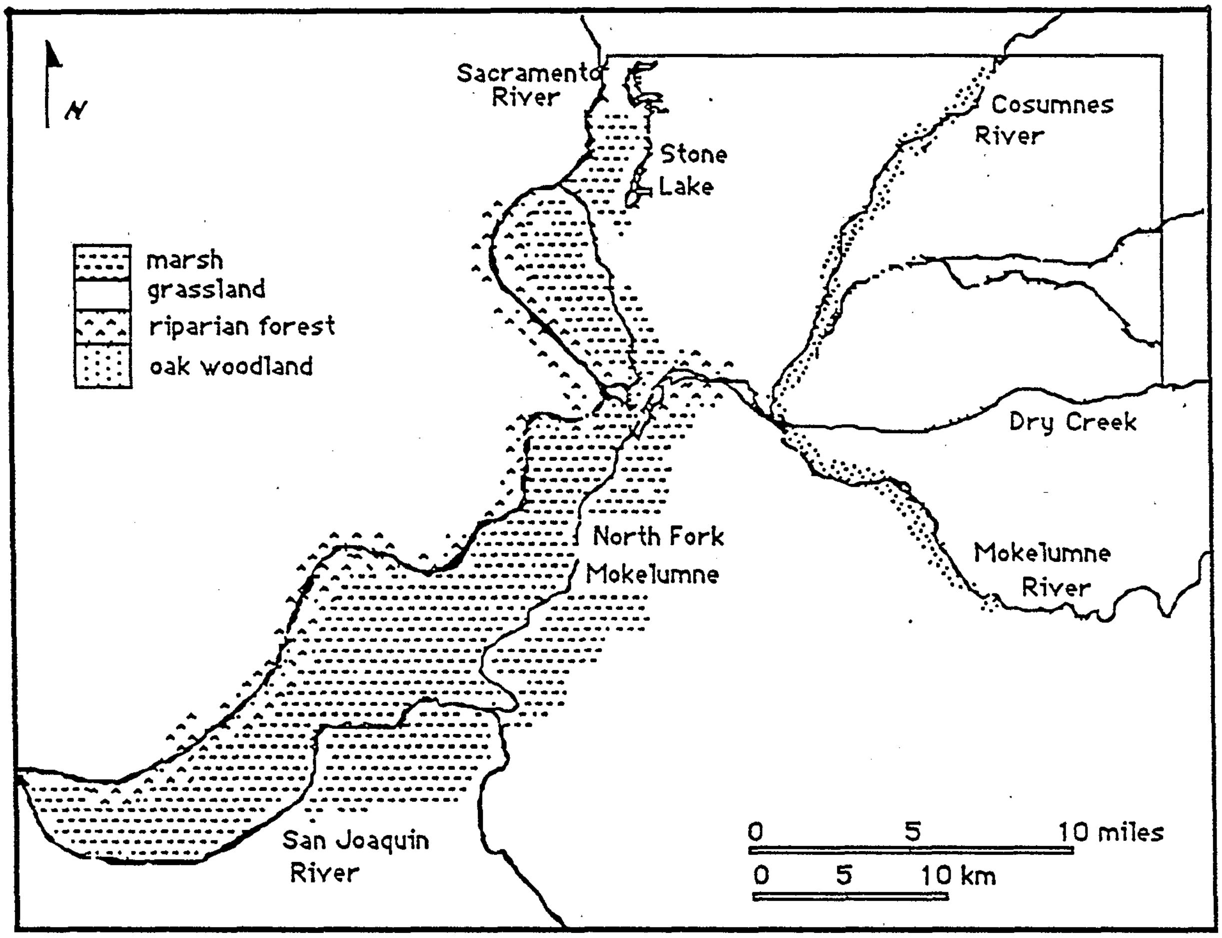

FIGURE 5: RECONSTRUCTED LATE HOLOCENE VEGETATION PATTERNS
(based on the work of Schulz 1981)

cottonwoods (Populus fremontii), valley oaks (Quercus lobata), walnut (Juglans hindsii), California sycamore (Platanus racemosa) and Oregon ash (Fraxinus latifolia). The sub-canopy consisted of white alder (Alnus rhombifolia), box elder (Acer negundo) and elderberry (Sambucu mexicana). The dense understory hosted willows (Salix sp.), lianas, grapevines (Vitis californica) and herbaceous plants. Most of this very dense forest was eliminated by the turn of the century as it supplied a ready fuel source for steamships which navigated the rivers (Thompson 1961).

West (1977) describes the oak woodland community as paralleling the riparian forest on the Delta-margin in bands up to 3-5 km wide. Schulz (1981), however, shows narrow band of oak woodland on tributary margins upstream from the riparian forests (Figure 5). Unfortunately, little is definitively known about the evolution of the oak community in prehistoric time. This oak resource became a crucial one for the Delta-margin inhabitants as well as into the foothill and sierra zones; however, the antiquity of this industry is as yet undecided (see Basgall 1987 and sources therein). Valley oak dominated; however, box elder and oregon ash were also common. Poison oak (Rhus diversiloba), elderberry, buckeye (Aesculus californicus) and wild rye grass (Elymus triticoides) formed the understory. It has been proposed that a mid-Holocene warming trend led to a retraction of the oak community to higher elevations (Schulz 1981). There is some evidence that indicates a mid-Holocene warming of under 2° C further north at Clear Lake (Adam and West 1983). A 200-300 m upslope retreat of oak communities, as a result of climatic change to warmer, drier conditions, has been documented elsewhere to the north (West in Hayes and Hildebrandt 1984). If there had been a retraction of the oak community due to climate, its timing may have been slightly later than at Clear Lake (West, p.c.). Irrespective of a mid-Holocene warming, certainly, the intrusion of saline water and sediment associated with marine transgression and shifting river base levels would have forced back any oak woodland which flanked the lower reaches of rivers on the valley floor. Further palynological research is required to assess the chronological distribution of the oak resource.

Valley grassland flanked the woodland area and included perennial bunch grasses such as needle grass (Stipa sp.), blue grass (Poa sp.) and three-awn (Aristida sp.). All of these have been replaced by introduced European grasses in the 19th century. This community was located on soils derived from alluvium which predates the Delta.

III. SUBSISTENCE

A. History of Debate

Culture change in Central California has been a topic of archaeological discussion since 1936 when J. B. Lillard and W. K. Purves described the three cultural levels - Early, Intermediate and Recent in the Deer Creek-Cosumnes area (Lillard and Purves 1936) based on mortuary practices and grave-associated artifacts. These levels were later described as an Early, Transitional, Late and Historic relative chronology (Lillard, Heizer, and Fenenga 1939:23) and then as Early, Middle, and Late Horizons (Heizer 1949).

Lillard & Purves 1936	Lillard, Heizer, Fenenga 1939	Heizer 1949
Recent level	Historic period	Historic
Intermediate level	Late period I, II	Late Horizon I, II
	Transitional period	Middle Horizon
Early level	Early period	Early Horizon

But the efforts to produce cultural chronologies provided only a glimpse of the resources utilized (Beardsley 1948, Ragir 1972, Meighan 1987).

The debate centering on prehistoric subsistence changes originated in the 1940s (Schulz 1981, Moratto 1984). It was proposed that a transition occurred from an Early

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Horizon hunting subsistence to a Middle Horizon gathering/acorn processing subsistence which climaxed in the Late Horizon (Beardsley 1948). The relative change in composition of mortuary artifacts (projectile points as opposed to mortar/pestles and fishing-related tools) supported this view which quickly crystallized into an argument on chronologic development of balanophagous technology based on archaeological presence/absence of bone awls for basketry, cooking hearths and millingstones (Heizer 1949 in Schulz 1981).

Since that time, many studies have sought to investigate the possibility that the Early Horizon lacked extensive acorn-based subsistence. Osteological evidence such as Harris line frequencies, noted by McHenry (1968), tested for the consequences of non-intensive acorn processing in the Early Horizon. His results showed that Harris lines, which are associated with starvation and disease, occurred more frequently during the Early Horizon, possibly due to the lack of stored resources which acorns can provide. Another study (Schulz 1970) used burial orientations in order to discover seasonal concentration of deaths. Noting that burials of the Early Horizon are known to orient toward the setting sun (Heizer 1949), Schulz interpreted the 80% frequency of inhumations during late winter/early spring as indicating stressful conditions caused by the possible lack of an acorn storage system. Other osteologic and paleodemographic studies further tested the increase in acorn processing from Early to Middle and Middle to Late periods (Doran 1980, McHenry and Schulz 1976, 1978, all cited in Basgall 1987). Some of these results, however, were in conflict by finding an increase or status quo in pathologies through time (Schulz 1981). As Schulz has noted, osteological/paleodemographic evidence for a shift in subsistence base conflicts with the most recent archaeological evidence which suggests an acorn-processing technique of considerable antiquity (Schulz 1981).

The analysis of SJo-68 by Ragir (1972), which contains Early Horizon components, was a turning point in the subsistence debate when she noted more mortars were found at this site than expected (based on earlier interpretation of Early Horizon subsistence). Radiocarbon dates for this period at SJo-68 approximate 4300 -3000 years b.p. (Ragir 1972). This observation introduced caution into subsequent archaeological analyses regarding the antiquity of balanophagy. However, the fragmented nature of Early Horizon mortars (which skews the count of minimum individuals) and their association with ochre-staining may support the argument for less acorn-processing in Early compared to later horizons (Schulz 1981). Following Ragir, Gerow (1974) argued that rarity of seed-processing implements in the Windmiller Culture of the Delta could be due either to greater importance of hunting or to scarcity of stone and hence the use of wooden mortars and pestles which were not preserved. Provided an allowance is given for the possibility that wooden mortars and pestles were left unpreserved, an argument could be supported for an industry of antiquity.

Thus the argument centering on balanophagous economies remains frustrated by insufficent evidence of technology, conflicting intradisciplinary evidence, and a shrinking availability of undestroyed component sequences in the Delta. It is clear that the presence of groundstone cannot always be taken as direct evidence for acorn processing since non-subsistence items or other non-acorn seeds may be processed by milling equipment (Basgall 1987, Schulz 1981). Furthermore, the absence of stone mortars cannot be equated necessarily with a lack of acorn-processing. Consideration of the acorn question can not remain isolated from a more complete analysis of diet as a whole in terms of resource availability and cost/benefit decisions (Basgall 1987). Specific archaeological evidence relating to balanophagy will not answer more encompassing questions of subsistence or subsistence change over time. It is only one component of many. This study endeavors to consider the relation of Delta evolution to subsistence behavior and settlement patterns in its effect on resource distribution and stability.

Some workers follow the argument that "arguments appealing to depressed environmental variables also fail to provide a reasonable explanation of late acorn use" and "the magnitude of the inferred environmental perturbation has yet to be established" (Basgall 1987: 40). This argument points to minimal suspected vegetation change in North Coast Ranges (Adam and West 1983) due to mid-Holocene warming. Conversely, Schulz attempts to link a hypsithermal episode during the mid-Holocene with an elevational retreat of oak woodland communities and thus an absence of intense acorn exploitation in the Early period (Schulz 1981). I do not find fault with Schulz's hypothesis - his suggestion is testable and does merit palynological study. In fact, I would argue that broad scale changes in environmental factors did occur in the Delta, not only in the oak woodland community but a in a very broad resource base relevant to the native population. Climatic change is one proposed factor in mid-Holocene environmental change; however, due to regional time lags in climatic change (West, p.c.) and oceanic buffering of climatic change (West in Hayes and Hildebrandt 1984) it is difficult to predict such change in the Delta based on Coastal Range or Sierran evidence. In addition to any possible climatic influence, the Delta oak community certainly experienced the converging influence of hydrologic, sedimentologic and marine factors.

B. Ethnographic/Ethnohistoric Documentation

The ethnographic analogs for prehistoric resource availability and procurement are employed here with caution. Ethnographical sources can be used to generate hypotheses regarding the archaeological record, however, they cannot provide explanations of particular cultural behaviors via extrapolation into prehistoric time. Differences in human technology, population size and composition, and climate (to name some factors) between the historic and prehistoric cultures may have led to different behavior. Nevertheless, if the processes influencing ethnographically-observed behavior are understood, and relevant prehistoric parameters which would alter this behavior are identified, then a prediction of aspects of prehistoric behavior can be suggested. Thus, this central California ethnographic information, particulary relevant to subsistence and settlement pattern behavior, is presented in the context of a fully climaxed deltaic paleoenvironment to provide a tentative analog for reconstructing limited aspects of prehistoric behavior. In this discussion, subsequent analysis of archaeological remains will consider the possible changes in the native resource utilization corresponding to Delta evolution, which may have led to the lifeways observed at the arrival of the Europeans.

A number of ethnohistoric and ethnographic sources describe both the resources available to the protohistoric and early historic central California occupants as well as some of the practices used to procure these resources. The archaeological components, referred to as the latest phase of the Late Horizon (see discussion on page 9), contain the remains of these historic, native settlements. Excavated faunal remains from Early, Middle and Late Horizon sites confirm that much of the historically-observed fauna was important to the prehistoric native diet (see Appendix A). However, in comparing ethnographic data with cultural remains of the earliest Delta sites it is important to consider the relation of subsistence resources to Delta evolution. That is, we could expect the following developments which led to the mid-Holocene ecologic system: 1) prior to Delta development, the concentration of game (e.g. elk, waterfowl, beaver, etc.) may have been restricted to corridors along rivers with grassland/oakland communities between 2) Delta evolution created a new, dominant ecologic system i.e. estuarine marsh with associated abundant fish and plant resources and 3) the huge expanse of marsh and slough waterways created a hub of resources and pushed grassland and oak woodland communities back from lower elevations.

Marsh fauna described by early travelers into the Sacramento Valley included great herds of tule elk as well as an abundance of beaver, river otter, raccoon, mink, grizzly bear and rodents (Bennyhoff: 6-7) Waterfowl were in extreme abundance during the winter and included ducks, geese, cranes, herons, pelicans, and whistling swans. Some of these species fed in great abundance on the grassland in search of insects and seeds (Yount 1923 in Bennyhoff 1977) in addition to their aquatic feeding. Decoys were used to lure waterfowl, and cordage nets with baked clay net weights were used to capture them (Barrett and Gifford 1933, Bennyhoff 1977). A large variety of fish species in both riverine and estuarine environments were available to the Delta and Delta-margin inhabitants (Schulz and Simons 1973). Fish were obtained using weirs, nets with baked clay weights, and poison (Bennyhoff 1977, Barrett and Gifford1933). Many of these activities were accomplished communally. Tule balsas were necessary to fish for the large sturgeon (Barrett and Gifford 1933) as was the bi-pointed, bone gorge hook. Balsas were also used for transportation throughout the many sloughs and riverine tributaries and for waterfowl hunting (Work 1923, Conrotto 1973).

Dominating the grassland fauna were deer, antelope, black bear, cottontail rabbits, jack rabbits, coyotes, badgers, skunks, ground squirrels, gophers, woodrats, wildcats, and foxes (Bennyhoff 1977: 6-7). Communal hunting for antelope is documented amongst the Maidu. Two hundred Maidu were observed returning from a communal hunt with 64 antelope. Only a few of the natives were armed (Work 1923 in Bennyhoff 1977).

They may have employed the brush corral trapping technique observed in the Great Basin (Steward 1955). The use of deer skin and head as camouflage when approaching deer herds is mentioned by Goethe (1910) for the Central Valley but was also observed much earlier at Mission Carmel, Monterey amongst the Esselen (LaPerouse 1786). Quail, mourning doves, flickers, woodpeckers, roadrunners, red-tailed hawks, horned owls, bald eagles, and turkey vultures were also common on the grassland plains and at least some were subsistence items (Barrett and Gifford 1933; Appendix A). Human hair or cordage snares were used to catch quail and pigeon (Barrett and Gifford 1933). Baskets were sometimes used as a component of small game traps (Bennyhoff 1977).

Despite the abundance of game, fishing and hunting appeared ethnographically as supplementary to plant-gathering and processing subsistence in at least Delta-margin and foothills. Acorn was the staple with supplements of seeds, nuts (including walnut), roots, elderberries, grapes, and greens such as Miner's lettuce. Historic accounts mention that seeds, sliced lily bulbs or herbs were added to acorn mush (Goethe 1910). A wide variety of herbs were collected and these can be noted archaeologically (see Appendix A). The roots of tule could be ground into flour and its seeds eaten. Wappato, an aquatic plant, had edible tubers. Young shoots and roots of cattail were also edible. Dried grasshopper cakes were also eaten (Goethe 1910). These grasshoppers were obtained by a communal "gathering" . The grassland was set afire to drive the grasshoppers into a ditch (Schulz 1981). Twined burden baskets, and seed beaters of willow or other shoots and a digging stick were common implements for the gathering activities of women.

Granaries made from saplings were the storage repository for acorn supplies. This storage technology produced a reliable caloric intake throughout the winter and even held sufficient supplies during very poor acorn crop years. The acorns were pulverized using various mortars and pestles then leached to remove tannins. Mortars of wood may have been used as opposed to the rock or bedrock mortars of foothill and montaine altitudes.

However, stone pestles traded or brought from the Sierras accompanied the wooden mortars and were used by all women of a communal household as they were lineage property (Bennyhoff 1977). Baskets of coiled sedge or redbud upon willow rods were used in cooking the acorn mush. Baked clay "cooking stones" provided the heat for boiling since stones were absent in the Delta. The antiquity of this processing technology is a dominant focus of archaeological debate; unfortunately, retrieval of the rarely-preserved acorn remains is the most decisive evidence.

Vegetation was also a resource for the construction of dwellings. Domed lodges covered with tule mats or grass thatch are reported (Conrotto 1973, Sullivan 1934 in Bennyhoff 1977). Some of these dwellings were apparently portable (Barrett and Gifford 1933).

Unfortunately, decimation of central California cultures in the early 19th century , particularly that of the Plains Miwok people of the Delta and Delta-margin, by European convergence on gold and agricultural resources left virtually no communities for ethnographic observation. Therefore, there is little data to answer, for instance, how different were the subsistence practices of the Delta from the Delta-margin nearer the foothills, that is, was fishing in sloughs and hunting of riparian fauna more dominant in the Delta core than acorn processing? What sort of seasonal changes in aboriginal activity occurred in the Delta during winter flooding periods? Regarding the latter, since few European travelers penetrated the Delta core in winter, since access was nearly impossible by horseback, there are few ethnohistoric records of the Delta in that season.

C. <u>Archaeological Documentation</u>

Of the over 300 sites located in Sacramento County, approximately half are included in this study area. Many have been excavated throughout the past 50 years with variable excavation techniques and priorities. Early archaeological efforts in the Delta did not produce a systematic accounting of faunal remains or paleoenvironemental indicators, hence, relative to the large number of sites, these data are very scarce. Consequently, this archaeological discussion will focus on those sites with records of remains reflecting economic activity, specifically the faunal remains which suggest diet composition, as well as other palynological or artifactual remains which identify resource exploitation. These data were located for only four sites: SJo 68, Sac 145, Sac 329, and Sac 65 (Appendix A). Fragmentary information is presented for a number of other sites including Sac 168, 45, 104 and 162. Similarly, palynological information is scarce. It was not until relatively recently that the techniques for palynological identification were available and applied to archaeological investigation. Determination of the relative importance of prehistoric gathering activities relative to hunting is an important component of a processual consideration of subsistence change. However, since this information is often lacking, and the Delta is no exception, some speculation is necessary.

The paleoenvironmental reconstruction presented for the 8 sites below is based on stratigraphic relations, Delta evolutionary chronology, and palynological data (where available). Archaeological data in the form of faunal, and technological remains are then used to form hypotheses concerning the subsistence strategy relative to presumed paleoenvironment. I limit the majority of this discussion to those sites with components which have been dated absolutely with ^{14}C dating rather than undertake a detailed consideration of the host of sites which have been dated relatively through bead types, seriation, or mortuary practices as the regional contemporaneity of the cultural horizons based on these classifications is not widely accepted (Gerow 1974, Frederickson 1974, Basgall 1987). Figure 6 shows the general chronologic correlation between the Delta evolution and the relative cultural sequences, as accepted, of this region. Those sites lacking ^{14}C dates which are discussed here, are those sites whose geographic or stratigraphic relation to deltaic evolution has implications for relative dating and resource

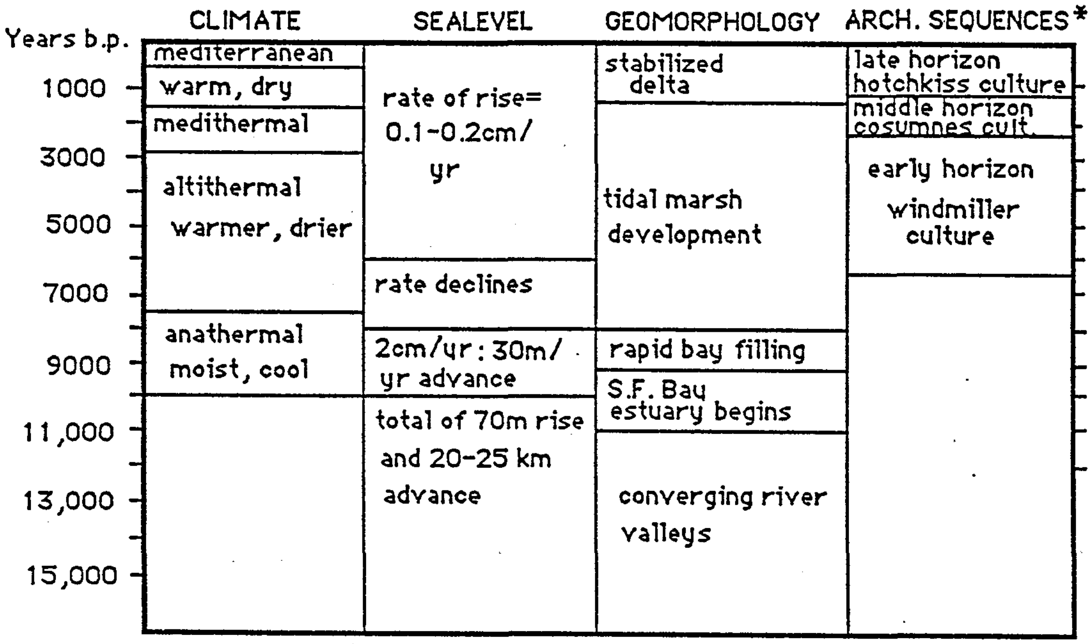

FIGURE 6: COMPARATIVE CHRONOLOGY OF DELTA EVOLUTION AND RELATIVE CULTURAL SEQUENCES

*see page 9 for discussion

availability (for example Sac 23 and Sac 104).

SJo 68

This site is located in a lowland at the toe of the Mokelumne River Fan on the Thornton quadrangle. It is roughly at a junction of the highly alluviated fan with the overlapping flood basin deposits from the Cosumnes/Mokelumne confluence to the north and the Sacramento nearby to the west (see Figure 4). As of 4,000 years b.p., the encroaching shoreline was still at least 4 miles to the west or southwest (Figure 3). Augering at SJo 68 provided sedimentologic evidence that this site was located prehistorically on a streambank. Its abandonment is proposed at 3750 b.p. as a response to extensive alluviation (Ragir 1972) on the Mokelumne fan that probably resulted from fluctuations in at least climate and sealevel. It appears that a surrounding tidal marsh developed after the proposed 3750 b.p. abandonment (Figure 3).

Ragir's description of site stratigraphy (1972) indicates that recent alluvium covers both the yellow-red clay mound base and the midden occupation deposits leaving approximately one third of the six foot high midden exposed. "River sand" was discovered by augering thirty to one hundred feet from the site on the north side. This undoubtedly represents one of the many fan distributaries. Apparent greater depth of midden deposits on the sides adjacent to the water source (Ragir 1972:27-30) support a relation to this fluvial resource. Heizer's field notes, as cited in Ragir, note that the river side displays more occupational evidence such as ash, animal bone and baked clay.

Given the disparity between paleoenvironment and historic environment at this site, new possibilities arise for interpretation of resource availability. Fishhooks, clay "pecans" similar to slingstones as used by Pomo on waterfowl (described by Kroeber 1925), baked clay with tule mat imprint and caches of river mussel and clam suggest exploitation of wetland and riverine resources at SJo 68. The small quantity of Hardhead and Chub, present in apparently equal proportions, indicates exploitation of both main channel and slow-water environments (see Appendix A). The quantity and composition of fish remains does not indicate the fishing specialization of later sites such as Sac 65 and 145. Eighty-two percent of all bird remains are waterfowl, notably ducks, cormorants, geese and coots (see Appendix A) which supports the postulate that at least riverine and quite possibly wetland resources were important.

The faunal assemblage favors the suggestion of wetland and open grassland exploitation. Seventy-five percent of the mammalian fauna is composed of, in order of abundance, elk, hare, pronghorn, mule deer, coyote, and raccoon. Elk remains suggests marsh hunting; raccoon suggests riparian hunting to some degree, as does the lesser presence of beaver and river otter. Hare, pronghorn, badger, kangaroo rat were more likely grassland prey. Four of these species (beaver, raccoon, elk and kangaroo rat) tend toward nocturnal activity although it is unknown whether night hunting was practiced.

Basketry is commonly interpreted as an implement for seed and acorn gathering. However, it is suggested here that baskets could be just as indicative of gathering mussels, tule roots, grapes, etc. At SJo 68, basketry evidence takes the form of awls, and twined basketry impressions on clay. Mortars, pestles, and clay pots also support the suggestion of seed, nut or other fiber processing. However, one of the clay bowls, stained with red ochre, suggests a non-subsistence function for this implement. The technique of using mortar and pestle for crushing minerals, particularly ochre, is known to preceed subsistence use of these implements elsewhere (Flannery 1969).

Faunal remains and the technological assemblage also suggest at least some marshland exploitation. However, based on paleoshoreline position at the time of occupation, marshland resources were approximately 4 miles away. If so, SJo 68 is a site which shows marshland exploitation at a distance. Since fishing does not seem well-developed, whereas hunting and gathering of grassland and riverine resources are

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well-documented, such exploitation of the marsh may have been a tentative subsistence "outreach" while maintaining a grassland resource base during the period of encroaching marshland from the west. Alternatively, such an assemblage may indicate simply a well-established strategy of which the marsh was a supplementary component. What is certainly demonstrated at SJo 68 is that the period of increased alluviation which occurred shortly after the mid-Holocene may have rendered the site location uninhabitable and the resource distribution substantially altered. Such a sedimentologic process suggests a manner in which any other sites contemporary to SJo 68 or any existing earlier Delta archaeological record might have been buried.

Sac 145

Sac 145 is located on the shore of Stone Lake, (2 miles) east of the natural levee deposits of the Sacramento River on the Courtland quadrangle (see Figure 4). Sac 145 is situated on the Sacramento silty clay loams derived from sediment of the river overflow basin (Ritter, n.d.). In winter this basin could contain rapidly moving flood water or quiet, percolating, post-flood water. At least since the mid-Holocene, after maturation of levee deposits, a diverse riparian forest was at hand for native occupants. To the east of the lake, grassland resources were readily available. The locally high water table apparently maintained marsh communities around the freshwater lake (Kautz, n.d.). The age of the lake is unknown although sedimentary deposits show that it once extended further westward than at present (Atwater 1982). Sealevel reached within a mile of Stone Lake during the last 4000 years; therefore, its dated occupation of 3300-200 years b.p. (Schulz 1981) coincides with encroachment of intertidal shoreline on this area of the Sacramento floodplain basinal deposits. The site then was situated at an interface of riverine, lacustrine, marsh, grassland and seasonal floodplain environments.

The faunal analysis at Sac 145 provides insight into the extensive fluvial/lacustrine exploitation (Schulz and Simons 1973) and the supplementary riparian and grassland community exploitation (Simons, Schulz and Wagner n.d.). The presence of charred fish bone confirm that a variety of fish were subsistence items. The following distribution of species was discovered to remain constant throughout occupation which suggests stability in the procurement strategy: 86.2% of fish were slow-water species including Sacramento Perch, Hitch, Thicktail Chub, Sacramento Blackfish and Tule Perch; 12.7% originated from a variety of possible environments and only 1.1% from a main channel, high energy system (see Appendix A). The dietary importance of the slow-water fishes alone is nearly as great as all meat sources combined (Simons, Schulz and Wagner n.d.). Grassland and riparian species are present representing the supplementary hunting subsistence (see Appendix A). The presence of waterfowl is consistent with that of the lentic fish species. Much of the amphibian and reptilian remains are attributable to non-cultural assimilation (ibid).

The macrofloral assemblage at Sac 145 suggests summer plant-gathering activities in the bordering grassland and, at least in the case of willow and sedge, probably spring gathering from the riparian forest (Appendix A). These floral remains testify to the diversity of plant food resources available aboriginally (Appendix A). The lily and pea families were represented by charred seeds, the former in an apparent roasting pit of baked clay balls (Furnis and Ritter 1976). Most plants represented here by seed remains are known ethnographically as either a dietary or basket-making material. The Stone Lake osteological remains display distinctive abrasion grooves on the teeth which have been interpreted as the result of fiber processing for nets, cordage and basketry materials (Schulz 1977). No evidence of acorns or processing equipment was found at this site (Furnis and Ritter 1976). Hence, this site appears to be a very specialized fishing site that successfully harvested from lake, flood basin and river with grassland supplements.

For at least the last 2000 years, one would expect flood waters spilling from the

Sacramento River channel into the Sacramento Basin to render Stone Lake indistinguishable from surrounding marsh and floodplain, a condition which would encourage at least seasonal occupation of the eolian dunes around the lake on which lie 5 sites. These sites are only mapped: Sac 63, 64, 323, 324 and 325. Archaeological indicators of seasonal occupation, however, point to both summer and winter habitation. Remains of a pronghorn fawn are indicative of June-July, and a juvenile coyote of October-January (Simons, Schulz and Wagner n.d.). Site abandonement during late winter or high precipiation years is still a viable proposition (ibid). Many other sites on the marsh edge (such as Sac 145) or on the Sacramento River levee deposits surround or halo these dune sites, including: Sac 62, 328, 329, 21, 41, 71, and 72, which are all within a 1.5 mile radius. Sac 65 is also a "halo" site and is discussed later in this section. Given the density of sites in this particular area, it is possible to speculate that as the Delta developed there, approximately 3000 years b.p., it created a new intersection of environments with an apparent highly productive resource yield. Hence, a model of population concentration at the shoreline is suggested.

<u>Sac 168</u>

Sac 168 is located in a levee deposit of the Cosumnes River in the Bruceville quadrangle. It lies on the west bank of the Cosumnes, ~0.4 mile east of a large abandoned channel of the Cosumnes which quite likely contained secondary flow in late or mid-late Holocene time (see Figure 4). Within a mile to the southeast is Laguna Creek tributary and its surrounding grassland and woodland. The site would have been within the riparian forest community although this community was eliminated historically by deforestation. In the older component of the site, 168B, fully extended burials oriented to the southwest were present. Burial characteristics and their distinct association of grave goods led to the classification of this site as containing Windmiller Culture remains (Heizer

1949). A radiocarbon date of 3070±170 (Ragir 1972) confirms that the Windmiller component has a similar antiquity to Sac 145, however, with an apparent hiatus in occupation until ~500 years b.p. whereupon the Late Horizon Phase 2 appears (Ragir's Hotchkiss Culture (1968)).

There is little archaeological or palynological indication of diet in either of these components. Although animal bone was excavated, it is not discussed by Ragir (1972). In the older component, 168B, the association of river mussel with a white quartz pebble cache suggests some Cosumnes River harvesting, the pebbles quite likely were transported from granite and andesitic conglomerate upstream. Baked clay impressions provide evidence for close-twined basketry and cordage (Ragir 1972). This indicates at least the capacity for gathering mussels, seeds, nuts etc. as well as the availability of cordage for net-making. Thirteen fragments of sandstone, granite or basalt mortars were excavated, apparently unassociated with burials. A granite and a schist pestle were also found unassociated. A clay bowl stained with ochre suggests, as at SJo 68, a multiple function for the mortar/pestle technology. Hence, although mortar and pestles are present here, it is not definitive that acorn-processing was the main subsistence activity. The more recent component of this site, 168A, contained charred single and double rod coiled basketry, a pestle fragment, cordage and "fishnet" in association with burials (Ragir 1968). The other scant indicators of subsistence activity include river mussels (Gonidea angulata), antler harpoons and bird bone (ibid). Little can be said about the subsistence of this site other than we would expect woodland hunting, woodland and grassland plant gathering, quite possibly acorn-processing, and possibly less fishing activity than Delta core sites.

This site location suggests that levee site location on a major tributary was an acceptable adaptation around 3000 years b.p. though apparently not for long-term occupation. At least two viable questions remain: does the post 3000 year b.p. abandonment coincide with a period of extensive alluviation which would have increased flooding and built up the levee surface? If so, such an abandonment would coincide roughly with that at SJo 68. And also, was there a sedentary village that was abandoned or does the Sac 168B component represent a seasonal site?

Sac 329

Sac 329 is located on levee deposits of the southern bank of the Sacramento River at the junction with Georgiana Slough. This is on the Isleton quad in the city of Walnut Grove (see Figure 4). The Sac 329 occupation is dated from 1170±150 to 350±150 (Soule 1976), a period sufficiently after the local marsh development at approximately 4,000 years b.p. (Figure 3). Although this levee currently stands over 10 feet above the surrounding peat islands, prehistorically it would have afforded little elevation advantage relative to the extensive tidal wetlands of Andrus, Tyler and Grand Islands (Figure 4). The base of the midden is only 10-29 cm above river level in late summer (Soule 1976). From the location of Sac 329, there would have been immediate access to the Sacramento's riparian forest and the surrounding wetland. Grassland was over 4.0 miles to the east.

Similar to Sac 145, fish remains at Sac 329 show a dominance of slow-water species. Sacramento Blackfish, Chub, Hitch, Sacramento Perch and Tule Perch occur from 65.8% in Stratum 1 to 83.7% in Stratum 2. Since Stratum 2 is a historically relocated section of Stratum 1 (see Soule 1976), changes in percentage should not be attributed to changes through time. Varied- environment Sacramento Squawfish, Splittail, and Sacramento Sucker occur from 22.4% in Stratum I to 12.9% in 2. Main-channel Sturgeon, Salmon, and Hardhead occur from 11.8% to 3.3% (see Appendix A). It is noteworthy that these fish remains conflict with the ethnographic emphasis on fishing for salmon and other river species by main channel settlements. Thus the archaeological data presents a procurement strategy largely unaccounted for by ethnography (Soule 1976, Schulz 1981). Bird remains are all waterfowl and include Canadian geese, coot, ducks, grebe, and snow geese (Appendix A). Their presence is consistent with the procurement from environments of dominantly "slow-water" fish. However, decomposed river mussels, specifically Margatifera sp., do indicate some exploitation of a riverine setting.

Mammalian remains show a preponderance of mice which probably does not reflect human subsistence activity (Appendix A). On-site rodent-trapping, although possible, is not ethnographically reported. Rabbits, coyote, skunk, and deer remains suggest grassland hunting (possibly cooperative in the case of rabbits). Tule elk, beaver, raccoon, and river otter represent hunting directly in the riverine/marsh surroundings (Appendix A). 67% of meat represented by the remains was mammalian and 31% was fish. The largest contributing species of the total are elk (54%), Sacramento perch (10.4%), sturgeon (8.3%) and deer (7.6%)(Soule 1976). Regarding plant resources, only charred black walnuts were found. They appear as a dietary item since they were excavated in association with a hearth.

Mammal bone flakers, harpoons, and fishhooks were apparently among the supporting hunting and fishing technology. Features such as bone caches and firepits support the proposition that both large and small animal butchering and cooking of fish and game occurred at this site. Bone awls were present, which in this Late Horizon deposit, are confidently associated with coiled basketry. Their function here is reaffirmed by baked clay with basketry impressions (Soule 1976).

Therefore, within the Delta core, by 1100 b.p. we see well-developed fishing, apparently more so than 2000 years previously (for instance at SJo 68). Although the fishing industry appears similar and contemporaneous, in part, with Sac 145 to the north, the Sac 329 occupants apparently included a greater degree of mammal and waterfowl in their diets. Presumably such a difference between sites suggests a variety of subsistence strategies, some more specialized than others with possible differences in supplementary subsistence items.

If a seasonal recluse was needed from extreme inundation by the combined flood waters of the Sacramento and Mokelumne Rivers, a plausible location would be the eolian dunes 1.5 miles to the north. Three archaeological sites occupy these dunes: Sac 47, 75, and 76. Sac 74 occupies a levee in a manner similar to Sac 329 near these dunes . Additional levee sites of similar paleoenvironment to Sac 329 are Sac 203 and 25 which are southwest of Sac 329. These have been recorded as Late Horizon sites (NCAIC records). Any relationship between the sites mentioned above is unknown.

Sac 65

Sac 65 is located in the Courtland quadrangle between Snodgrass Slough and the shoreline of Stone Lake, less than 0.3 mile to each (see Figure 4). This site is situated on a knoll of possible eolian-deposit composition (Atwater 1982) overlying the Riverbank Formation of Upper Pleistocene age. This site balances at a juncture of lake, river, marsh, and floodplain environments. Given Sac 65's occupation date of 530±160 (Schulz, Abels, and Ritter 1979), its economic complex represents the state of very late prehistoric (Late Horizon Phase 1 and 2) subsistence under conditions of fully developed marshland. Faunal and fish remains at Sac 65 (Appendix A) indicate a subsistence strategy directed toward a mixture of habitats.

Fishbone indicates predominant exploitation of slow-water versus main river channel environment. 78.6% of the identified individuals were slow-water species including Sacramento Blackfish, Hitch, Chub, Sacramento Perch and Tule Perch. Such species inhabit sloughs, lowland lakes, ponds, overflow basins and marshes (Schulz and Simons 1973). The remaining population was composed of 14.3% varied-environment species including Sacramento Sucker, Splittail and Sacramento Squawfish and 7.1% main-channel species including Sturgeon, King Salmon and Hardhead (Appendix A). Therefore, riverine fishing occurred to a lesser degree than lacustrine and estuarine fishing.

This fish assemblage is like that of Sac 145, less than a mile to the northeast. Bone harpoon and apparent baked clay fishnet weights were present; however no other subsistence implements were discussed in Schulz et al. (1979). Of native bird remains (Appendix A), all those represented were waterfowl species which inhabit marshes, ponds, and lakes (Grzimek 1974, Whitfield 1984) therefore reaffirming the lacustrine/estuarine exploitation. Gathering of waterfowl eggs, presumably for consumption, is known to occur at least in the Late Horizon, (for instance Sac 67, J. Johnson, pers. comm.). The association here of fowl, fish and reptiles is much like Sac 329 (see Appendix A).

Mammalian bone displays evidence for a broader region of game procurement. Grassland and possibly woodland species are represented with no apparent dominance by any (Appendix A). Hares and rabbits are indicative of grassland communities as are fox, though the latter could be encountered in woodland habitat. Elk would be present in marsh and overflow basin. The mammalian remains are dominated by rodents, such as mice, gophers, and squirrels, which inhabit a variety of environments and may not indicate dietary items. The absence of pronghorn and relative paucity of hare lends little support for the scenario of large-scale cooperative hunting described in the Great Basin (Steward 1955).

There is little indication that this site was occupied for more than a short period (Schulz, Abels and Ritter 1979). Although there is mammalian evidence for grassland exploitation, there are no grinding implements or bone awls to suggest seed-processing activity which certainly was well-developed in the foothills by this period. This led Schulz et al. (1979) to suggest that this may have been a specialized site either restricted to hunting and fishing by men or restricted to winter occupation when gathering was not abundant in the grassland. A possible lower socioeconomic status is also suggested due to the paucity of wealth objects in burials (Schulz et al. 1979). A relation to Sac 145 and any other

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contemporaneous Stone Lake "halo" sites is expected.

Sac 45, 104 and 162

Sac 45, 104, and 162 are located on eolian dunes which remained partially above intertidal peat and mud (Atwater 1982) at the southern end of Tyler Island in the Isleton quad (see Figure 4). The age of these dunes has been geologically bracketed by ^{14}C as ~40,000 to a minimum of 7,000-11,000 years b.p. (Atwater 1982). Bradford Island dunes to the southwest, bracketed more finely at 10-14,000 years b.p. (ibid), are 20-40 feet thick whereas those dunes to the north at Stone Lake are, at least historically, approximately 5 feet thick. Within a 2 mile radius of Sac 45, 104, and 162 are Sacramento River riparian forest, wetland, and slough resources. Between 8,000 and 4,000 years b.p. the shoreline reached and went miles beyond Tyler Island, partially inundating these mounds (Figure 3). The date of basal peat on the island to the south, Bouldin Island, is 4675 $\pm$ 200 (Atwater 1982) which confirms the mid-Holocene arrival of sealevel in this area.

These are three sites out of a large group of dune sites in the Delta. Seventeen such sites in Sacramento and Contra Costa Counties are discussed in Cook and Elsasser (1956). About half of these dune sites consist of the first type: "late occupation midden" (latest Holocene time) over a sandy dune base; the other half of the dune sites are the second type: composed of sterile strata, such as peat or sand, overlying the indurated sand dune which contains burials. Sac 104, along with CCo 141, are unique members of a third type in that they include both midden dune cap and indurated burial components (Cook and Elsasser 1956).

The burial characteristics and associated artifacts of the Sac 104 indurated dune suggest Early to Middle Horizon deposits (Cook and Elsasser 1956). Of nine burials, five were extended, 3 semi-extended and 1 tightly flexed (Lowie M.S. #65). Since these burials are interred in carbonate-cemented dune material (Cook and Elsasser 1956), they could not have been interred post-cementation. Hence, I would suggest that this burial component is concurrent with or precedes the earliest stages of local, relative sea level rise. No ^{14}C dates of these dune deposits, which could confirm this prediction, are known to exist. Four projectile points and powdered ochre were the only artifacts associated with the burials (Cook and Elsasser 1956). One of the projectile points, a large, serrated, concave-based point of white chert (NCAIC records) is representative of Middle Horizon sites (Lillard, Heizer, Fenenga 1939). The Late Horizon occupation cap consists of charcoal, bone fragments, shell fragments and obsidian (Cook and Elsasser 1956). Regarding absolute dating, the nearest basal peat date suggests burials were interred contemporaneous with or previous to the Windmiller SJo 68 component of 3750 years b.p. ^{14}C dating at this site could confirm this prediction.

Little is known of Sac 45 and 162 other than their stratigraphic similarity to Sac 104. Sac 45 is a 3 foot cap of occupation debris over a sandy base. Burials were located in the midden deposit. Surface observations, in this study, of the occupation deposit suggest that elk and possibly deer were hunted. A bone awl and "Stockton" obsidian point were also noted but without provenience. Artifacts housed at the Lowie include: charmstone fragments, red ochre, quartz crystals, mussel shell, possible mortar fragment and possible small carbonized seeds - of these artifacts, the first three are indicative of Early to Middle Horizon. Sac 162 contains charcoal, mammal bones and river mussel but has never been excavated (Cook and Elsasser 1956).

Based on the faunal associations that occur at other sites where elk is present, and based on the resource availability, it is predicted that later occupants of the dunes (post-marsh development) hunted marsh and riparian game as well as waterfowl. Fishing and gathering are also expected although the degree of specialization cannot be predicted here.

Based on rates of relative sealevel rise, it is estimated that sealevel reached the uppermost level of the cemented dune material approximately 1000 years ago. Presumably then, the indurated burials were interred at least between 4000 and 1000 years ago. Further excavations could address the changing role of these dunes from their presumably early (4000 years b.p.?) use as burial grounds, followed by an apparent period of abandonment, during which time sand or peat was deposited, and then later use as occupation mounds. Given that these dunes are quite ancient, they are one of the rare geomorphic features within the Delta which has not been completely buried. Since they would have offered suitable settlement locations, burial sites, or game look-outs throughout the period of Delta development, their archaeological components deserve consideration in studies of mid Holocene settlement and subsistence adaptation. Although most of the Late Horizon deposits may have been stripped by modern agriculture, and some of the cemented dune mined for various reasons (Cook and Elsasser 1956), there are some dunes which could provide valuable information.

Sac 23

Sac 23 is located 3 miles north of the confluence of the Cosumnes and Mokelumne Rivers and 2 1/2 miles east of Snodgrass Slough on the Bruceville quadrangle. To date, no excavations have investigated this site. Sac 23 is seemingly distant from other Delta sites and their desirable resources; however, upon paleoenvironmental investigation, it is seen that this site is located on an eolian dune deposit at a prehistoric arm of wetland, an extension winding nearly two miles back from the main shoreline. In a direct line, this site would have been located only 0.8 mile from the most recent prehistoric shoreline. Sac 23 would not have been in this relation to marshland until sometime within the past 1000-1500 years, based on basal peat dating and paleoshoreline mapping of Atwater (1982). The basal peat date used here is 1910±55 located to the west near the Sacramento

River south of Courtland. It is predicted here that Sac 23 would display a complex wetland/grassland hunting, gathering and possibly fishing subsistence strategy. Its occupation is expected to have commenced within 1000 years b.p. at this strategic junction of marsh and grassland communities on an eolian dune.

D. Subsistence Discussion

Although ethnographic observation can provide valuable insight into prehistoric resource utilization, particularly when these resources are currently extinct, it cannot provide reconstruction of changing lifeways through time. The archaeological evidence gathered here suggests that subsistence practices in the Delta were variable through time and space. This variability is interpreted here as an adaptation to the changes in resource distribution as related to Delta evolution, differences between environments of contemporaneous sites (Delta vs. Delta-margin) or advantage of seasonal or locational, site specialization. Another possible explanation for the intersite subsistence variability could be that each site (as possible representatives of specialized subsistence) represents only a fraction of the total economy at that time. Hence, due to the lack of sampling procedures in picking these sites for discussion, each site may represent a different aspect of the same economic activity spectrum which remained constant through time. The following summary of Delta and Delta-margin sites illustrates this variability.

Approximately 4000 years b.p., fishing was apparently not a well-developed industry at SJo 68 although hunting and gathering in grassland and riparian forest communities was developed. The location and date of this site place it chronologically in a transitional phase of marsh and alluvial fan development. A thousand years later (3000 years b.p.) to the north of SJo 68 on the margin of Stone Lake an apparently very specialized fishing settlement appeared, Sac 145. Plant gathering and grassland/riparian hunting appear supplementary to this form of subsistence. Did this specialized fishing adaptation develop between 4000 and 3000 years b.p. on the Sacramento, Cosumnes or Mokelumne banks? Or did the Stone Lake subsistence tradition "migrate" eastward with the shoreline, having had a long history of fishing but for which there is no record? Sac 168B on a levee of the Cosumnes was used ~3000 years b.p. as both a burial and occupation mound. Both grave goods and subsistence items are scarce. This site does not show the successful, long-term occupation of SJo 68 and Sac 145 nor any specialization, hence the possibility that it did not maintain a sedentary village. If this were the case, Sac 168 may represent a component of a seasonally shifting settlement pattern. Sac 329 began occupation 2000 years after Sac 168B and is contemporaneous with later components of Sac 145. The Sac 329 assemblage of fish remains is very similar to Sac 145, however its apparent additional reliance on marsh and riverine fauna would perhaps classify it as a less specialized site. The relatively more dominant fishing industry in the record at Sac 145 than at Sac 329 could be explained by: a seasonal fishing settlement at Stone Lake i.e. a different subsistence/settlement pattern strategy or more abundant fish resources at Stone Lake than in the slough near Sac 329. Sac 65 was only occupied for a short duration circa 530 years ago. At that time, hunting, fishing and fowling took place in the marsh, grassland and woodland. Seasonal occupation or lower socioeconomic status of the occupants is suspected to explain the limited duration and material wealth of this settlement.

Little is known archaeologically of the subsistence behavior of those natives who occupied the sand dunes in the Delta. The geologic age of these dunes defines them as one of the oldest, unburied land surfaces in the Delta. Interments which occurred prior to cementation associated with sealevel rise suggests that these sites were first occupied quite early, possibly 4000 years b.p. in this study area. Later use of these dunes, within the last 1500 years probably entailed procurement of marsh and riparian fauna.

IV. Settlement Patterns

This study attempts to broaden the previous view of Delta settlement patterns by focusing on this specific geomorphic landscape of central California and noting the differences between Delta and Delta-margin. The subject of prehistoric settlement patterns has not been addressed fully in this region for a number of reasons: 1) Most sites were studied prior to 1960, at which time relative chronology and culture classification were the main goals 2) Cultural horizons are not contemporary across the Delta region and 3)

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Available ^{14}C dates are scarce. Given that changing landforms are expected to strongly influence settlement patterns in the Delta, a focus on their evolution is the perspective contributed by this study.

A. Previous Views

Historic sources which address the settlements of the Central California natives repeatedly map villages as lining major river courses (Ringgold 1850, Sutter 1848). One 1853 drawing, however, shows a Miwok village on Dry Creek, a tributary of intermittent flow (Schenck and Dawson 1929) which joins the Mokelumne River near its confluence with the Cosumnes. This ethnohistoric source demonstrates use of dome houses and tule balsas (Barrett and Gifford 1933). Archaeologists as well have considered the dominant settlement pattern as a concentration on natural levees which provide an elevational advantage to flood basins (Beardsley 1948, Heizer and Elsasser 1980, Schenck and Dawson 1929) or as reflecting a preference for "low knolls near streams and above marshy floodplains" (Moratto 1984: 172). Schenck and Dawson describe settlements as occurring on mounds 6"-5' above the surrounding plain on apparently natural mounds whose height is enhanced by deposits of cultural debris (Schenck and Dawson 1929). One source indicates the possibility that mounds were sometimes man-made whereby a week of effort was expended by a community for the purpose of building up a mound on the Cosumnes River (Barrett and Gifford 1933). No other accounts like this nor any archaeological evidence were found in this study which would prove or disprove such a suggestion. Certainly mound construction could have been possible if suitable locations were unavailable.

Schenck and Dawson astutely assumed that sites along present watercourses would tend to be the most recent given the shifting nature of the hydrologic environment; however, they mistakenly assumed that sites at sealevel would be older than stream sites. This would be true only if sites at the transgressive paleoshorelines were compared to sites on modern watercourses. Regarding seasonality, Schenck and Dawson (1929) surmised that the annual flooding of the valley basins provided an incentive for eastward winter migration to higher elevations; however, they also suggest movement was likely to the hills in summer due to heat and insects. Consequently, small sites with little occupational evidence in their study were considered temporary camp sites (Schenck and Dawson 1929).

B. Method of Study

This discussion of settlement patterns includes specific site examples where dates are available as well as more general observations when relating undated sites to those which are dated based on geologic and archaeologic contexts. Mapping analyses were undertaken in the study area to determine more precisely the paleoenvironmental implications of each site location based on: 1)geologic substratum and 2)geomorphic site location. Using the site records and site maps of the North Central Archaeological Information Center at Sacramento State University, and the U.S.G.S. geologic map series of the Delta (Atwater 1982), each site was located on a U.S.G.S. 7.5 minute topographic map, and its geologic substratum determined. Some degree of error is expected in the site records since some sites, which were originally described decades ago, were not necessarily plotted on maps at that time. Hence some reconstruction of site location has been necessary. Also, the resolution of geologic formations based on a minimum thickness criteria (Atwater 1982) renders the map information ultimately less accurate than a site-by-site field determination. However, the latter was not feasible for this study given the extent of the field area. Nevertheless, these errors are not sufficient enough to alter the overall patterns which are revealed by this analysis.

The geoarchaeological aspect of this analysis aids: 1) in classifying the site "geomorphic type" in order to reveal pertinent aspects of the paleoenvironment 2) in relative dating of each site occupation and 3) in clarifying stratigraphic position of that site

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relative to Delta evolution. Where a site was locally characterized by more than one geomorphic aspect (for instance, a sand dune surrounded by wetland) both aspects were contained within the site classification. Historic reclamation of extensive tidal wetlands, shifting watercourses, migrating shoreline, and floodplain development, which are an integral part of the Delta and Delta-margin history, complicate paleoenvironmental interpretations. Information from unpublished field notes, site records or published site descriptions when available, was also used to verify the stratigraphic context of each site. When a site occurred on a geologic boundary, both units involved were included in the data tabulation.

In this analysis, 130 sites were used to establish settlement patterns in the Sacramento-San Joaquin Delta and Delta-margin area, (the Delta-margin being specifically adjacent to the lower Cosumnes River basin). Each site was classified into one or more "geomorphic site types", including:

Geomorphic Site Classification

Type A. sand dune - sites in the Delta located on top of Pleistocene eolian sand dunes most of which are overlapped by late Holocene peat and peaty mud.

Type B. natural levee - sites located on or in natural levee deposits of the Sacramento, Mokelumne or Cosumnes Rivers

Type C. knoll - mounds located in a plain on an apparently elevated knoll of unknown origin

Type D. stream bank - sites located on the bank of existing or pre-existing perennial or intermittent streams

Type E. floodplain - sites located on historic or prehistoric floodplains subjected to nearly annual flood inundation by Sacramento, Mokelumne or Cosumnes Rivers; many of these sites are now rarely flooded due to modern levee systems.

Type F. terrace - sites located on a resistant base material which provides topographic relief relative to the surrounding area; such terraces are formed via erosion by any hydrologic action during the Pleistocene and Holocene and are now partially flanked by recent alluvial or marine sedimentary deposits.

Type G. unknown - a characterization could not be determined from maps or field notes .

Type H. lake/abandoned channel/slough - sites located at current or aboriginal freshwater lakes, abandoned river channels or estuarine sloughs.

Type I. marsh - sites located amongst wetlands under aboriginal conditions.

The geologic substratum of each archaeological site for this field area was also determined and classified in one of the following categories:

Geologic Substratum Categories

Qa - natural levee and channel deposits of Holocene supratidal river origin.

Qb - riverine flood basin deposits of Holocene age.

Qt - peat and tidal mud of Holocene Delta wetlands and waterways

Qr - Riverbank Formation; late Pleistocene alluvial fan deposits derived from glaciated Sierran drainage basin; flanked by Holocene basin or alluvial deposits.

Qs - upper Pleistocene eolian sand dune deposits on islands of the Delta, Delta-margin or Mokelumne River fan deposits; material originates from both Sacramento and San Joaquin drainage detritus; flanked or partially overlain by Holocene tidal peat.

C. Discussion

After categorizing each site by the above method, data was tabulated for analysis (Appendix B). The results described below reflect mainly the geographic distribution of the late Holocene period settlement pattern, at least a fraction of the mid-Holocene settlement pattern, but none of any early Holocene occupation, if it existed, since much of the early Holocene terrain is buried beneath alluvial fan or tidal deposits (except those areas on the Riverbank Formation at higher Delta-margin elevations). In general, results confirm the ethnographic observation of abundant levee habitations; however, this site type does not dominate the settlement pattern configuration. Settlement patterns indicate that a variety of site locations were desired. Of the 130 sites, three geologic substratum dominate: 1) 27.1% are natural levee and channel deposits (Qa) 2) 24.0% are at the junction of natural levee and channel deposits with the Riverbank Formation (Qa/Qr) and 3) 22.5% are on the

Riverbank Formation itself (Qr)(see Table 1). Just at this level of analysis, site placement reveals the inadequacy of characterizing settlements in this area as levee habitations. Therefore these three categories are broken down further to reveal the variety of occupied environments.

I. Of those sites in the Qa group, 40% were the natural levee geomorphic site type and 37% were the floodplain type. The majority of the levee sites are located on the Cosumnes River with two others located in association with the Sacramento River and an adjacent slough. The floodplain sites are situated either between the Cosumnes River and Deer Creek or at the juncture of the Cosumnes with its tributaries such as Laguna or Badger Creek. Therefore sites on the floodplain are as common as those on the levee which have additional drainage and flood protection in the riparian forest or woodland community. Whether these two groups of sites represent locations of seasonal shifts from levee to floodplain and back again or contemporaneous, specialized sites is not known. For example, Sac 168 is a member of this site classification group as it is part of a levee of the Cosumnes River. On the lower reach of the Cosumnes, one would expect the Qa sites to exhibit the effects of environmental pressure around 3000 years b.p. due to the apparent transition of hydrologic/sedimentologic regimes at this time. The Sac 168 hiatus may be such an effect. Although Sac 168 contains an Early Horizon component it does not have the antiquity of the earliest SJo 68 component. Any stratified sites in the lower Cosumnes mid-Holocene age are quite possibly buried under floodplain and channel sediments along abandoned channels of the Cosumnes.

II. Of those sites in the Qa/Qr boundary group, 48% are located on the banks of streams which are geomorphically associated with the edges of terraces, such as along the western bank of Deer Creek, along small unnamed streams, or along abandoned channels of the Cosumnes. 16% of these Qa/Qr boundary sites are located at the base of the terraces on the floodplain. We see then nearly as many Qa/Qr sites on a terrace-like boundary at freshwater sources (24% of total sites) as Qa sites directly on levees or floodplain deposits

(27.1% of total). Presumably, since these terraces mark the boundary of grasslands abutting the floodplain, such sites offer strategic positioning for access to a wide variety of resources. Sac 107, the type site for the Windmiller Culture is one of these sites. The apparently successful and continuous occupation of this site (which contains Early, Middle and Late Horizon components) implies that a successful subsistence strategy was employed. Little is known of this strategy, however.

III. Of those sites located on the third most common geologic substratum, the Riverbank Formation (Qr), 41% are located on stream banks such as Laguna and Badger Creek and Deadman's Gulch., 17% border on a stream bank/marsh junction such as at the Cosumnes/Mokelumne confluence, and 21% are on erosional terraces at the margin of sloughs, lakes, and abandoned channels (associated with Cosumnes and Badger Creek) or marshes (at the confluence of Cosumnes and Mokelumne). Sac 6 is one of this Qr group, a large site located on a terrace at a stream bank. As one of the principal sites of the Delta-margin region (Schenck and Dawson 1929, Sac. Jr. College Field Notes), its location here further emphasizes the successful variations in site placement. Since the Riverbank Formation is of Pleistocene age and remained stable in the Delta-margin during Delta evolution, it may host some occupational remains along stream banks which are older than many of the Cosumnes River levee sites. Any such sites could display well-developed procurement of grassland floral and faunal resources with little tendency for sedentary settlements. However, the latter tendency could reduce archaeological visibility.

When the data are subdivided by geomorphic type rather than by geologic substratum, additional patterns emerge. The dominating geomorphic type (30%) was the stream bank locations followed by levee sites (18.5%), floodplain (16.9%), lake, abandoned channel, slough and marsh (13.8%), terrace (7.7%), and sand dune (6.9%)(see Table 2). While the marsh type comprises 13.8%, an additional 4.2% of the other types have marsh as one of the classification components. Thus we see that by this arrangement, there is a relatively greater quantity of stream bank sites (including secondary streams on floodplains, streams at the base of or dissecting a terrace, or streams that juncture with wetlands) than the major river sites. And as mentioned previously, floodplain sites are nearly as common as levee sites.

Out of the 130 sites, site size data (area) was available for 65% (or 84) of them. This data was obtained from the NCAIC records and represents an accumulation of site measurements by a variety of field workers. Whether these data were obtained via measurement or estimation is not known, hence, high data quality is not assumed. Nevertheless, the data are presented to estimate any differences in site size between different locations. The average size of all sites in the study is 10,847 m^2 (104 m X 104 m). Average site area does vary with the location of site, i.e. geologic substratum, in the following manner:

1) in the Qa group, Av_{area} = 9516 m^2 (97.5 m X 97.5 m)
2) in the Qa/Qr group, Av_{area} = 4295 m^2 (65.5 m X 65.5 m)
3) in the Qr group, Av_{area} = 3178 m^2 (56.4 m X 56.4)

It is noteworthy that the majority of sites (73.6% of total) have an average area which is smaller than the infrequently occurring site types. Those sites which are larger tend to be either dune sites or site types of high complexity e.g. at a junction of three environments. There is the possibility that dune site areas reflect more the field investigator's estimation of dune size rather than that of the actual site.

TABLE 1

Geologic substratum	# sites	% of total
Qa	35	27.1
Qa/Qb	6	4.6
Qa/Qb/Qt	2	1.6
Qa/Qr	31	24.0
Qb	7	5.4
Qb/Qr	5	3.9
Qb/Qs	2	1.6
Qb/Qs/Qt	2	1.6
Qb/Qt	2	1.6
Qr	29	22.5
Qr/Qs	3	2.3
Qs	3	2.3
Qt	2	1.6

TABLE 2

Geomorphic site type	# sites per type	% of site groups relative to total # of sites
A,H	4	6.9
A,I	5	
B	21	18.5
B,I	3	
D,E	7	30.0
D,H	1	
D,F	5	
D	19	
D,I	6	
D,C	1	
E	18	16.9
E,H	1	
E,I	1	
E,F	1	
E,C	1	
F	3	7.7
F,I	4	
F,H	3	
H	10	13.8
H,I	4	
H,C	1	
H,F	2	
I	1	
G	8	6.2

V. Conclusions

In the last 10,000 years, the Sacramento-San Joaquin Delta area has undergone significant geomorphic evolution involving eustatic, hydrologic, sedimentologic and climatic changes. Due to the geomorphic configuration of the Delta, these processes converged in a unique manner and resulted in paleoenvironmental change of sufficient degree to require consideration when identifying archaeological contexts. Ethnographic observations and previous archaeological models which characterize the subsistence organization and settlement patterns of prehistoric Delta inhabitants only partly represent prehistoric lifeways and, in many cases, emphasize Delta-margin (mid-upper Cosumnes River basin) settlements of the late Holocene.

The presence of early Holocene, pre-Delta inhabitants of this area is not known although it is speculated here that any inhabitants would have encountered a resource distribution different from that of mid- and late- Holocene times which would have been a factor in their ecological adaptation. We might propose that the pre-Delta region was dominated by the major, converging river systems with their associated riparian plant and animal community, as well as surrounding stream-dissected grasslands. Crucial questions regarding this time period remain: was this area inhabited? If so, were the people migratory or sedentary hunter-gatherers and what type of subsistence strategy did they employ?

It is hypothesized here that Delta evolution forced changes on the subsistence and settlement systems of any existing pre-Delta people by eradicating or shifting certain pre-existing environments and creating new ones. Furthermore, this ecologic evolution, which continued through the mid- and into the late Holocene, most likely had an ongoing influence on late Holocene settlement patterns and subsistence systems. Geoarchaeological data suggests that, during the last 4000 years, the Delta and Delta-margin settlement pattern was composed of an arrangement of sites with disparate resource availability. It is expected that development of the Delta ecosystem encouraged the diversification of subsistence strategies, in part, due to the increased variety of intersecting plant and animal communities relative to early Holocene times. This unique quality of the fully-developed Delta, its interlocking mosaic of marsh/grassland/riparian forest/oak woodland environments, produces a wide variety of abundant resources. It is interpreted here that the archaeological remains and site locations of the mid to late Holocene Delta and Delta-margin indicate a strategy whereby native inhabitants sought to maximize their access to this variety, while in some cases, specializing in procurement of particular resources.

Critically, this resource specialization appears to vary across space, presumably in response to resource distribution and the different procurement efficiencies for those various resources. Archaeological models have been put forth to describe Delta subsistence (Baumhoff 1963) whereby the main dietary components are (in decreasing order of importance) salmon, game and acorn. This was distinguished from the foothill areas which relied more on acorns and game (Baumhoff 1963). However, archaeological evidence does not support this particular Delta subsistence model. As we have seen, Sac 145 and 329 supported a considerable fishing industry, however, neither site displays any notable quantity of salmon remains. Instead, those sites in the Delta core, for which there are good faunal records, contain lentic fish species (slow water fish) as their major dietary component, for example, Sac 65, 329, and 145 (see Appendix A and discussions in Simons, Schulz and Wagner, n.d. and Soule 1976). This indicates lake, slough and marsh exploitation rather than riverine procurement. Furthermore, the degree of acorn-processing in the Delta core remains unsettled. While archaeological evidence for extensive balanophagous activity in the Delta-margin to foothill area of the Cosumnes River basin is strong, it is possible that these Delta-margin settlements and their resource procurement bear a relation to the stabilization of the river levees. Hence, the possibility of this industry as a very late Holocene adaptation is a viable proposition. Earlier, in the mid-Holocene, Delta-margin acorn-processing may have supplied only a supplementary role. In the Delta core settlements, balanophagy may never have reached theprominance of the "slow-water" fishing or mixed fish-game-plant resource strategies. Data regarding the evolution of the oak woodland biotic community in response to Delta development is an important factor which is missing from a proper assessment of changing resource availability. It must be emphasized that this discussion of the balanophagous aspect of subsistence refers specifically to the Delta and does not imply that acorn-processing did not occur previously in other central California areas.

Geologic and osteologic evidence support the notion that some degree of subsistence base reorganization occurred during the last 4000 years. It is proposed here that Delta evolution is ultimately linked to such a change. Eventual Delta stabilization, concluded here to be between 2000-3000 years b.p., may have encouraged a strategy for harvesting a variety of resources from semi-sedentary or sedentary settlements. Seasonal shifts in settlement and resource procurement may have been necessary or advantageous depending on site location. Any efforts to further test this perspective on prehistoric Delta subsistence would require further field study with the critical inclusion of ^{14}C dating and palynological analysis, directed at the differences in Delta versus Delta-margin sites and the discovery of possible earlier Holocene occupations on more ancient surfaces such as eolian dunes and Pleistocene terraces.

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APPENDIX A

Faunal Remains at SJo 68*

Name	**# individuals**
Fish:	
Mylopharodon conocephalus (Hardhead)	3
Gila crassicauda (Chub)	4
Reptiles:	
Clemmys marmorata (Turtle)	2
Birds:	
Phalacrocorax (Cormorant)	8
Anas sp. (Teal, Mallard, Gadall or Pintail)	10
Fulica americana (Coot)	4
Grus canadensis (Crane)	1
Branta canadensis (Canada Goose)	1
Goose (Unspecified)	9
Anser albifrons (Goose)	5
Anas platyrhynchos (Mallard)	2
Cygnus sp. (Swan)	1
Falco sp. (Falcon)	2
Cathartes aura (Turkey Vulture)	1
Corvus corax (Common Raven)	1
Corvus brachyrhynchos (Raven)	2
Corvus sp. (Raven)	2
Buteo sp. (Hawk)	1
Mammals:	
Canis sp. (Coyote)	18
Ursus sp. (Bear)	1
Castor canadensis (Beaver)	9
Procyon lotor (Raccoon)	16
Lutra canadensis (River Otter)	2
Taxidea taxus (Badger)	2
Mephitis mephitis (Striped Skunk)	1
Dipodomys heermanni (Kangaroo Rat)	2
Thomomys bottae (Western Pocket Gopher)	2
Lepus californicus (Hare)	31
Sylvilagus auduboni (Rabbit)	10
Citellus beecheyi (California Ground Squirrel)	10
Cervus nannodes (Elk)	42
Cervidae sp.(Deer)	6
Antilocapra americana(Pronghorn)	27
Odocoileus sp. (Mule Deer)	24
Artiodactyl sp. (Even-toed Ungulate)	8

*from Ragir 1972, p. 159

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APPENDIX A

Macrofloral Remains at Sac 145 (excluding exotics)*

Feature-associated remains	Description	Flowering season
Liliaceae (lily family)	perennial herbs	
Leguminosae (pea family)	herbs, shrubs, sm. trees	February - August

Non Feature-associated remains	Description	Flowering season
Ranunculus sp. (buttercup)	annual or perennial herb	February - Sept
Erodium sp. (Storksbill)	annual wildflower	February - August
Calandrinia sp.	annual or perennial herb	February - June
Montia perfoliata(Miner's lettuce)**	annual wildflower	February - June
Polygonum sp.(Knotweed)**	annual or perennial herbs	March - November
Arctostaphylos manzanita**	evergreen shrub	March - May
Fraxinus sp. (Ash)	tree or shrub	March - May
Salix sp. (Willow)	tree or shrub	February - April
Madia sp. (Tarweed)**	herb	March - November
Cirsium sp. (Thistle)	annual, biennial or perennial herb	May - September
Scirpus sp. (Tule)**	annual or perennial	May - October
Carex sp. (Sedge)	perennial herb	April - May

*From Furnis and Ritter 1976
**ethnographically documented as a subsistence resource

Faunal Remains from Sac 145*

Name	# Individuals
Archoplites interruptus (Sacramento perch)	410
Lavinia exilicauda (Hitch)	161
Gila crassicauda (Thicktail Chub)	100
Pogonichthys macrolepidotus (Splittail)	50
Catostomus occidentalis (Sacramento Sucker)	47
Orthodon microlepidotus (Sacramento Blackfish)	12
Hysterocarpus traski (Tule Perch)	10
Mylopharodon conocephalus (Hardhead)	6
Ptychocheilus grandis (Sacramento Squawfish)	5
Oncorhynchus tshawytscha (King Salmon)	2
Cottus sp. (Sculpin)	1
Acipenser sp. (Sturgeon)	present
Total	804

*From Schulz and Simons 1973, Table 1

APPENDIX A

Faunal Remains at Sac 145 (continued)*

Name	#Individuals
Amphibians:	
Bufo boreas (Western toad)	1
Scaphiopus hammondi (Western spadefoot)	1
Rana aurora (Red-legged frog)	2
	4
Reptiles:	
Clemmys marmorata (Pacific pond turtle)	3
Charina bottae (Rubber boa)	1
Coluber constrictor (Racer)	1
Lampropeltis getulus (Common King snake)	1
Pituophis melanoleucus (Gopher snake)	1
Thamnophis sirtalis (Garter snake)	1
Crotalus viridis (Western rattlesnake)	1
	9
Birds:	
large waterfowl	3
small waterfowl	21
	24
Mammals:	
Lepus californicus (Black-tailed hare)	3
Sylvilagus sp. (Cottontail rabbit)	1
Otosphermophilus beecheyi (Ground squirrel)	3
Thomomys bottae (Botta pocket gopher)	25
Castor canadensis (Beaver)	1
Reithrodontomys megalotis (Western harvest mouse)	6
Microtus californicus (California meadow mouse)	36
Canis latrans (Coyote)	1
Procyon lotor (Raccoon)	2
Cervus elaphus (Tule elk)	1
Odocoileus hemionus (Mule deer)	2
Antilocapra americana (Pronghorn)	3
Bos sp. (Domestic cattle)	1
	85

*From Simons, Schulz and Wagner n.d.

APPENDIX A

Faunal and Floral Remains at Sac - 329*

Name Association	Condition	Feature
Flora:		
Juglans sp. (Black walnut) firepits	charred shells	in and around
Invertebrates:		
Margatifera sp. (river mussel)	decomposed	none
Gonedia angulata (river mussel)	decomposed	none

*from Soule 1976

Vertebrate Faunal Remains at Sac 329

Name	# INDIVIDUALS Stratum 1	Stratum 2
Fish:		
Acipenser sp. (Sturgeon)	6	7
Oncorhynchus sp. (Salmon)	2	2
Orthodon sp. (Sacramento Blackfish)	13	37
Gila sp. (Thicktail Chub)	53	168
Ptychocheilus sp. (Sacramento squawfish)	24	55
Mylopharodon sp. (Hardhead)	20	37
Lavinia sp. (Hitch)	16	84
Pogonichthys sp. (Splittail)	16	34
Catostomuc sp. (Sacramento Sucker)	13	90
Archoplites sp. (Sacramento Perch)	70	795
Hysterocarpus sp. (Tule Perch)	4	74
Amphibians:		
Bufo sp. (Western Toad)	2	
Reptiles:		
Clemmys sp. (Pacific Pond Turtle)	1	1
Thamnophis sp. (Garter Snake)	1	1
Pituophis sp. (Gopher Snake)	1	1
Birds:		
Anas sp. (Mallard, Gadwall or Pintail)		2
Anas sp. (Teal)		1
Branta sp. (Canada Goose)	2	3
Chen sp. (Snow Goose)		1
Fulica sp. (Coot)	1	3

Sac 329 (continued)

Podilymbus sp. (Pied-billed Grebe)		1
Mammals:		
Lepus sp. (Jack Rabbit)		1
Sylvilagus sp. (Cottontail)	1	1
Sciurus sp. (Grey Squirrel)		1
Castor sp. (Beaver)	1	2
Reithrodontomys sp. (Harvest Mouse)	1	
Peromyscus sp. (White-footed Mouse)	2	6
Microtus sp. (Field Mouse)	19	54
Canis sp. (Coyote)		
Procyon sp. (Raccoon)	2	4
Mustela sp. (Mink)		1
Spilogale sp. (Spotted Skunk)	1	
Mephitis sp. (Striped Skunk)		1
Lutra sp. (River Otter)		1
Cervus sp. (Tule Elk)	1	5
Odocoileus sp. (Mule Deer)	1	3

*from Soule 1976

Faunal Remains at Sac-65*

Name	# Individuals
Fish:	
Acipenser sp. (Sturgeon)	1
On corhynchus sp. (King Salmon)	1
Catostomus sp. (Sacramento sucker)	4
Mylopharodon sp. (Hardhead)	1
Pogonichthys sp. (Splittail)	1
Orthodon sp. (Sacramento blackfish)	1
Lavinia sp. (Hitch)	7
Ptychocheilus sp. (Sacramento squawfish)	1
Gila sp. (Thicktail chub)	14
Archoplites sp. (Sacramento perch)	10
Hysterocarpus sp. (Tule perch)	1
Reptiles:	
Clemmys sp. (Pond turtle)	1
Racer	1
Common kingsnake	1
Sac 65 (continued)	
Pituophis sp. (Gopher snake)	1
Thamnophis sp. (Garter snake)	1
Birds:	
Chen sp. (Snow goose)	1
"Mid-size" duck	3

Sac 65 (continued)

Teak	1
Anas sp. (Mallard)	2
Fulica sp. (Coot)	1
Turkey**	1
Mammals:	
Sylvilagus sp. (Cottontail)	1
Lepus sp. (Jackrabbit)	1
Citellus sp. (Ground squirrel)	1
Thomomys sp. (Botta pocket gopher)	2
Peromyscus sp. (White-footed mouse)	1
Microtus sp. (Field mouse)	10
Procyon sp. (Raccoon)	1
Vulpes sp. (Fox)	1
Canis sp. (Dog or coyote)	1
Domestic cat**	1
Pig**	1
Odocoileus sp. (Mule deer)	1
Cervus sp. (Elk)	1
Cow	1

* Table 4 of Schulz et al. 1979
**Historically introduced species

APPENDIX B

KEY FOR SETTLEMENT PATTERN TABLE:

Geologic Unit:
Qa-Levee and channel deposits; Qb-Alluvial basin deposits; Qt-Intertidal deposits (peaty mud); Qs-Dune sand; Qr-Riverbank Formation (consolidated alluvium)

Geomorphic site type:
A-Sand dune site; B-Natural levee; C-Knoll; D-Stream bank; E-Floodplain; F-River terrace; G-Unknown; H-Lake/abandoned channel/slough; I-Marsh

Nearest Water:
AC-Abandoned channel; B-Badger Creek; BS-Bear Slough; C-Cosumnes River; D-Dry Creek; DC-Deer Creek; DG-Deadman's Gulch; GS-Georgiana Slough; GZS-Grizzly Slough; L-Laguna Creek; M-Mokelumne River; MS-Meadows Slough; S-Sacramento River; SL-Stone Lake; SS-Snodgrass Slough; STS-Steamboat Slough; US-Unnamed stream

Area
data in terms of meters^2

SITE_ID	GEOUNIT	SITETYPE	NEARWAT	ABSAGE	AREA
SAC 62	Qa/Qb	B	S, SL		3600
SAC 249	Qa/Qb	B, I	M		
SAC 11	Qa/Qb	H	GZS, M, BS		
SAC 8	Qa/Qb	H	GZS, BS		901
SAC 10	Qa/Qb	H	GZS, M, BS		2700
SAC 248	Qa/Qb	I	M		289
SAC 71	Qa/Qb/Qt	H, I	SS		3600
SAC 72	Qa/Qb/Qt	H, I	SS		250000
SAC 140	Qa/Qr	B	C		850
Sac 115	Qa/Qr	B	C		
SAC 107	Qa/Qr	C, E	C, DC	2675+125-3075+105	2100
SAC 7	Qa/Qr	D	C		
SAC 137	Qa/Qr	D	C, US		4150
SAC 142	Qa/Qr	D	AC, C		
SAC 187	Qa/Qr	D	C, US		2100
SAC 200	Qa/Qr	D	C, US		2500
SAC 143	Qa/Qr	D	AC, C		
SAC 260	Qa/Qr	D	C		
SAC 117	Qa/Qr	D, E	C, DC		5400
SAC 111	Qa/Qr	D, E	C, DC		400
Sac 108	Qa/Qr	D, E	C, DC		
Sac 135	Qa/Qr	D, F	C, DC		
SAC 134	Qa/Qr	D, F	C, DC		4500
Sac 105	Qa/Qr	D, F	C, DC		
SAC 114	Qa/Qr	D, F	C, DC		2500
SAC 24	Qa/Qr	D, F	C, DC		15000
SAC 3	Qa/Qr	E	C		2178
SAC 4	Qa/Qr	E	C		160
SAC 351	Qa/Qr	E	C, DC		
SAC 113	Qa/Qr	E	C, DC		10000
SAC 110	Qa/Qr	E	C, DC		2500
SAC 109	Qa/Qr	E, F	C, DC		7500
SAC 230	Qa/Qr	F	C, DC		6689
Sac 100	Qa/Qr	G	C		
Sac 68	Qa/Qr	G	C		
Sac 27	Qa/Qr	G	C		
Sac 101	Qa/Qr	G	C		
SAC 69	Qa/Qt	B	S		4900
SAC 70	Qa/Qt	B	S,STS		

SITE_ID	GEOUNIT	SITETYPE	NEARWAT	ABSAGE	AREA
Sac 148	Qa	B	B, C		
SAC 147	Qa	B	C		45000
SAC 168	Qa	B	C	3070+170-200	1419
SAC 211	Qa	B	C		10000
SAC 98	Qa	B	C		
SAC 103	Qa	B	C		300
Sac 79	Qa	B	C		
SAC 146	Qa	B	C		40000
SAC 139	Qa	B	C		625
SAC 329	Qa	B	GS, S	1170+150 - 350+150	2025
SAC 330	Qa	B	C		2500
SAC 328	Qa	B	S, SL		
SAC 264	Qa	B	C		
SAC 258	Qa	B	C		289
SJO 68	Qa	C/D	M	4350+250-3080+300;3	
SAC 138	Qa	D, E	AC, C		289
SAC 144	Qa	D, E	AC, C		
SAC 67	Qa	D, E	L		
SAC 265	Qa	D, E	L		1089
Sac 191	Qa	D, H	BS, D		
Sac 93	Qa	E	B, C		
SAC 95	Qa	E	B, C		22500
SAC 118	Qa	E	C, DC		1200
Sac 116	Qa	E	C, DC		
SAC 112	Qa	E	C, DC		22500
SAC 121	Qa	E	C, DC		26250
SAC 2	Qa	E	C		78
Sac 119	Qa	E	C, DC		
SAC 150	Qa	E	L		625
Sac 149	Qa	E	B, C		
SAC 152	Qa	E	L		1296
SAC 151	Qa	E	C		11039
Sac 78	Qa	E	C		
Sac 94	Qa	E, H	AC, B, C		
SAC 66	Qa	E, I	C, M		1296

Sac 310	Qb	B			
SAC 14	Qb	D, I	C, M		559
SAC 12	Qb	E, I	C, M		289
SAC 21	Qb	H	S, SL, SS	780+150 MIDDLE/LATE	4875
SAC 9	Qb	H	GZS, M, BS		
SAC 76	Qb	H	MS, SS		4900
SAC 41	Qb	H	S, SL, SS		1600
SAC 65	Qb/Qr	C, H	S, SL, SS	530+160	6700
SAC 13	Qb/Qr	F, I	C, M		144
SAC 141	Qb/Qr	F, I	C, M		1675
SAC 395	Qb/Qr	H	SL, SS		16
SAC 145	Qb/Qr	H	SL	3300-200+80	12000
SAC 324	Qb/Qs	A, H	SL		14000
SAC 325	Qb/Qs	A, H	SL		2100
SAC 47	Qb/Qs/Qt	A, I	MS, S		3300
SAC 75	Qb/Qs/Qt	A, I	MS, S		18000
SAC 74	Qb/Qt	B	MS, S		2500
SAC 73	Qb/Qt	H, I	SS		4000
SAC 6	Qr	D	C,US	~1800-2600 B.P.	20000
SAC 161	Qr	D	C, US		2500
SAC 257	Qr	D	C		225
Sac 256	Qr	D	L		
SAC 49	Qr	D	C, M		1161
SAC 212	Qr	D	B, C		1505
SAC 5	Qr	D	US		64
SAC 311	Qr	D	DG		825
SAC 171	Qr	D	C, US		
SAC 312	Qr	D	DG		
Sac 352	Qr	D	L		
SAC 169	Qr	D	C, US		2500
SAC 20	Qr	D, I	C, M		2739

SAC 154	Qr	D, I	C, M	60
SAC 153	Qr	D, I	C, M	30
Sac 97	Qr	D, I	B, C	
SAC 19	Qr	D, I	C, M	36
Sac 81	Qr	F	B, C	
Sac 80	Qr	F	B, C	
SAC 1	Qr	F, H	AC, C, BC	2178
SAC 314	Qr	G	C	
Sac 82	Qr	G	B, C	
SAC 313	Qr	G	C	
SAC 165	Qr	G	SL	36
SAC 323	Qr	H	SL	10000
Sac 106	Qr	H, F	AC, C	
SAC 96	Qr	H, F	AC, B, C	10000
SAC 16	Qr	I, F	C, M	
SAC 190	Qr	I, F	C, M	169
SAC 64	Qr/Qs	A, H	SL	2500
SAC 23	Qr/Qs	A, I	M, SL, SS	2116
SAC 63	Qr/Qs	A,H	SL	10000
SAC 45	Qs	A, I	GS, M, S	900
SAC 104	Qs	A/I	GS, M, S	10000
SAC 162	Qs	B, I	GS, M, S	225000
SAC 203	Qt	B, I	GS, M, S	1302
SAC 25	Qt	H, I	GS, M, S	3600