NATIVE CALIFORNIAN PREHISTORY AND CLIMATE IN THE SAN FRANCISCO BAY AREA

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ABSTRACT

NATIVE CALIFORNIAN PREHISTORY AND CLIMATE IN THE SAN FRANCISCO BAY AREA

By Stella D'Oro

The Middle/Late Transition Period in California (1,100 - 750 B.P.) has recently been viewed by archaeologists as a time of dramatic environmental and archaeological changes, such as shifts in diet and the emergence of complexity among some Native American populations. Recently, paleoenvironmental and archaeological data presented by L. Mark Raab and Daniel O. Larson (Raab and Larson 1997) argue that the Medieval Climatic Anomaly (MCA), which involved a long period of drought, played a prominent role in the cultural changes noted in the greater Southern California Bight. This thesis tests the Raab and Larson "Southern California Model" in the southern San Francisco Bay Area and does not produce the same sort of behavioral changes during the anomaly. While the Southern California Model documents settlement disruption, increased violence, malnutrition, and intensification of resources, similar phenomena did not take place in this study area. I propose that prehistoric populations in the study area were not significantly impacted by the Medieval Climatic Anomaly.

ACKNOWLEDGEMENTS

This thesis is the result of the efforts of many individuals. First, thanks are due to Dr. Mark D. McCoy, my committee chair. Without his dedicated assistance and strict deadlines, this thesis would never have been written. Secondly, great appreciation is due to Mark Hylkema whose willingness to share his faunal data has resulted in new analyses and conclusions about the effects of drought in the diets of prehistoric Californians.

Much of the unpublished "gray" literature was generously supplied by Alan Leventhal of the Department of Social Sciences at SJSU. His first-hand knowledge of San Francisco Bay Area mortuary sites contributed significantly to this thesis. Additional thanks must be extended to Chuck Striplen, Leigh Jordan, Dr. Mark Raab, Denise Wills, and Charlotte Sunseri who assisted me with locating important site-specific and paleoenvironmental information. Lastly, I wish to thank Dr. Mark W. Allen and Dr. Thomas S. Garlinghouse for providing valuable input regarding theory and writing style. Their contributions have made this an interesting and readable thesis.

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1.0 INTRODUCTION

1.1 *Objectives*

California's Middle/Late Transition Period (1,100 - 800 B.P.) has recently been identified as an era of dramatic environmental and behavioral change, specifically a shift in diet and the emergence of social complexity among some Native American populations (Arnold 1992; Jones et al. 1999; Raab and Larson 1997). In a recent paper focusing on Southern California, L. Mark Raab and Daniel O. Larson (1997) argue that many of these changes can be attributed to a period of increased aridity between 1200 and 750 B.P., a time that has come be known as the "Medieval Climatic Anomaly." Raab and Larson (1997) present evidence of skeletal stress and settlement disruption, which they attribute to the MCA.

This thesis tests Raab and Larson's "Southern California Model" in the San Francisco Bay Area region using identical archaeological data in three counties: Santa Cruz, San Mateo, and Santa Clara and using paleoenvironmental data from near the same counties (Figure 1). Specifically, I examine environmental data including sea-surface temperature (SST), pollen, and tree rings. Archaeological data, including skeletal stress analysis and faunal remains for evaluating dietary patterns, are also evaluated and compared to those of the Southern California Model. Using Geographic Information Systems (GIS), sites from the San Francisco Bay Area are mapped chronologically to identify settlement disruption patterns during the MCA.

The concluding discussion on the comparative results of paleoenvironmental data places particular emphasis on a recent analysis of sea-surface temperatures from the Northern Channel Islands. Comparative results of archaeological data show disparities in diet, skeletal stress, and settlement patterns. The southern San Francisco Bay Area faunal assemblages do not indicate resource intensification, as described by the Southern California Model. Percentages of trauma indicators in skeletal evidence do not support an increase in warfare or malnutrition during the MCA. Analysis of settlement patterns throughout time does not indicate disruption during the same period. Although there is ample support in the Santa Barbara region for the MCA being linked to population disruption, health deterioration, and warfare, the same cannot be said for the Southern San Francisco Bay Area.

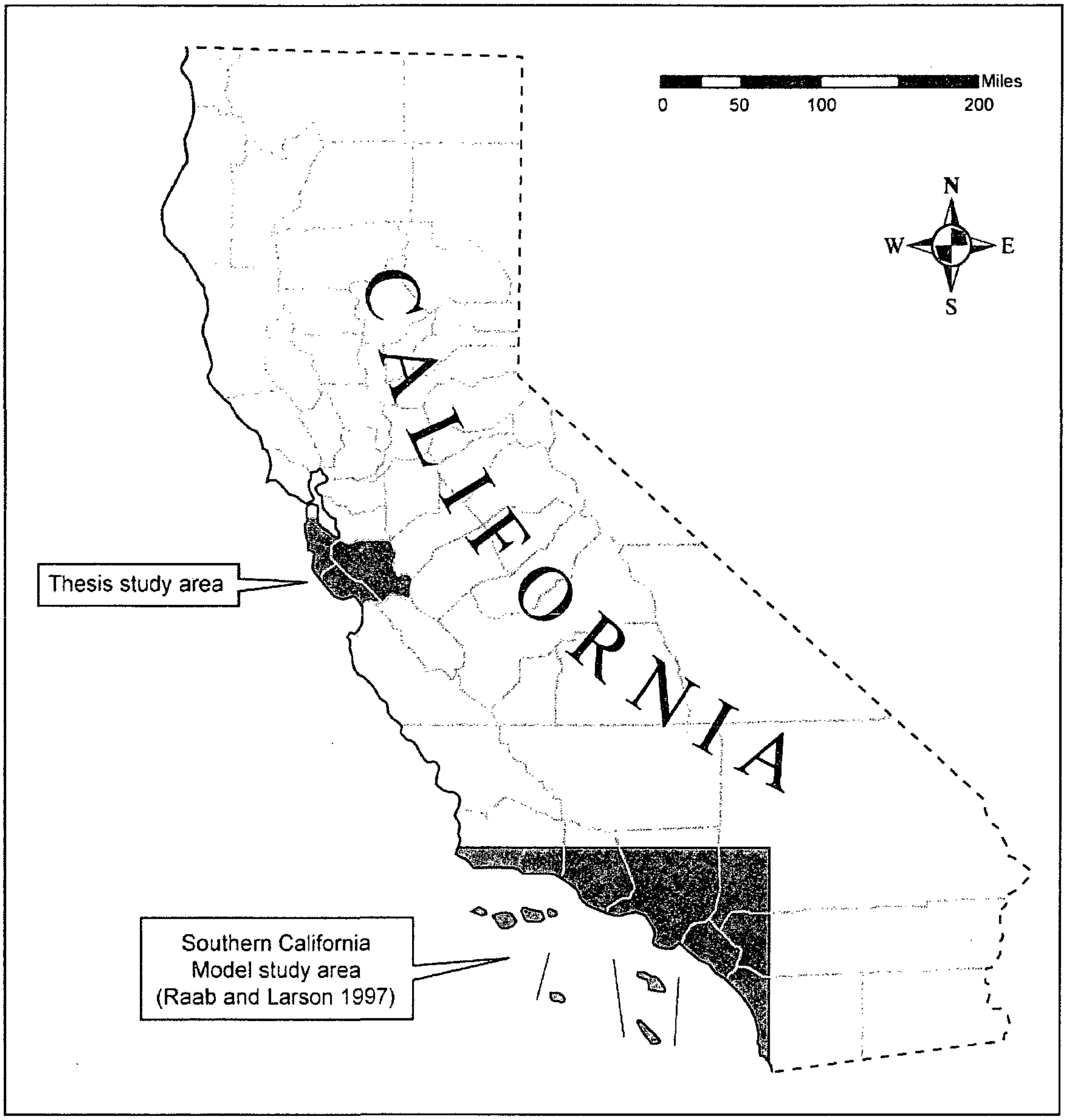


Figure 1. Locations of Thesis Study Area and Comparison Study Area.

1.2 *Theoretical Background*

To begin, it is important to consider the place of this research in the context of previous studies. This section provides a synopsis of the history of archaeology and an overview of its theoretical history. Evolutionary ecology and other modern theories such as post-processualism and processual-plus are also discussed. Lastly, I provide an explanation of the theory relevant to this thesis.

The roots of archaeology in the New World may be traced back to European-descended "antiquarians" who collected artifacts without consideration of the people who produced them. Although artifacts from North American mounds were prized by antiquarians, scholars between the sixteenth and eighteenth centuries did not consider that fact that indigenous peoples created mounds and the ornate artifacts found within them. Native Americans at that time were considered much too ignorant and barbaric. "It was widely maintained that the Indians were brutal and warlike by nature and biologically incapable of significant cultural development" (Trigger 2006:159). It was not until Samuel Haven's Smithsonian-commissioned publication in 1856, *Archaeology of the United States*, that indigenous people were finally given credit for their cultural heritage.

Collections of archaeological material from all over North America were being amassed by antiquarians and universities. It is, therefore, no surprise that classifying artifacts became the next stage of American archaeology. Classifications were usually based on the form and stylistic qualities of an artifact. Early anthropologists explained artifactual changes as corresponding to "cultural evolution" in which societies progress from "savagery" to "civilization" (Trigger 2006:101).

In the late nineteenth century, Darwin published his biological treatise *On the Origins of Species,* in which he proposed that all species evolve through a series of morphological changes as a survival strategy. During that time, artifacts were viewed as having gone through similar evolutionary processes. In 1903, William Holmes became the first professional hired by the Bureau of American Ethnology to publish taxonomies of ancient pottery from mounds in sites on the east coast of the United States (Holmes 1903). It was not long before others began creating similar taxonomies of pottery from other areas, including the southwest where stratified pottery deposits were used to create chronological sequences (Fagan 2005:42). Cultural evolutionary models were used to explain the sequences of artifactual changes over time.

American archaeology was still in its infancy; universities continued collecting material throughout the United States providing museums with a wide diversity of artifacts. Due to the variety of artifacts, there was gradual disillusionment about the cultural evolution theory. There did not appear to be a "simplistic, linear scheme of human progress" from savagery to civilization (Fagan 2005:39). Critics of cultural evolution argued that the notion of "civilized" societies bore a strong resemblance to contemporary European societies and rejected the theory as being ethnocentric.

Cultural anthropologists in the early twentieth century, such as Franz Boas, dismissed cultural evolution in favor of "historical particularism," the idea that cultures must be understood in their own terms and not compared to others' cultural processes or guidelines. It would take another two decades for archaeologists to consider historical particularism, later to be termed "cultural relativism" and its implications (Fagan 2005:39). Cultural relativism is the concept that cultural beliefs, and in this case artifacts, are the result of a specific culture's historical process. Artifactual changes, according to cultural relativity, are the result of cultural history rather than evolution.

A major catalyst contributing to the revolution of archaeological theory was the publication of *A Study of*

Archaeology by W. W. Taylor in 1948. Taylor admonished North American archaeologists as being more concerned about the material culture than with the culture of the people who made it. He urged practitioners to address settlement and dietary questions instead of focusing on chronological sequences and artifact classification (Fagan 2005:40). Taylor's "conjunctive approach" stressed the fact that many aspects of culture, other than the knowledge required to produce an artifact, are reflected in cultural material (Trigger 2006:367). His method combined anthropology with archaeology to produce a holistic interpretation of past cultures.

Technological advances during the twentieth century had significant impacts on archaeology. Perhaps the most noteworthy application of technology was the advent of radiocarbon dating in 1949. Knowing the rate at which carbon-14 isotopes decay, it is now possible to date items containing carbon, that is, organic remains from archaeological sites (Sharer and Ashmore 2003:332). Several earlier chronologies of artifacts had to be re-evaluated according to new radiocarbon dates. Previous taxonomies were simply sequential categories of artifacts; they were not assigned temporal categories until an adequate dating technology, radiocarbon dating, became available.

1.2.1 Cultural Ecology. Cultural adaptations may be perceived as a strategy to combat environmental stress. This section discusses the ideas behind this theory, called cultural ecology. The history of cultural ecological theory is examined and followed by a discussion about its place in the overall concept of processual archaeology. Various offshoots of cultural ecology are examined as well.

In the 1950s, Julian Steward proposed that the environment plays a significant role in cultural change (Steward 1955). His research inspired archaeologists, including Robert Heizer in California (Heizer 1959), to reconstruct prehistoric cultures along with their landscapes (Fagan 2005:55). In the 1960s, Steward and others began borrowing models from other disciplines considering other factors to cultural change, such as technology and sociology, in addition to the environment (Steward 1960:155).

Neo-evolutionists of the 1950s and 1960s argued that populations preferred "a familiar style of life unless change was forced on them by factors that were beyond their control," such as climate change or population diffusion (Trigger 2006:390). While the nineteenth century version of cultural evolution, posited the construct that cultures evolved through a unilineal process from savagery to civilization through individual innovations, neo-evolutionists attributed cultural change to the process of adaptation to the environment and/or social stresses.

The concept of cultural ecology is integral to the processionalist movement, or "new archaeology" advocated by Lewis Binford in the early 1960s. Binford argued that an explanation of forms and structures of an assemblage "…lies in the nature of the social system which it represents" (Binford 1962:219). He advocated that changes in material culture must be viewed as an adaptive strategy caused by social or environmental factors. Processual archaeology employs strict scientific methods to studying the process of culture change. This practice is maintained by most archaeologists today.

Evolutionary ecology is based on the idea that traditional Darwinian evolution is the primary factor behind basic human adaptations, such as survival and reproduction choices (Bird and O'Connell 2006; Hildebrandt and McGuire 2002; Winterhalder and Smith 1992). Although processualists use evolutionary theory, they are not to be confused with evolutionary archaeologists known as selectionists who apply Darwin's theory to cultural material and attribute natural selection to the "fitness" or artifact types (Schiffer 1996). In other words, selectionist archaeologists believe artifacts are a part of the human phenotype and are shaped by the evolutionary process of selection (O'Brien et al. 1998:487). Selectionists do not believe reconstructing behavior or using behavior models is sound science (Broughton and O'Donnell 1999:157), a concept embraced by evolutionary ecologists.

Behavioral archaeology studies the relationships between human behavior and material culture. It emphasizes the fact that behavioral or societal change is manifested in the archaeological record (Schiffer 1996:644, 1999:166). How an artifact is created, used, and eventually disposed of is may be used to reconstruct human behavior. Understanding the behavior of an individual provides insight regarding societal adaptations. Behavioral archaeology and evolutionary and behavioral ecology (discussed below) provide the theoretical framework of this thesis.

Some evolutionary ecologists take social considerations, such as gender-differentiation of work and individual fitness into consideration. Hildebrandt and McGuire state, "We believe that men and women can, at times, follow very different and even conflicting subsistence agendas that can potentially result in less-than-optimal group adaptations" (Hildebrandt and McGuire 2003:791). An example being "show-off hunting," that is, big-game hunting designed to enhance a male's personal fitness "at the expense of regular and dependable provisioning of one's family" (Hildebrandt and McGuire 2002, 2003).

Deriving from evolutionary ecology, behavioral ecology is the study of behavioral adaptations to social and environmental conditions. Some of the questions asked by behavioral ecologists relate to "resource transport, subsistence-related changes in technology, the origin and diffusion of agriculture, the material correlates of social status, [and]…the development of social hierarchies…" not simply questions regarding the optimal foraging theory (Bird and O'Connell 2006:144; Broughton and O'Connell 1999; Winterhalder and Smith 1992).

1.2.2 Post-Processualism and Processual-Plus. Theoretical developments during the past two decades have challenged traditional archaeological ideas, including strict scientific methodologies commonly employed by many other disciplines. This section discusses two modern theories, post-processualism and processualist-plus archaeological theories. Post-processualism archaeological theory derives from post-modern concepts popular in the 1980s and processual-plus theory is a combination of modern and post-modern ideas. Although neither of these approaches is applied directly here, they provide important methodological and conceptual frameworks for any archaeological problem.

Post-processual archaeology is based largely on the rejection of the scientific method and hypothetico-deductive archaeology (Hodder 1982; Miller and Tilley 1984; Shanks and Tilley 1987). Concepts of culture and typologies are replaced with agency, symbolism, and behavior of individuals (Hegmon 2003:217). Post-processualists believe empirical science is a product of western civilization and that deductive or processual approaches to archaeological problems are problematic since objectivity is not possible. They argue for multivocal and politically-aware archaeology designed to read the past according to an individual's non-priviledged perspective.

Processual-plus is a combination of post-processual and traditional ideas in an effort to include general social theory into archaeological interpretation and to bridge the gap between processual and post-prosessual ideas. Standard archaeological research questions are blended with interpretations of "issues beyond the archaeological record" (Hegmon 2003:231). Processual-plus advocates "dialogue between various theoretical approaches in an effort to determine to what extent they are complimentary and might serve as the basis for constructing more comprehensive and useful hybrids" (Trigger 2006:497).

Both post-processualism and processual-plus theories are useful for research questions concerning gender, ethnicity, power, and ideology. This thesis, in fact, utilizes a report on the mortuary site CA-SCL-732, also called "Kaphan Umux/Three Wolves," which was excavated under the direction of Ohlone Families Consulting Services, the archaeological consulting firm of the Muwekma Ohlone Tribe. Rosemary Cambra, the tribal chairperson and primary author of the report, provides the voice of the "subject," thereby making the report post-processual in nature. These modern theories, however, are not the central tenets of the theoretical model explored in this thesis. The emphasis here is on environmental variables. These variables are best captured through quantitative analyses of data on climate, dietary resources, settlement patterns, and skeletal stress of prehistoric populations.

1.2.3 Relevant Theory. Are populations modifying their behavior to accommodate for drought conditions during the MCA? The theory I believe to be best-suited to answer this question is cultural ecology. Steward's consideration of the complex interaction between societies and their environment is a central theme of this thesis. The Southern California Model suggests climate change resulted in the increase of warfare, malnutrition, settlement disruption, and resource intensification. This thesis also embraces evolutionary ecology, but finds adaptations to climatic conditions vary between the study areas.

1.3 Chronology of California

This section discusses the history of archaeological research in North America, and more specifically, California. The advent and development of chronological schemes in California are outlined as well. Regional differences are examined with an emphasis on the current models. Prehistoric temporal sequences are then summarized using the latest and most relevant scheme.

1.3.1 History of Research. Archaeology in North America began with studies of aboriginal pottery along the East Coast and stratigraphic investigations in California by Max Uhle in the late nineteenth century (Fagan 2005:37). The goal of these studies was to create chronological schemes for artifacts. Cultural evolution was the predominate theory the time. Changes in archaeological assemblages were attributed to societies graduating from savagery to barbarism, and finally to civilization (Trigger 2006:101).

As scholars became disillusioned with cultural evolution, changes in culture were explained by theories of migration and diffusion. Diffusion is the notion that technologies, languages, and every other cultural aspect could spread through the process of mobile populations or trade (Trigger 2006:129). Stylistic changes in artifacts were often attributed to the introduction of a new culture or through trade. Theories regarding migrations and diffusion were fine-tuned with technological advances in the following decades.

Much the early analyses of California's archaeological sites were conducted in the San Francisco Bay and the Santa Barbara regions where major universities sponsored academic research. The goal of the excavations in the early twentieth century was to find artifacts typical of local indigenous peoples (Moratto 1984:xl). Broader research questions regarding cultural adaptation were not addressed and many early excavations disregarded valuable information about environment and diet. California was not examined thoroughly until the advent of environmental protection laws in the 1970s requiring cultural resource management to be conducted.

Until the advent of dendrochronology in the 1930s and radiocarbon dating in the 1940s, chronological schemes in California, and in fact all of North America were based on cultural material organized into temporal sequences without being attached to actual dates (Fagan 2005:45; Sharer and Ashmore 2003:310; Trigger 1989:17). Chronological schemes were developed for regions of California as early as the beginning of the twentieth century. David Banks Rogers (1929) developed a scheme for the Santa Barbara area after noticing differences between archaeological assemblages of varying time periods. His original sequence included three parts, including 1) Millingstone, 2) Hunting, and 3) Chumash (Farquhar 2003). Lillard, Heizer, and Fenenga (1939) developed a scheme for Central California, and M. Rogers (1939) created one for the San Diego area. Recent chronologies include the San Francisco Bay (Milliken and Bennyhoff 1993), the Central Coast (Jones and Ferneau 2003), and the Santa Barbara Channel schemes (Erlandson and Jones 2003:5-6; King 1990).

The San Francisco Bay area and Central California regions were originally estimated to have been occupied as early as 3500 BP based on the works of Nelson, (1910) and Gifford (1916). The area continued to be investigated sporadically by academics over the next several decades with notable contributions to the chronological sequence by Heizer (1949) and Gerow (1968). Ever since environmental laws in the 1970s necessitated the work of CRM specialists, much more information about the study area has become available. We now know, for example, that the study area of this thesis has been occupied for at least 12,000 B.P. (Cartier 1993). Additionally, the Society for California Archaeology proceedings and the Journal of California and

Great Basin Archaeology have become invaluable for disseminating the latest research and findings in the state of California and beyond.

Time periods in California have primarily been differentiated by the types of artifacts found in archaeological deposits, including shell beads and ornaments, projectile points, and bone tools. Shell beads have been the most useful indicator of temporal differences due to the fact that they "show tremendous similarity in temporal distributions over wide areas of California" (Erlandson and Jones 2003:5). More recent chronologies have considered subsistence, settlement, and ecological patterns instead of the traditional strictly artifactual determinations (Breschini and Haversat 1980; Dietz and Jackson 1981). In the Santa Barbara Channel area, cultural sequences continue to be determined by the types of shell beads and ornaments (Jones 2002). Although cultural schemes in the San Francisco Bay and in the Santa Barbara regions have been well-established since the 1970s, they proved to be problematic when applied to assemblages found within the South Bay and Central Coast (Hylkema 2002).

Modern schemes are similar to each other; however, there are enough regional differences, especially among projectile point styles, to warrant specific chronologies for different geographic areas of California (see Section 1.3.3). For example, along the coastlines of San Mateo and Santa Cruz counties, Año Nuevo long-stemmed projectile points are found throughout Milliken and Bennyhoff's (1993) chronological scheme of the San Fransico Bay Area; they are found from the Early, through the Middle, and possibly into the Late Period (Hylkema 2002:247). The long duration of artifact styles in the study area makes the use of radiocarbon dating necessary for accurate chronological placement of site components.

1.3.2 Regional Approaches. A chronological scheme for the study area has never been specifically worked out, although its location places it within two possible cultural chronologies, Milliken and Bennyhoff's San Francisco Bay Area scheme, and the recent Central Coast scheme developed by Jones and Ferneau (2003). Figure 2 compares the chronological schemes of the study area of this thesis and the Santa Barbara area chronology (Erlandson and Jones 2000), which may be applied to the Southern California Model. Jones and Ferneau's Central Coast scheme is used here. It is noteworthy that the Central Coast scheme delineates the Middle/Late Transition Period as being more aligned with the MCA than any other chronological scheme and simplifies the Middle and Late Periods.

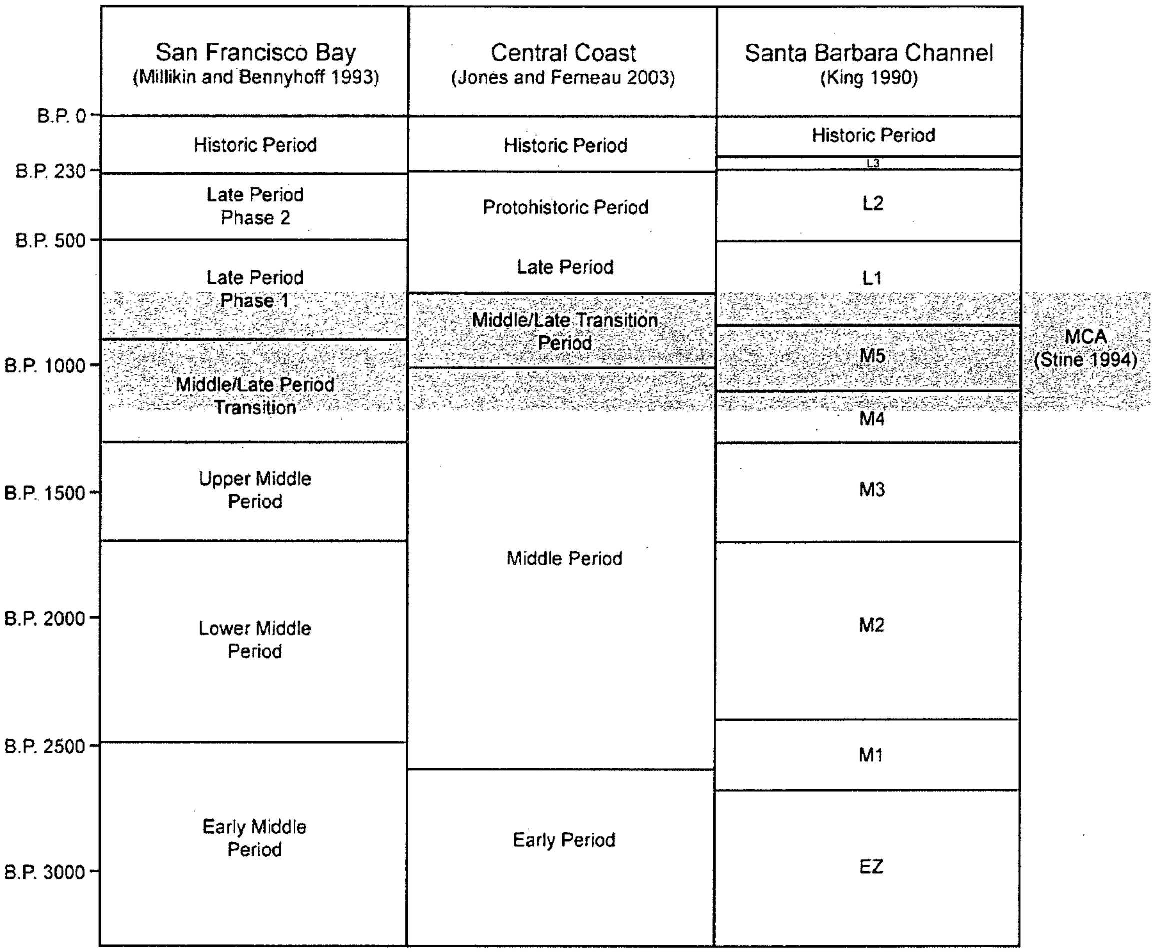


Figure 2. Chronological Sequences for the San Francisco Bay and California Coast (adapted from Erlandson and Jones 2000:6 and Jones and Ferneau 2003).

The San Francisco Bay and Santa Barbara Channel schemes are a decade older than the Central Coast scheme. They are likely to be revised as more archaeological evidence is uncovered. Increased development in the two regions will necessitate the requirement of CRM investigations which may result in modifications to the current chronologies.

1.3.3 Relevant Time Periods. The California coast has been occupied by human populations as early as 12,000 to 13,000 B.P. according to recent radiocarbon dates from the Northern Channel Islands (Erlandson 2002; Erlandson et al. 2007; Moratto and Chartoff 2007). These finds predate the Clovis culture and add support to the theory of maritime colonization of the Americas. Rather than the older theory of the Clovis culture crossing the Bering Strait chasing herds of mammoth and other large game rapidly through the Americas via an ice-free corridor, new theories suggest maritime populations colonized the Americas along the Pacific coastlines (Erlandson 2002; Fagan 2005:84; Nemecek 2000).

Several archaeological sites in the study area are extremely old, including CA-SCR-177 in Scotts Valley (Cartier 1993), which dates to 12,000 B.P. Santa Clara Valley (Fitzgerald and Porcasi 2003) and San Luis Obispo (Fitzgerald 2000:123) also contain some very early sites dating to cal. 7,500 B.P. and cal. 10,400 B.P, respectively. While these sites represent the Paleoindian (pre-8,500 B.P.) and Millingstone Periods (8,500 - 5,000 B.P.), this study focuses on the past 5,000 years which includes four primary time periods based on Jones and Ferneau's Central Coast scheme: the Early Period (5,000 - 2,600 B.P.), the Middle Period (2,600 - 1,000 B.P.), the Middle/Late Transition Period (1,000 - 750 B.P.), and the Late Period (750 B.P. - Historic). The following sections summarize the four time periods.

1.3.3.1 *Early Period: 5,000 - 2,600 B.P..* Subsistence patterns during the Early Period are indicated by the appearance of mortars and pestles representing a greater reliance upon processing pulpy nuts such as acorns than in previous periods (Farquhar 2003). Sites from the Monterey Bay area indicate that in addition to acorns, a wide variety of food resources were used during the Early Period, including shellfish (mainly mussel), marine mammals, terrestrial mammals, and avifauna (Jones and Hildebrandt 1990; Jones and Hildebrandt 1994; Smith and Breschini 1988). Although the faunal evidence suggests hunting terrestrial mammals was not as frequent as in earlier periods, the Early Period exhibits increased numbers of large projectile points, including the large side-notched and contracting stem points. Glassow (1996) believes the reason is due to the development of gender roles; while women stayed in residential encampments gathering and processing resources, men pursued tool manufacture, maintenance, and hunting activities.

Long-distance trading in the study area is evidenced by the appearance of obsidian from eastern California (Figure 3), mainly the Casa Diablo source (Jones 1995). Bead types found during the Early Period include L-series (thick rectangular), B-series (barrel), and C-series *Olivella* beads as well as square *Haliotis* beads (Farquhar 2003). An Early Period mortuary site, the Saunders Site in Monterey County (CA-MNT-391), directly south of the study area, reveals mostly flexed position burials interred with Rossi square-stemmed points, L-series *Olivella* shell beads, and fish gorges (Cartier 1993). Within the study area, the Early Period site CA-SMA-77 (the University Village site), also contained flexed burials. Bead types included L-series *Olivella* shell beads as well as whole *Olivella* shells (Hylkema 2002). Contrasting-stemmed, Año Nuevo long-stemmed, and large side-notched projectile points are also characteristic of Early Period sites along the Central coast (Jones et al. 2007).

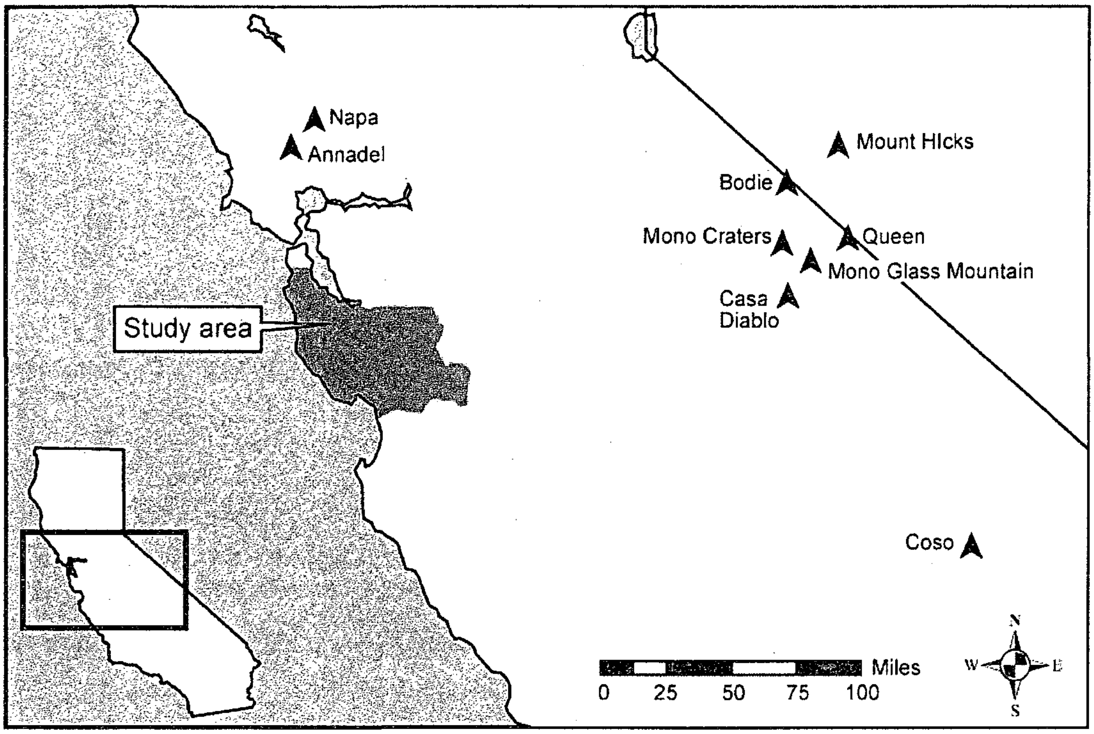


Figure 3. Map of Obsidian Sources in California (adapted from Jones 1995).

Cultural traditions in the Early Period near the study area include Windmiller in the Sacramento-San Joaquin Delta (approximately 50 miles north of the study area). The Windmiller is a distinctly separate population based on the practice of extended burials and Gerow's craniometric analysis (Gerow 1968, 1974; Hylkema 2002). The population from CA-SMA-77 was more similar to Southern California with regards to flexed burials, such as those of CA-MNT-391, than to Windmiller individuals from the Sacramento-San Joaquin Delta. These differences led Gerow to believe that the Windmiller culture represented Penutian-speakers, while the "Early Bay" culture of University Village within the study area and the southern California coast populations were Hokan-speakers (Gerow 1974; Wiberg 2002).

1.3.3.2 *Middle Period: 2,600 - 1,000 B.P..* There was a diversification of subsistence practices during the Middle Period as evidenced by both changes in dietary remains and artifacts. Shellfish usage declined while small schooling fish and small mammals (i.e. rabbits and sea otters) were used more. For example, northern fur seals and otters predominate in the faunal assemblages at sites at Año Nuevo in San Mateo County and the Monterey Peninsula, respectively (Jones et al. 2007). Mortar and pestles are found with greater frequency, as are net weights. Lithic technologies during the Middle Period include contracting-stemmed (Jones et al. 2007) and long-stemmed projectile points (Farquhar 2003). The Middle Period also marks the introduction of the circular fish hook. Olivella shell bead types include the saucer (G-series) and saddle (F-series) (Farquhar 2003). Obsidian trading continued throughout the study areas, although Coso Range obsidian is found in higher frequencies than material from Casa Diablo. T. Jones suggests the Chumash were trading otter pelts for Coso Range obsidian (Jones 2003:226). All grave-related sites from the Middle Period show flexed skeletons and contain grave goods such as G-series beads and occasional bone flutes and tubes (Jones et al. 2007).

1.3.3.3 *Middle/Late Transition Period: 1,000 - 750 B.P.*. In most regions of California, or when discussing certain traits, the Middle/Late Transition Period is appropriate. Regional approximations of this time period include 1300-800 B.P. in the San Francisco Bay area (Hylkema 2003), and 850-750 B.P. in the Santa Barbara region (Arnold 1992). Archaeological assemblages from the Santa Barbara area during the Middle/Late Transition Period are characterized by the appearance of small leaf-shaped points instead of contracting-stem points (Farquhar 2003), although contracting-stemmed points continued to be used in the San Luis Obispo area. Double side-notched points are also characteristic of the Middle/Late Transition Period (Jones et al. 2007). For the purposes of this thesis, Jones and Ferneau's (2003) proposed chronology of the Central Coast is appropriate.

Tree ring studies (Stine 1994) demonstrate the climate at this time was warmer and drier than average. There is disagreement, however, about the impact the dry climate had upon the populations in California. Glassow (1996) argues that warmer sea temperatures wreak havoc on kelp forests, which provide many of the resources used by coastal populations. Similarly, Arnold (1992) suggests resource depression triggered stratification of society with chiefs and elites managing resources and craft specialization. Jones (1995) believes the climatic conditions of this period caused not only depression of resources, but settlement disruption and competition for resources. The Raab and Larson Southern California MCA Model, on the other hand, suggest that despite the warmer climate, populations in the Santa Barbara area had ample access to resources, particularly, marine resources. The Corral Canyon site (CA-SBA-1731), "the most intensively analyzed Transitional-Period site to date on the mainland (Erlandson 1993:191) shows a pattern in which maritime subsistence productivity peaked during what was ostensibly the interval of highest water temperatures during the Transitional Period" (Raab and Larson 1997:326).

Sites showing continual occupational during the Middle/Late Transitional Period are rare (Jones et al. 2007). Jones et al. suggest a disruption of settlement patterns and movement of people in Central California in response to changes in water sources stemming from severe and prolonged droughts (Jones and Ferneau 2003). This change coincides with Stine's paleoenvironmental data demonstrating extended dry periods (Stine 1994). Stine analyzed tree-rings from drowned stumps in the Sierra Nevada Range and identified the phenomenon known as the Medieval Climatic Anomaly (MCA) (see Section 2.1).

1.3.3.4 *Late Period: 750 B.P. - Historic.* In this period, new and numerous projectile points mark Late Period assemblages in California. These include small side notched (Desert side notched), triangular (Cottonwood), and leaf-shaped points. Other typical Late Period artifact styles include hopper mortars, Class-E (lipped) and Class-K (cupped) Olivella shell beads, small bi-facial bead drills, and steatite disk beads. In the Monterey Bay area, Class-M Olivella beads and small serrated arrow points are noted (Jones et al. 2007).

2.0 BACKGROUND

This section is an explanation of the MCA, methods used to measure climatic variation, and evidence of the anomaly locally and throughout the world. California experiences droughts of different lengths. Some are short, lasting only months at a time, while others go on for extended periods. The drought discussed here is over a hundred years of significantly reduced precipitation. The environmental effects of such a drought would impact vegetation and water sources, likely impacting local populations as well.

2.1 *The Medieval Climatic Anomaly*

Spanish diaries from the Spaniards' expeditions into California record the abundance and diversity of vegetation and game available to the indigenous peoples (Costansó 1970; Fages and Priestly 1919; Raab and Jones 2002). Pedro Fages was a member of the first overland expedition to Monterey in 1769. He observed, "It is not to be denied that this land exceeds all the preceeding territory in fertility and abundance of things necessary for sustenance"

(Fages and Priestly 1919:74). The first scholarly examination of prehistoric California likewise proposed a rich environment with little chance of populations suffering from malnutrition or starvation.

> If a drought withered the corn shoots, if the buffalo unaccountably shifted, or if the salmon failed to run, the very existence of people in other regions was shaken to its foundations. But the manifold distribution of available foods in California and the working out of corresponding means of reclaiming them prevented a failure of the acorn crop from producing similar effects. It might produce short rations and racking hunger, but scarcely starvation [Kroeber 1925:524].

Recent studies, however, demonstrate evidence of the MCA in paleoenvironmental records. Archaeological assemblages also suggest that human behavior changed during the anomaly. The following section begins with a discussion of the specific indicators of drought conditions, including sea-surface temperatures, pollen analysis, and tree-ring studies for paleoenvironmental data. Archaeological materials are also examined to determine the extent of human adaptation to climatic conditions. These include faunal analyses to indicate dietary changes in response to drought and skeletal analyses to find patterns of warfare and malnutrition. This section ends with a comprehensive discussion about other studies researching the MCA in California.

2.1.1 Environmental Indicators of the MCA. There have been several recent studies documenting the existence of a long term drought in California during the Middle/Late Transition Period. This section discusses paleoenvironmental research including tree-rings, sea-surface temperatures, and pollen studies. Tree-ring and pollen analyses are indicators of precipitation. Sea-surface temperatures indicate warming trends offshore which impact marine resources.

Scott Stine, a professor of geography and environmental studies, analyzed rings from tree stumps rooted in present-day lakes, marshes, and streams. He found that California's Sierra Nevada experienced extremely severe drought conditions during two intervals. The first drought lasted 220 years (1100-900 B.P.) and the other for 140 years (from 800 to 650 B.P.) with a wet interval in between (Stine 1994, 1998). Stine's results match those of LaMarche who analyzed tree-rings in bristlecone pines, *Pinus longaevea*, in the White Mountains of Eastern California two decades earlier (LaMarche 1974).

Short droughts are not uncommon on the Pacific coast, even today. The El Niño Southern Oscillation (ENSO), which is associated with droughts and floods, was first identified in the early twentieth century by Sir Gilbert Thomas Walker, a British physicist and statistician (Katz 2002). Climatologists have been using sea-surface temperatures (SSTs) as the metric of ENSO since then. Past SSTs are measured by drilling core samples in the seafloor and examining temperature-sensitive radiolarian fossils. When SSTs rise more than 0.5 degrees Celsius for over a five-month period, it is termed an El Niño episode (Trenberth 1997). The appearance of El Niño is irregular and usually the condition lasts several weeks or a month (Malamud-Roam et al. 2007:15); but occasionally, it lasts longer and can have serious effects on the eastern Pacific Ocean's ecosystem. Special circumstances must be chosen for the sampled areas including high rates of sedimentation and an abundance of radiolarian species.

Pollen research, palynology, is another way to determine environmental conditions. Core samples taken from marsh environments are especially useful because the pollen samples reflect fresh- or salt-water conditions. More fresh water plants indicate more rainfall and a greater stream discharge while more salt water plants suggest less rainfall and decreased stream flow.

2.1.2 Archaeological Indicators of Behavioral Change in the MCA. Human behavior is interpreted through archaeological finds such as faunal remains and burials. This section outlines the types of drought indicators available through analyses of archaeological data. Faunal remains, for example, are used to reconstruct prehistoric diets. Settlement patterns may be gleaned from analyzing the temporal spans of site occupation. Skeletal remains are analyzed to determine the health of populations as well as evidence of violence or trauma. By combining the results of these analyses, it is possible to create a holistic perspective of prehistoric behavioral patterns.

Kelp forests support many edible taxa including birds, fish, and sea mammals. These resources provided the southern coastal California prehistoric populations with a large portion of their diets (Arnold 1992; Raab and Larson 1997:322-323; Walker 1986). Arnold claims that sea-surface temperatures higher than 20 degrees Celsius disrupt the kelp forest ecosystem (Arnold 1992:69). The Southern California Model, however, posits that procurement of marine resources was, in fact, intensified during the period of high SSTs.

Settlement disruption is often due to changing water sources stemming from severe and prolonged droughts (Jones and Ferneau 2003). True (1990) found that during the late Holocene, sites in the northern San Diego County clustered near perennial water sources rather than near both perennial and ephemeral streams as during the Early Holocene. True acknowledged drought as a possible cause, but did not accept it as the primary reason for the demographic shift. He was more inclined to believe the shift was due to an increase in population (True 1990:57-58).

Skeletal stress manifested in malnutrition may also indicate resource depression caused by climatic variation. Population health indicators include skeletal height and cribra orbitalia, pores or "pitting" in the surface of orbital roofs caused by iron-deficiency or contaminated water sources (Walker 1986). While it is possible that health problems can be the result of other societal stresses, such as overpopulation, the Southern California Model links the environment as being the causal factor. Likewise, skeletal trauma, including cranial and long bone fractures may be caused by other factors including accidents or self-mutilation (Walker 1989), but in the Southern California Model and in this thesis, are considered to be a proxy for violence and warfare (Raab and Larson 1997).

2.1.3 Previous Archaeological Studies of the MCA in California. Given the diverse environments of California and the differences in subsistence strategies and political organizations of the populations, it seems reasonable to assume that the effects of drought would have various types of impacts (Jones et al. 1999). The effects of the MCA on Native Californians appear to have been regionally varied with respect to warfare, nutritional stress, and settlement patterns (Jones and Schwitalla 2008). The following section describes recent research about the MCA and its effects, if any, on local populations within California.

In the Central Sierra Foothills, Wohlgemuth conducted archaeological investigations at CA-AMA-56, the Applegate Site, ahead of a Caltrans bridge replacement in 2000. He found that deposits are thinner during the MCA suggesting limited occupation. Skeletons from nearby Buchanan Reservoir from the same period show evidence of violent deaths and a decrease in regional trade (Wohlgemuth 2005:308-310). Wohlgemuth suggests the settlement shift, increase in violence, and decreases of imported goods are a direct result of warmer climatic conditions.

Other researchers (Jones et al. 1999) believe the MCA had a significant impact on populations and was the primary reason for site abandonment. Along the central coast in Monterey County, Jones et al. (1999) plotted radiocarbon dates along a chronological scale. They found that there appears to be settlement disruption during the MCA with few sites being continuously occupied through the period of droughts. At the same time, there appears to have been a break-down of long distance trade evidenced in the drop of obsidian artifacts from the archaeological record.

In the Mojave Desert, evidence from vegetation in pack rat middens and paleohydrologic records show an increase in aridity from 1400 - 800 B.P. (Jones et al. 1999). There is evidence for population disruption during the MCA, but the area was not completely abandoned. Instead, it appears populations may have aggregated around diminished resource areas (Schwitalla and Jones 2008:49). The most recently proposed chronology for the Mojave Desert describes the MCA as coinciding with the latter part of the Rose Spring

Complex at 1,000-900 B.P. The reasons for the end of the complex may have been due to environmental factors such as drought, or it may represent depression of game resources due to the technological advance of the bow and arrow, or both (Sutton et al. 2007:242). The subsequent Late Prehistoric Complex involved significant changes in technology, settlement pattern, patterns of rock art, and subsistence. It is has been postulated that these changes are themselves related to drier conditions during the MCA (Gardner 2006; Sutton et al. 2007).

Directly north of the study area in Alameda County, Pilloud (2006) reported on the osteology of cemetery populations spanning the Middle, Middle/Late Transition, and Late Periods at CA-ALA-613/H. Her findings suggested there were no significant health or violence issues between the periods, with the exception of an increase in dental caries among women during the MCA, which she attributed to dietary changes. Pilloud did not link dietary changes to the MCA.

Gamble (2005) argues that the current trend of explaining punctuated social complexity as a result of environmental stress is overly simplistic. Indigenous knowledge during the late Holocene would have successfully combated the effects of prolonged drought with minimal, if any, significant cultural adaptations (Jones and Schwitalla 2008:45). Although environmental degradation would likely be seriously detrimental to agricultural societies, Gamble argues that "hunter-gather societies, particularly maritime hunter-gatherers, are more capable of coping with severe climatic changes than agriculturalists" (Gamble 2005:101). Additionally, she notes strategies employed by the Chumash for combating the impacts of drought, namely, techniques for storing food and water. "The most common form of storing water used by the Chumash was the twined basketry water bottle with asphaltum lining on the interior" (Gamble 2005:100). The Chumash and other southern California groups, such as the Cahuilla, were also known to have dug wells which would have been a continual source of water during prolonged droughts.

Resource intensification, that is, using more energy to collect more resources from the same given area, is often associated with social or environmental stress. Intensification has been observed by Bettinger (1991, 1999) in the western Great Basin region of the White Mountains on the border of southwestern California. Bettinger notes that Alpine villages were used for longer durations to procure ungulates and vegetal resources such as piñon nuts.

> The archeological record in eastern California provides additional support for the idea that more than climate must be involved in the appearance of alpine villages. It indicates that both the pace of aboriginal adaptive shifts and the intensity of aboriginal resource use increased there during the Holocene in the absence of any evidence of a parallel, that is, continuing directional, trend in climate [Bettinger 1991:672].

Bettinger suggests the higher altitude intensification was not due to environmental factors. He instead believes it was the result of population growth and the spread of Numic-speaking peoples into the immediate area (Bettinger 1991; Jones and Schwitalla 2008:42). According to Bettinger, the Numic-speaking immigrants were able to expand their population through harvesting piñon nuts while the native populations focused on hunting. Harvesting piñon was "a costly but highly effective adaptation capable of sustaining relatively large numbers of people on relatively small tracts of land" (Bettinger 1991:674). Their conclusions are now supported by DNA evidence. Kaestle and Smith (2001) have demonstrated that the ancient Numic-speakers from the Western Great Basin had mtDNA sequences that differ significantly from the recent Native American populations of the same region.

Basgall (1999, 1987) likewise considers the MCA explanation as described by the Southern California Model to be an oversimplification of reality. He suggests technological advances, such as the bow and arrow, and population increases must be examined more thoroughly before jumping to conclusions that the MCA had such a drastic impact.

> It is one thing to posit a general relationship between effective moisture and primary productivity, which is well established ecologically, but quite another to presume that increases or decreases in the same must have had serious consequences for prehistoric hunter-gatherers [Basgall 1991:157].

Basgall also points to data from Fort Irwin, a desert environment in southern California. Occupational evidence from sites in Fort Irwin contradicts the Southern California Model. Instead of seeing the desert region sites abandoned during the MCA, Basgall notes increases in occupation.

> Data from Fort Irwin, the most systematically examined tract in this region, indicate a dramatic increase in assays after A.D. 500 that continues into early historic times. If desert populations were constrained by water during this period…, the spring-poor Fort Irwin environment is hardly a likely destination [Basgall 1991:158].

Researchers are far from agreement about the behavioral adaptations of Native Californians during the MCA. While the Southern California Model proposes a convincing argument about the drastic social consequences of prolonged drought, so far the evidence elsewhere in the state tells different stories. The anomaly was not isolated to California, of couse. Its effects were felt globally. This thesis benefits from an examination behavioral adaptations associated with the MCA outside of the modern political boundaries of California.

2.2 *Evidence of MCA-linked Behavioral Changes Outside of California*

This section provides a discussion of studies about the MCA in other parts of North America and abroad. There have been several investigations regarding human adaptations to the anomaly throughout the western hemisphere, northern Australia, and the Fijian Islands. Droughts have recently become a popular explanation for the collapse of many cultures. These include the Ancestral Puebloans of the American Southwest, the Classic Mayan society of the Yucatán Peninsula, and the Tiwanaku of Peru.

DeMenocal (2000) notes that the end of the 13th Century A.D. marked the era when the Ancestral Puebloans deserted their villages in the Four Corners area of the United States; that is, the area of southwest Colorado, southeast Utah, northeast Arizona, and northwest New Mexico.

> Cited reasons for the collapse of the Anasazi include emergent balkanization, warfare, and religious turmoil within the region, as well as the onset of severe drought conditions and regional deforestation …. Whether the multidecadal drought of the 1280s was the determining factor in the collapse of the Anasazi continues to be debated…but current archaeological evidence firmly implicates drought as a contributing destabilizing factor… [deMenocal 2001:668].

The collapse of the Classic Maya in 900 A.D. also corresponds to the MCA (Lucero 2002; DeMenocal 2001). Citing stable isotopic analyses of ostracode shells in sediment cores, deMenocal (2001) identifies a 200-year drought centered near 1200 B.P. He suggests that the extended period of reduced precipitation had catastrophic effects on farming societies in the area.

> The densely populated southern lowlands of the Yucatán Peninsula were highly reliant on surface water supplies for human and agricultural needs, and it was these regions that were most acutely affected during the drought from 800 to 1000 A.D. [deMenocal 2001:670].

Lucero suggests that the prolonged drought undermined the rulers' authority in the water-scarce area of the Yucatan Peninsula (Lucero 2002). During the dry season, Mayan kings of the Classic era exacted tribute from their subjects in exchange for access to artificial reservoirs and other water sources. During the MCA, however, "climate change undermined the institution of rulership when existing ceremonies and technology failed to provide sufficient water" (Lucero 2002:814). Rulers were the first ones to be blamed when the climate conditions changed and they lost their power as a direct result.

The anomaly was also present at Lake Titicaca and the surrounding Bolivian-Peruvian altiplano, as evidenced by lake sediment cores. Binford et al. have discovered low lake-levels during the MCA and suggest it had significant negative impacts on the agricultural Tiwanaku culture near Lake Titicaca in Peru (Binford et al. 1997; Dillehay and Kolata 2004). The Tiwanaku cultivated raised fields which were dependent on water run-off from Lake Titicaca. Archaeological evidence from the MCA period indicates "declining agricultural production, field abandonment, and cultural collapse" (Binford et al. 1997:235). Binford et al. note that when the fields were abandoned, the urban centers were also abandoned and monumental construction ceased for 300 years. They attribute the social upheaval to the drought conditions of the MCA.

Researchers in the South Pacific have identified a dry time period corresponding with the MCA, also called the Little Climatic Optimum (LCO) (1200 B.P.), which is supported by data extracted from coral, foraminifera, and sediments. The analysis of three indigenous hunter-gatherer archaeological sites in Northern Australia indicates behavioral changes in foraging choices of environmentally-sensitive mollusks due to climate variability during the MCA (Bourke et al. 2007). In the Fijian Islands, recent archaeological analysis suggests shoreline shell deposits demonstrate the emergence of social complexity and inter-regional exchange (Nunn and Britton 2001). Field (2004) attributes social changes as the result of climatic upheaval during the drought conditions of the LCO from 1250-750 B.P. and the transition to the subsequent Little Ice Age (LIA):

> …the difficulties experienced during the LCO/LIA transition [750-525 BP] may have also selected for alternative strategies, such as increased cooperation or interaction between isolated populations, the growth of social hierarchies, or increased mobility [Field 2004:95].

Research from outside of California demonstrates the range of human adaptations to the MCA. Archaeological evidence supports societal collapse in some areas while other areas evidence an increase of social complexity. The agricultural societies of the Americas, according to the research discussed above, appear to be more vulnerable during drought while the hunter-gatherer populations in the Pacific regions tend to be more flexible to environmental changes. The following section examines the hunter-gatherer adaptations of Native Californians as described by the Southern California Model.

2.3 *Raab and Larson's MCA in Southern California Model*

This section reviews the data presented by Raab and Larson (1997) in what is termed in this thesis as the Southern California Model. The model discusses results of paleoenvironmental and archaeological research. The paleoenvironmental data is derived from marine paleotemperature records, pollen records, and tree-ring analysis from sites in the Santa Barbara region and abroad. Archaeological data including faunal remains, settlement patterns, and skeletal stress indicators are derived from three sites in the Santa Barbara area: CA-SBA-1731 also known as Corral Canyon, CA-VEN-110 or Calleguas Creek, and CA-SCAI-17 on Santa Catalina Island at Little Harbor (Figure 4). In their opinion, the Santa Barbara region populations demonstrate drastic cultural adaptations as the direct result of the droughts during the MCA.

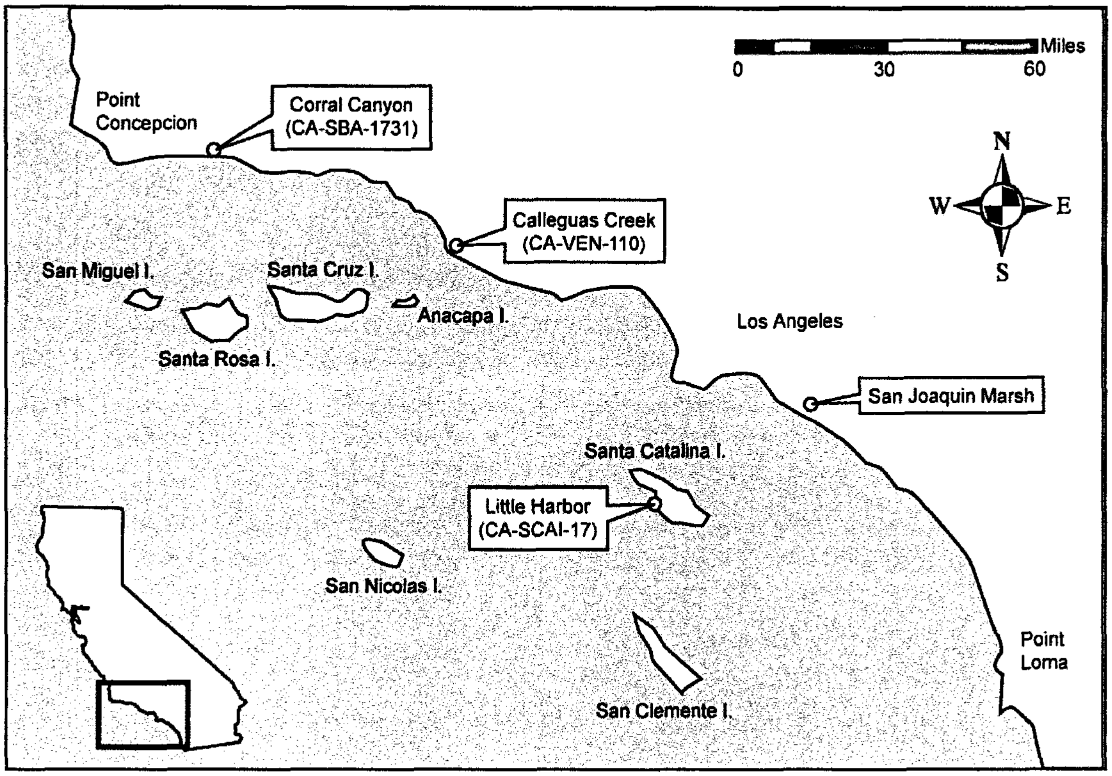


Figure 4. The Southern California Model area (adapted from Raab and Larson 1997).

Faunal remains used to determine subsistence intensification were gathered from two of the three sites in Figure 4. The first site, Corral Canyon (CA-SBA-1731), was extensively analyzed by Jon Erlanson for a CRM report (Erlandson 1993). The second site, Little Harbor (CA-SCAI-

17) on Santa Catalina Island, was analyzed by Raab et al. (1995). CA-VEN-110, Calleguas Creek, is a mortuary site on the coast of Ventura County approximately 30 km east of Santa Cruz Island. The skeletal remains were analyzed by Walker and Lambert (1989) for paleopathologies. Excavation at Calleguas Creek was funded by the Los Angeles District Corps of Engineers, Department of Defense as mitigation for subsequent construction projects.

2.3.1 Fossils in Core Samples for Marine Paleotemperature. Raab and Larson (1997) present data collected by Pisias (1978, 1979) describing the analysis of a sea core taken from the Santa Barbara Basin. Based on an analysis of 32 species of temperature-sensitive radiolarian fossils, Pisias was able to determine sea surface temperatures (SSTs) over the past 8,000 years. The information is significant due to sea temperature's alleged impact on the resource-bearing kelp forests. A graph displaying sea-surface temperatures is reproduced below (Figure 5).

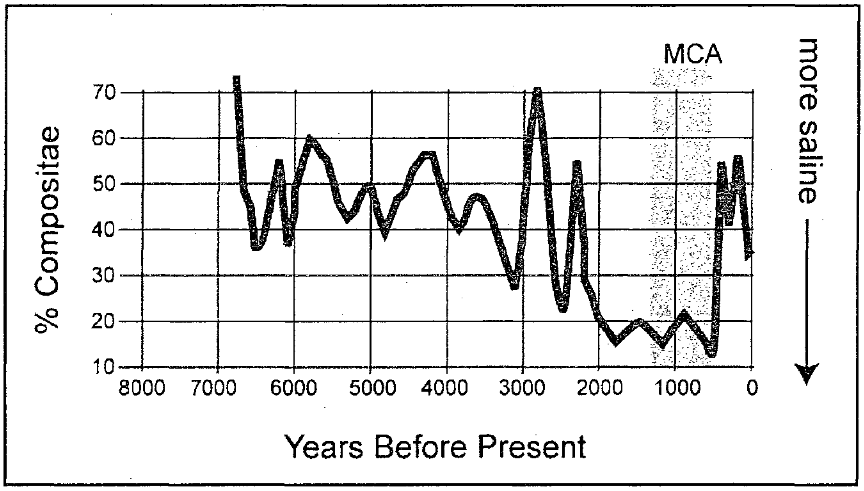


Figure 5. Sea-surface Temperatures (adapted from Raab and Larson 1997 and Pisias 1978).

Pisias has calculated correlation coefficients for month-to month temperatures. Using February's equation, which has the lowest standard of error of approximately 1.4 degrees Celsius, he illustrates the general pattern of sea-surface temperatures and suggests a high peak of 21 degrees Celsius during the MCA (Pisias 1978:379). Such a high sea-surface temperature would have had serious detrimental consequences to kelp forests and marine productivity (Kennett and Kennett 2000; Raab and Larson 1997). A discussion of more recent and contradictory evaluation of a nearby sea core may be found later (Section 4.1.1).

2.3.2 Pollen Evidence for Decreased Rainfall. Referencing the work of Owen K. Davis (1992), Raab and Larson (1997) note paleoclimatic conditions derived from a pollen sample taken from the San Joaquin Marsh. The marsh, located at the head of Newport Bay in Orange County within the Southern California Model study area, is subject to both fresh and saltwater conditions. The authors note that after 1,800 B.P. decreased stream flow and lower spring discharge allowed the incursion of saltwater (Figure 6). Marine-estuarian organisms (i.e. dinoflagellates and foraminifera) and pollen from salt marsh plants are present. Although the record may represent local phenomena, when compared to the other environmental data such as tree-rings and sea-surface temperatures, the data seems to support the onset of the MCA.

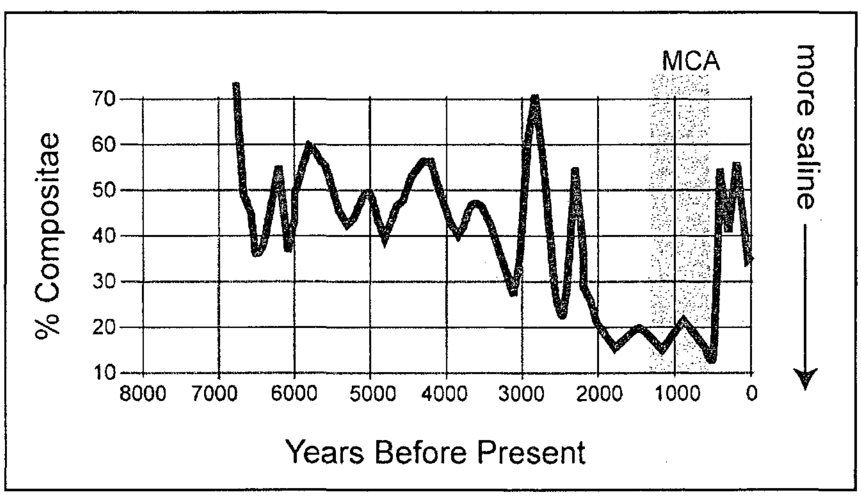


Figure 6. San Joaquin Marsh Compositae Percentages (Davis 1992).

Salinity levels of the marsh were measured by examining the percentages of Chenopodiaceae-*Amaranthus* and "other compositae" representing freshwater marsh plants (Davis 1992:92-93). High compositae percentages indicate freshwater conditions prevailed during the MCA.

2.3.3 Dendrochronology Evidence for Decreased Rainfall. Raab and Larson (1997) cite tree ring information from Southern California using samples from the Transverse Ranges in Santa Barbara County (Larson and Michaelson 1989). Additionally, they have added information from Scott Stine's (1994) Sierra Nevada tree ring study gathered from ancient drowned tree stumps rooted in present-day lakes. The Sierra Nevada Range is approximately 300 miles north of Santa Barbara but only 100 miles northeast of the study area. Stine determined that the region experienced extremely severe drought conditions from A.D. 892 - 1350 (1117 - 750 B.P.). The chart in their report has been duplicated below (Figure 7).

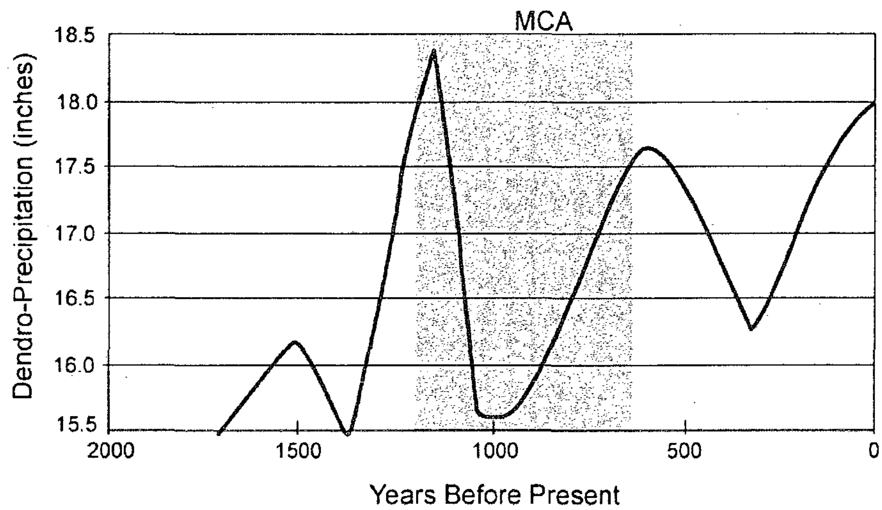


Figure 7. Dendrochronological Record of Southern California Data (adapted from Raab and Larson 1997). Tree ring data was gathered from Larson and Michaelson (1989) in Southern California and Stine (1994) from the Sierra Nevada Ranges.

2.3.4 Faunal Evidence for Shifts in Diet. It is noteworthy that the Raab and Larson MCA in Southern California Model is in direct conflict with Jeanne E. Arnold's assessment (Arnold 1992:70) that marine resources were depressed during the MCA due to the increase in SSTs instigating stressful conditions for the Chumash. Although SSTs peaked during the Middle/Late Transition Period, the zooarchaeological data from the two sites cited by Raab and Larson (1997) does not support resource depression. According to Raab et al. (1995), the archaeological records from sites in the Santa Barbara area contradict the idea that high SSTs caused marine resource depression. Citing

CA-SBA-1731 (Erlandson 1993:91), "maritime subsistence productivity peaked during what was ostensibly the interval of highest water temperatures during the Transitional Period (Raab and Larson 1997:326)." Unfortunately, the same article did not provide detailed, itemized faunal information in support of the assessment.

2.3.5 Settlement Patterns as Evidence for Social Stress. Settlement patterns in Southern California are described by Raab and Larson as being disrupted during the MCA. Raab and Larson discuss a comprehensive case study (True 1990) of northern San Diego County in which sites dating from the early Holocene were associated with both perennial and ephemeral streams. During the late Holocene, however, there is a clear tendency of sites associated with perennial streams suggesting springs had gone dry. Raab and Larson also cite Arnold (1992) and Petersen (1994) whose studies on the Santa Cruz Islands suggest an occupational hiatus during the MCA (Raab and Larson 1997:327), with the exception of a single rock shelter site (RP-3), which is near a perennial water source.

2.3.6 *Skeletal Stress Indicators.* Raab and Larson warn readers that their data representing skeletal stress "should be approached with caution" (1997:329) due to the fact that their samples were very small and also that there was difficulty with assigning ages to some burials. For example, they did not state if juvenile samples were included, which would skew the average height information. Height information is used in this case as a proxy for disease. Lambert calculated an index of severity for all affected bones by dividing the maximum length of lesions by the maximum length of the bone.

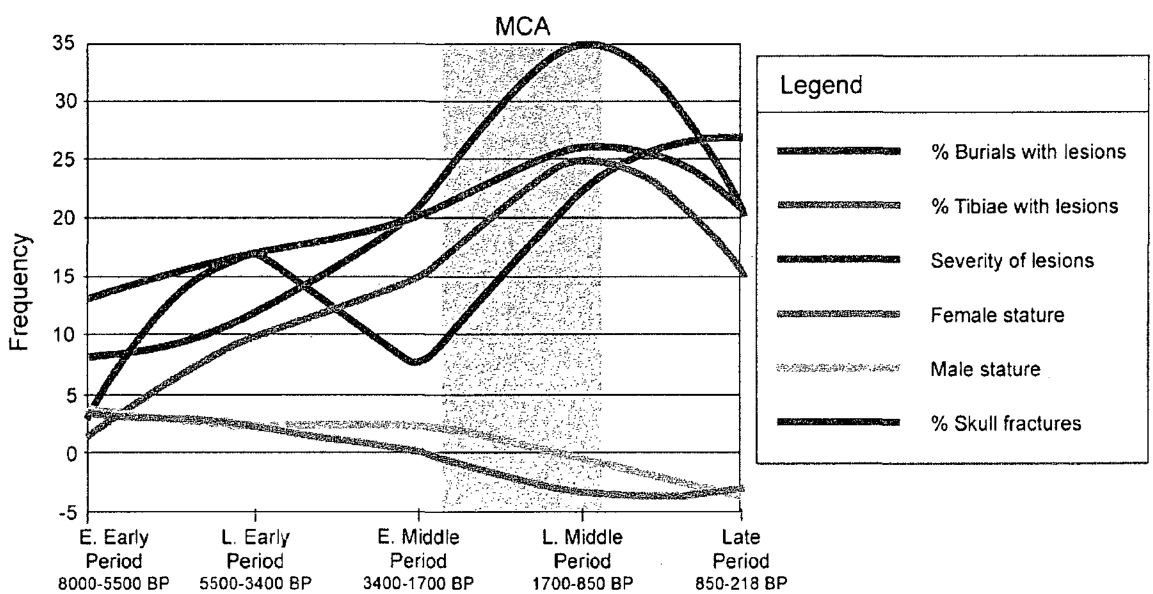


Figure 8. Changes in frequency and severity of periosteal lesions and stature and cranial trauma for Santa Barbara Channel populations (from Lambert 1993; Walker 1989a. Chart adapted from Raab and Larson 1997).

According to Raab and Larson,

> Inbreeding is a conceivable factor in stature reduction among relatively isolated populations. Nevertheless, the inverse relationship between disease

> and stature…implicates the former as a plausible cause of the latter. Interpersonal violence, as measured by compression fractures to the skull, also reaches a peak during the Late Middle and Late periods, or the time interval with the greatest incidence of disease and stature reduction [Raab and Larson 1997:330].

Cribra orbitalia is not used as an index of health in the graphic above. The condition, however, has been addressed by Walker (1986). Walker observed that the incidents of cribra is "inversely related to island size; i.e. the smallest islands reflect the highest incidents of this condition" (Raab and Larson 1997:328; Walker 1986).

3.0 METHODOLOGY

This section discusses the processes used to collect the data for this thesis. It is followed by a description of the techniques used to quantify and represent the data. Map creation using GIS is explained as is the creation of charts and graphs using Microsoft Excel and Adobe Illustrator. Special attention is given to graphic representations of the data to facilitate comparison between this study area and that of the Southern California Model.

3.1 *Data Collection Methods*

The archaeological data used in this comparison came from both published and unpublished literature. Site reports were provided by Alan Leventhal at San Jose State University, the library at Albion Environmental, Inc., and by California State Parks archaeologist Mark G. Hylkema. I focused on four kinds of data: site locations, radiocarbon dates, faunal remains, and human remains. The dates I used for my analysis archaeological of sites are divided into the following periods as defined by the Jones and Ferneau (2003) chronological scheme:

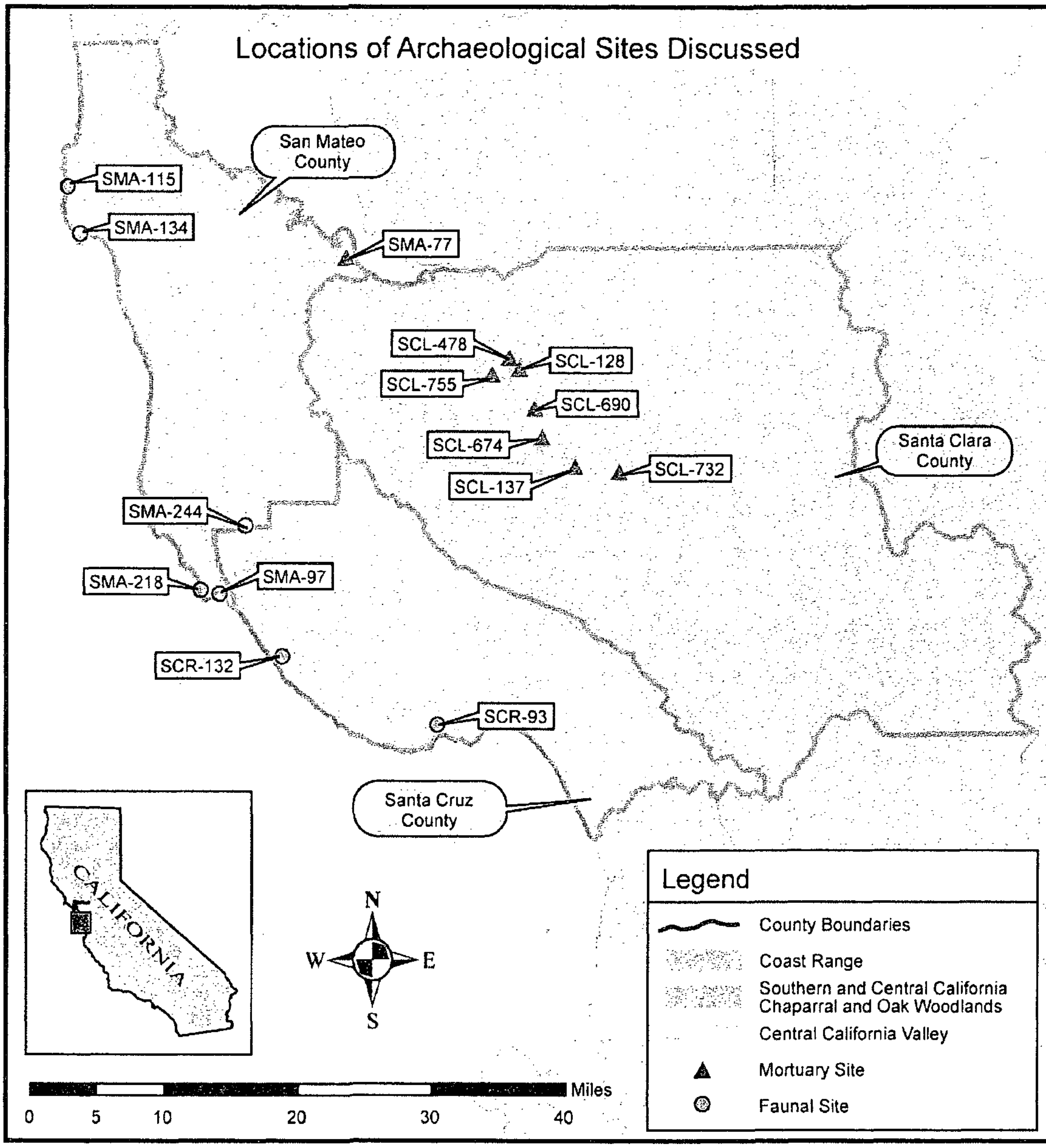
Early Period: 5,000 - 2,600 B.P.

Middle Period: 2,600 - 1,100 B.P.

Middle/Late Transition Period: 1,100 - 700 B.P.

Late Period: 700 B.P. - Historic

Site reports initially gathered for this thesis included 37 sites. Only 15 of the 37 sites were selected based on the presence of calibrated radiocarbon dates and ecozone location, as defined by the USGS (2002). Samples for radiocarbon data have been extracted from various artifacts including bone, shell, and charcoal. The dates from shell have been corrected using Stuiver and Reimer's (1993) CALIB program or a comparable calibration program. Sites from which faunal data are analyzed are all located near the Pacific Ocean. The same region does not provide enough skeletal material to compile meaningful data for comparison; therefore, mortuary sites have all been sampled from inland regions in the Santa Clara Valley. They are mapped below along with their respective ecozones (Figure 9).



References

SCL-128: Winter 1978
SCL-137: Cartier et al. 1987
SCL-478: Wiberg 2002
SCL-755: Skowronek and Pierce, ed. 2006
SCL-674: Grady et al. 2001
SCL-690: Hylkema 2003
SCL-732: Cambra et al. 1996
SCR-93: Hylkema 2002, Breschini and Haversat 1981
SCR-132: Hylkema 2002
SMA-77: Gerow 1968
SMA-97: Hylkema 2002
SMA-115: Hylkema 2002
SMA-134: Hylkema 2002
SMA-218: Hylkema 2002
SMA-244: Hylkema 2002

Figure 9. Locations of Archaeological Sites in Study Area.

Dietary changes in prehistoric populations are evaluated by examining the food products preserved in archaeological assemblages. For the most part, plant food sources deteriorate rapidly, while bones from prey choices generally preserve well enough to identify taxa or at least size. Information about prey taxa and size is useful for determining specific human behaviors. For example, a fishbone implies the procurement of marine resources. Size of prey is useful for knowing how much effort was used to acquire a food source. It is far more difficult and dangerous for a hunter to kill a deer than a rabbit.

For the analysis of faunal material, data from sites containing burials are not used. Although it has been assumed throughout the history of California archaeology that burials indicate the presence of villages, recent studies conducted by A. Leventhal (1996) suggest mortuary complexes in the San Francisco Bay Area were ceremonial areas, not village or settlement locations. The faunal material in prehistoric middens containing burials is indicative of feasting habits rather than every-day dietary habits, according to Leventhal. In the case of CA-SCL-38 (Bellifemine 1997), the majority of faunal material represents the moieties associated with the interred individuals (i.e. bear and deer). Animals may also be interred and not consumed, as in the case of CA-SCL-690 and CA-SCL-732 (Bellifemine 1997; Hylkema 2003).

This study uses faunal data gathered and previously analyzed by Mark Hylkema in which he compared a wide range of sites in a variety of ecozones. Hylkema categorized the sites in only three time periods, the Early, Middle, and Late (Hylkema 2002). I have reanalyzed much of the same data, refining the sample to examine coastal regions only. Also, I categorized the sites into four, instead of three time periods to include the Middle/Late Transition. The sampled sites for faunal analysis are all within 16 miles inland from the Pacific coast and are in the coastal terrace ecozone (USGS 2002). Hunter-gatherer strategies in the event of climatic crises are likely to be different for inland versus coastal populations (Jones and Schwitalla 2008:43). The Southern California Model describes faunal material from coastal sites; therefore, this thesis will do the same in an effort to compare similar faunal remains.

Hylkema noted that CA-SCL-690, a site that contained 126 burials, contained a high frequency of rabbit bones and low frequency of deer and elk. He suggested this may be possibly the result of drier climatic conditions associated with the MCA (Hylkema 2002:249-250). Although this study uses data from CA-SCL-690 for skeletal stress analysis, I have not incorporated the faunal data due to possible moiety connections of prey choices associated with the interred individuals.

3.2 *GIS Analysis*

This section discusses the methods used to acquire digital information and create maps. Using public data available online at the USGS website, digital spatial layers containing county boundaries and ecozones were downloaded as shapefiles. The shapefiles were then imported into ESRI's ArcMap 9.3, GIS software designed to create dynamic maps. GIS is used in this thesis to create maps depicting site locations, site types (i.e. faunal deposits or mortuary), and site ages based on radiocarbon dates.

A database containing site information was created using Microsoft Excel 2007 which was then imported into Microsoft Access 2007 and added to the ArcMap file. All GPS points were recorded in the NAD27 Zone 10 UTM coordinate system, and then converted to NAD83 using ArcTools, a feature within ArcMap. This process insures proper geographical alignment of the site information database and USGS shapefiles. Metadata regarding the GIS layers may be found in Appendix A. The three tables used in GIS files containing ecozone, county borders, and site information may be found in Appendix B.

3.3 *Graphical Analysis*

The Southern California Model does not quantify the assessment that subsistence productivity increased during the MCA, nor does it present a graphic analysis of settlement patterns to demonstrate a correlation between the occupations of sites in different ecozones throughout time. Nonetheless, I will be creating visual aids to assist in the analysis and comparison of paleoenvironmental and archaeological data for this thesis. The following section describes how the data from the sampled sites in the southern San Francisco Bay Area are quantified and graphically represented. I discuss the methods and specific software used to present the data.

Radiocarbon dates, used as a proxy for occupation, are tabulated and graphed to illustrate differences of site occupation throughout time. For example, the number of sites occupied per period is tabulated and graphed according to chronological periods. This particular analytical method, however, comes with a caveat. It is possible, and probable, that a greater number of radiocarbon dates does not actually imply a greater population. More radiocarbon dates may simply be a result of more funding available for a thorough archaeological analysis.

This thesis examines the faunal materials by three different methods. First, the taxa are categorized by large, medium, and small mammals, birds and fish and then compared to each other by temporal spans. The second evaluation will compare marine versus terrestrial prey over temporal spans. Lastly, the bone weight from each temporal span is compared to the number of radiocarbon dates - the proxy for settlement in this thesis - from the same temporal spans to identify possible patterns of resource intensification. The Southern California Model suggests resource intensification but does not provide empirical evidence. The data presented by this analysis not only provides visual evidence of intensification (or lack thereof), but also graphically presents a wider range of dietary information.

4.0 ANALYSIS OF SOUTHERN BAY AREA DATA

4.1 *Paleoenvironment*

This section discusses the results of studies in or near the study area that examine paleoenvironmental conditions. Using the same criteria as the Southern California Model, this thesis will review marine paleotemperature, pollen, and dendrochronology to determine what impacts the MCA had on the environment in the study area. Marine paleotemperature is an indicator of marine resource productivity. Higher sea-surface temperatures have a detrimental effect on kelp forests which provide dietary staples to the southern California Native populations. Pollen and dendrochronological records are indicators of precipitation.

4.1.1 Fossils in Core Samples for Marine Paleotemperature. Marine paleotemperature records are derived from cores drilled into sea beds. The sea core record used for this thesis is from a sample extracted from an area directly between the Northern Channel Islands and the mainland of California (Kennett and Kennett 2000). It is located 200 miles south of this thesis study area and is, in fact, located within the Southern California Model region (Figure 10). The results of this recent study, however, are markedly different than those from Pisias (1978), which provide the basis for the Southern California Model.

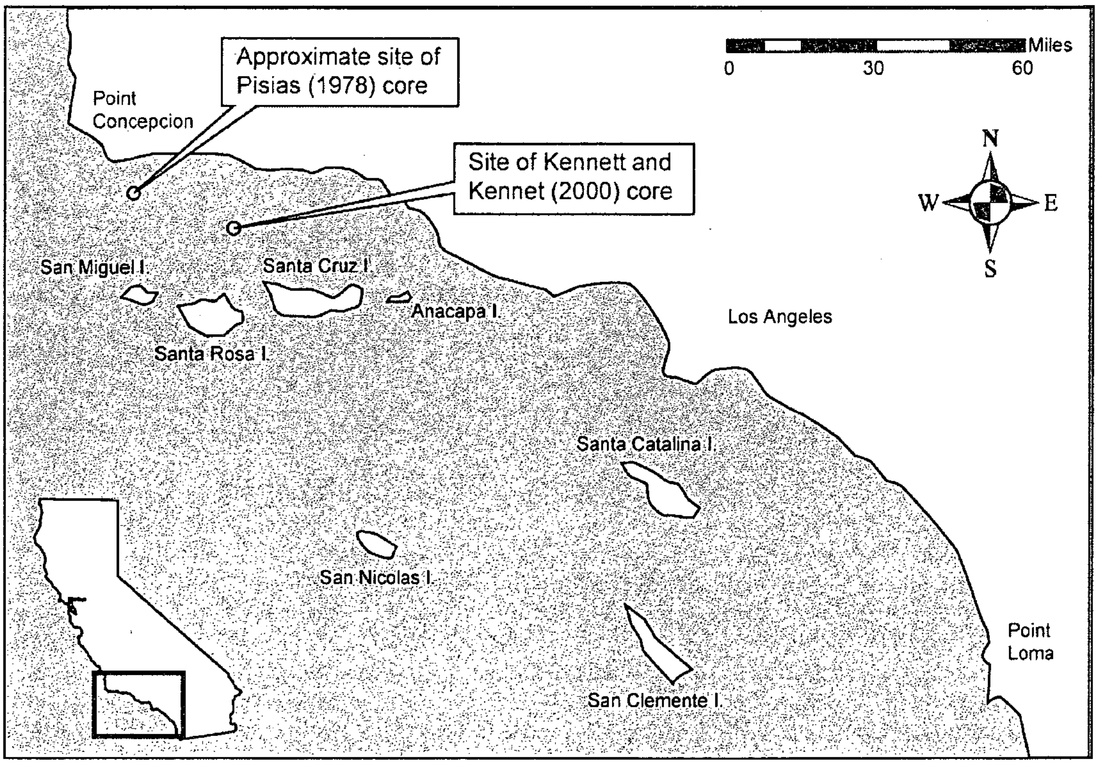


Figure 10. Location of sea core samples used for measuring SSTs.

Kennett and Kennett (2000) have published an extremely accurate record of SSTs during the Holocene with 25-year intervals for the last 3,000 years and 50-year intervals from 3000-11,000 years B.P. By analyzing oxygen isotopic changes of two planktonic foraminifera species, *Globigerina* *bulloides* and *Neogloboquadrinaria pachyderma*, Kennett and Kennett demonstrate that sea-surface temperatures during the two droughts identified by Stine (1994) were actually lower, not higher, than usual. Furthermore, annual temperature variations were approximately 2-5 degrees Celsius, not 13 degrees, as stated by Pisias (1978, 1979). Kennett and Kennett explain the differences in results as being due to the fact that Pisias did not use conventional radiocarbon dating methods due to sample contamination from nearby oil seeps (Kennett and Kennett 2000).

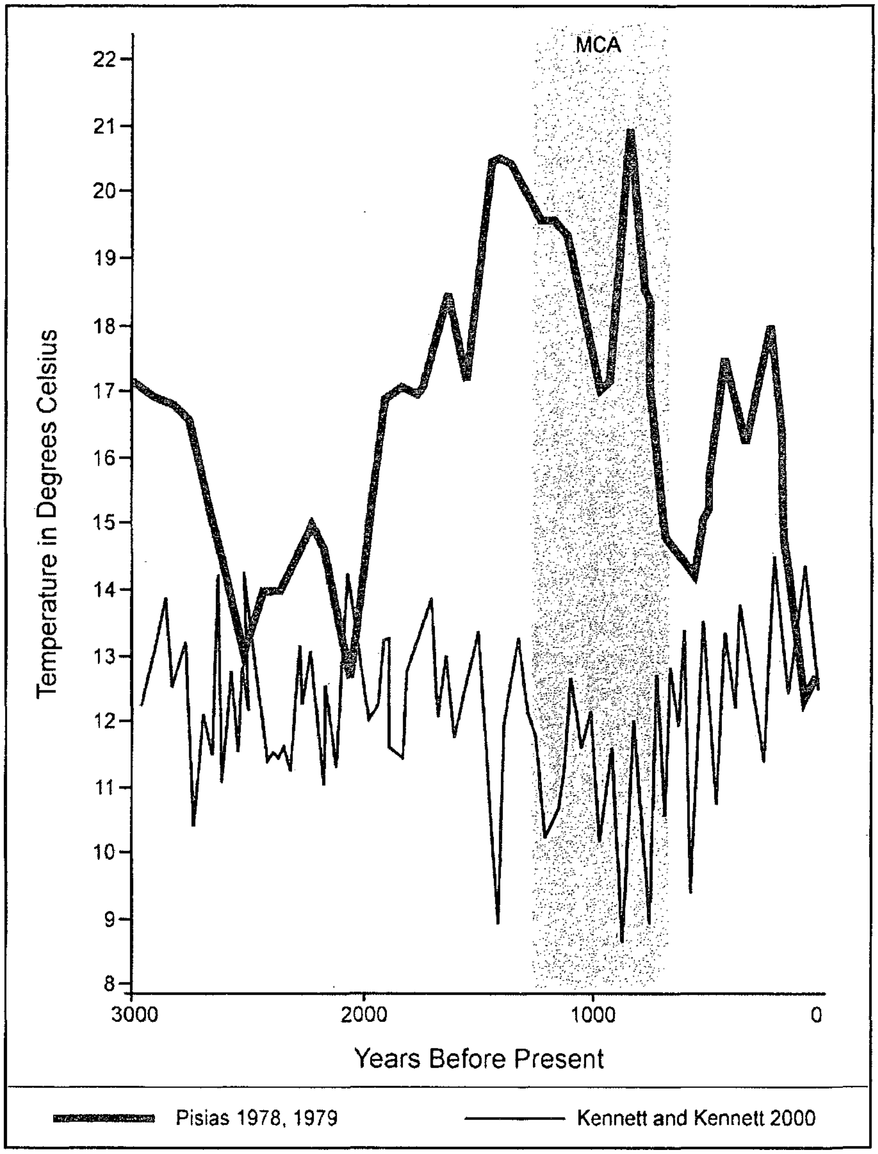


Figure 11. A Comparison of Sea-surface Temperatures from two sources in the Southern California Model study area.

The newer analysis suggests marine productivity was high during the MCA, which would explain the high marine subsistence productivity evidenced by Raab and Larson (1997). As stated previously, higher SSTs as those suggested by the Southern California Model would have been disastrous to the off-shore kelp forests. Because they were using an erroneous SST record, Raab and Larson disputed that high SSTs were detrimental to kelp forests; "There is little evidence of depressed marine food productivity" (Raab and Larson 1997:326). The data also suggest a direct relationship between low SSTs and lower terrestrial precipitation (Kennett and Kennett 2000).

4.1.2. Pollen Evidence for Decreased Rainfall. A pollen study from 2001 based on data collected from Rush Ranch in the Suisun Marsh north of the Suisun Bay is used for this comparison (Byrne et al. 2001). The Suisun area is a brackish marsh located at the interface between fresh-water flow from rivers and salt water entering through the San Francisco Bay. The site of Rush Ranch was selected because of its central location on the estuary's salinity gradient (Byrne et al. 2001:67). Rush Ranch is located 40 miles northeast of San Mateo County (Figure 12).

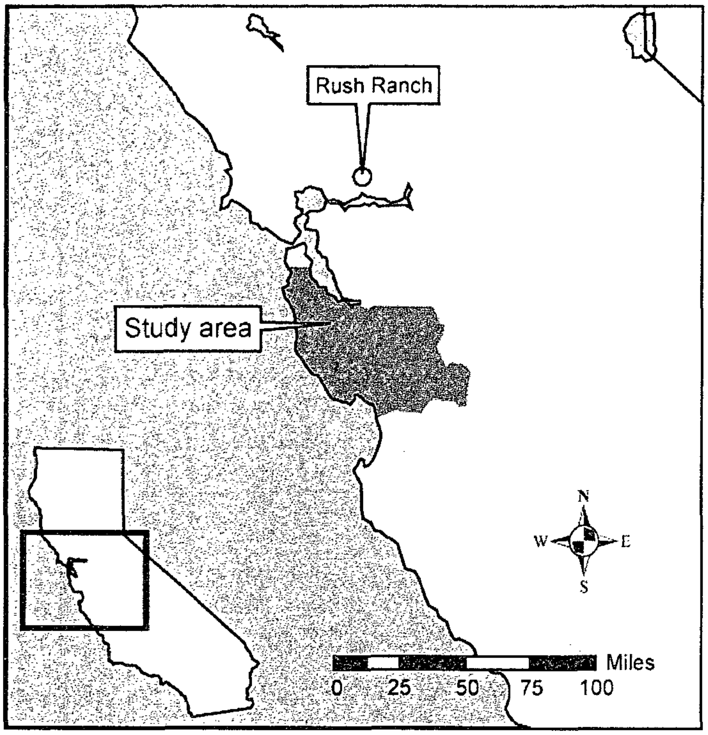


Figure 12. Map of the Rush Ranch pollen study site.

The data are compared directly to the Southern California data collected by Davis (1992) in Figure 6. In the Byrne et al. 2001 graph (top of Figure 13), the index represents *Chenopodiaceae* plus *Poaceae* pollen as a percentage of *Chenopodiaceae*, *Poaceae*, *Cyperaceae*, and *Asteraceae*. *Chenopodiaceae* and *Poaceaea* thrive in salt water conditions, while *Cyperaceae* and *Asteraceae* live in fresh water. The San Joaquin Pollen Marsh index from Davis (1992) represents the percentage of *Asteraceae* pollen (Figure 13).

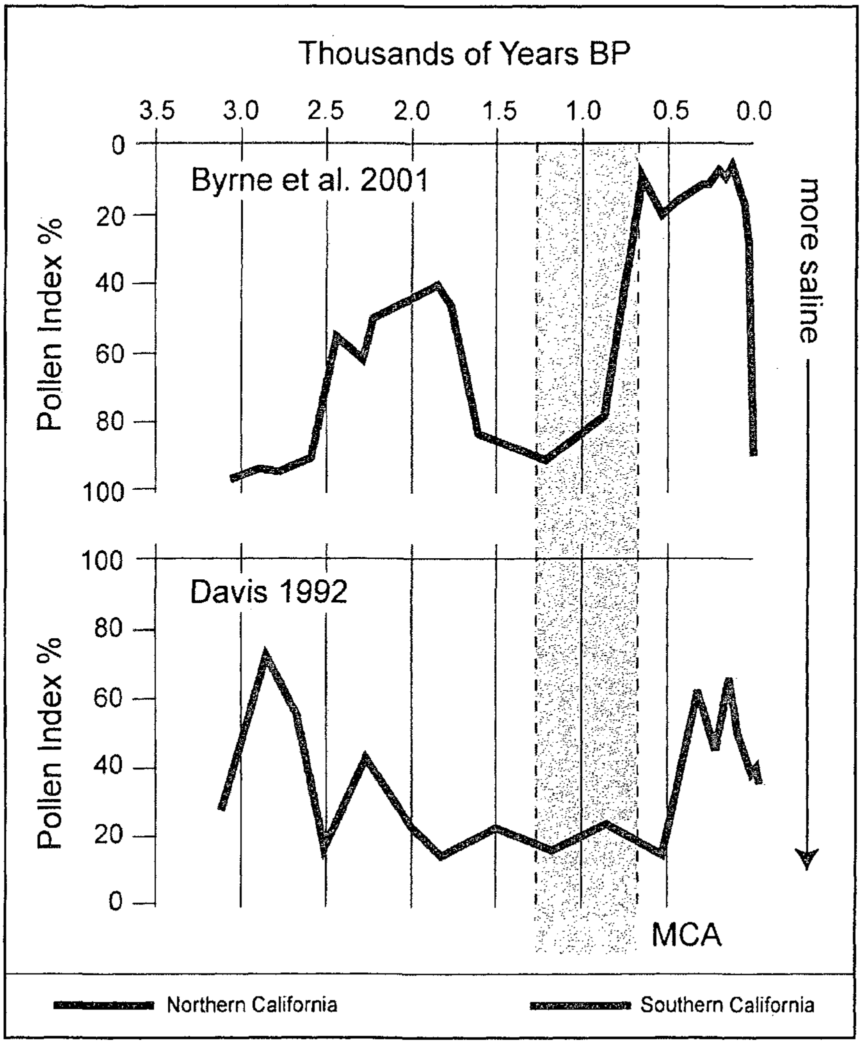


Figure 13. Paleosalinity Records and Indices from Northern and Southern California (adapted from Byrne at al. 2001).

High percentages of *Asteraceae* are interpreted as freshwater conditions. The results show similar salinity compositions during the same period of time indicating decreased stream flow during the MCA. The Southern California Model example and the example used for this thesis indicate the same rise in salinity during the MCA, therefore, it is reasonable to assume decreased rainfall had similar effects on both regions.

4.1.3 Dendochronology Evidence for Decreased Rainfall. The studies used in the Southern California Model for tree-rings included a data set from the Transverse Ranges in Santa Barbara County (Larson and Michaelson 1989) and from the Sierra Nevada region (Stine 1994). Stine's (1994) tree ring study is actually more applicable to the study area of this thesis than for the Santa Barbara region. As stated previously, the Sierra Nevada Range is approximately 300 miles north of Santa Barbara and only 100 miles northeast of the study area. The results of Stine's analysis are represented in Figure 14. Each bar represents a tree-ring sample with drought ranges (Stine's 1-Sigma calculations were derived from the CALIB 3.0.3 program).

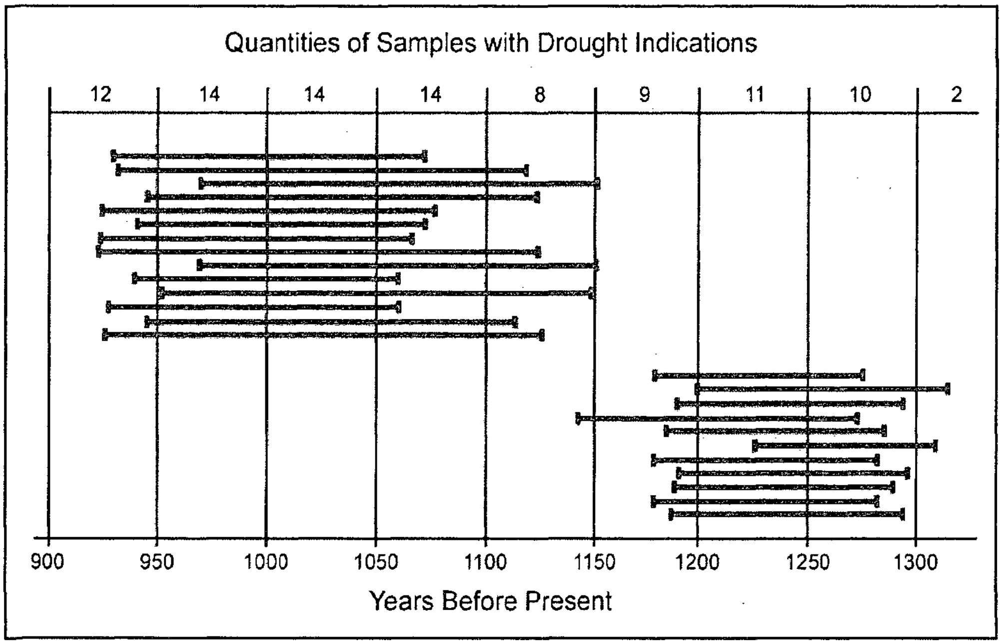


Figure 14. Dendrochronology Results (adapted from Stine 1994). Each bar represents a drought-affected span of rings in an individual sample.

4.2 *Paleodemography and Settlement*

Settlement pattern analyses is discussed and presented in this section. Radiocarbon dates gathered together here are used as a proxy for site occupation. This section is an overview of the radiocarbon data collected from the fifteen sites in the study area. Three analyses are conducted for this thesis. The first analysis is to determine site occupation over time by tabulating the number of sites occupied per period and presenting the data as a line graph. The second analysis presents the ratios of inland versus coastal sites over time as a table and then a histogram. The final analysis is a cartographic analysis of settlement distribution over time with sites plotted in chronological sequences.

4.2.1 Radiocarbon Dates. To conduct an analysis of settlement patterns in the study area, 109 radiocarbon dates from the 15 sites included in this thesis have been tabulated in the table below (Table 1).

Table 1. Radiocarbon Dates from Examined Sites

Site	Lab-Sample#/Context	Context	14C Year BP	2-Sigma Range BP	Median BP
SCL-478	Beta-152212/ 478-F1-3	Charcoal	2100 +/-160	2370-1710	2040
SCL-478	Beta-152213/ 478-F3-1	Charcoal	2270 +/-60	2360-2140	2250
SCL-478	Beta-152214/ 478-F3-3	Charcoal	2200 +/-80	2350-1990	2170
SCL-478	Beta-152215/ 478-F4-5	Charcoal	2730 +/-70	2970-2740	2855
SCL-478	Beta-152219/ 478-F15-2	Charcoal	2020 +/-130	2330-1700	2015
SCL-478	Beta-152220/ 478-F17-1	Charcoal	2320 +/-70	2480-2150	2315
SCL-478	Beta-152222/ 478-F22-1	Charcoal	2300 +/-50	2260-2160	2210
SCL-478	Beta-152225/ 478-F27-5	Charcoal	2360 +/-50	2480-2320	2400
SCL-478	Beta-152226/ 478-F28-1	Charcoal	2120 +/-90	2340-1880	2110
SCL-478	Beta-152227/ 478-F30-1	Charcoal	2210 +/-60	2340-2050	2195
SCL-478	Beta-152228/ 478-F31-7	Charcoal	2060 +/-60	2150-1880	2015
SCL-478	Beta-152229/ 478-F31-5	Charcoal	2270 +/-70	2370-2120	2245
SCL-478	Beta-152230/ 478-F33-1	Charcoal	2370 +/-50	2490-2330	2410
SCL-478	Beta-152231/ 478-B81-1	Charcoal	2350 +/-40	2380-2330	2505
SCL-478	Beta-152232/ 478-B83-1	Charcoal	2340 +/-40	2370-2320	2345
SCL-137	Beta-21923/	Charcoal	2085 +/-90	2399-1929	2164

	Burial 20-89				
SCL-137	Beta-12682/Unit (?) 90-100 cm	Charcoal	2015 +/-80	2356-1879	2118
SCL-137	Beta-12683/Unit (?) 100-110 cm	Charcoal	2075 +/-120	2409-1799	2104
SCL-137	Beta-21923/Unit (?) 160-170 cm	Charcoal	2685 +/-90	3081-2605	2843
SCL-137	(?)/Burial 62-90	Charcoal	2145 +/-90	2409-1959	2184
SCL-137	(?)/Burial 55-90	Charcoal	2880 +/-100	2749-2129	2439
SCL-137	(?)/Burial 59-90	Charcoal	2815 +/-120	3383-2799	3091
SCL-690	Beta-44249/U-33 Feature 3	Charcoal	695 +/50	782-617	700
SCL-690	Beta-46644/Burial 55	Human bone	780 +/60	937-729	833
SCL-690	Beta-46643/Burial 41	Human bone	800 +/60	968-729	849
SCL-690	Beta-46646/Burial 78	Human bone	920 +/60	1019-753	886
SCL-690	Beta-44244/Burial 24	*Olivella* A1 beads	1250 +/60	749-559	654
SCL-690	Beta-44248/Burial 92	*Olivella* A1 beads	1280 +/60	769-569	669
SCL-690	Beta-44246/Burial 31	Charcoal	915 +/70	1019-749	884
SCL-690	Beta-46641/Burial 31	Human bone	1020 +/80	1227-803	1015
SCL-690	Beta-46645/Burial 55	*Olivella* A1 beads	1450 +/50	959-719	839
SCL-690	Beta-44250/Burial 39	*Olivella* D1 beads	1460 +/60	979-709	844
SCL-690	Beta-44642/Burial 39	Human bone	1180 +/60	1329-1019	1174
SCL-690	Beta-44247/Burial 41	*Olivella* M1a beads	1570 +/50	1049-799	924
SCL-690	Beta-44245/Burial 31	*Olivella* G1a beads	1640 +/70	1179-839	1009
SCL-732	WSU-4604/ Animal burial 1	Bone	360 +/-80	599-59	329
SCL-732	WSU-4608/ Rock feature 1	Charcoal	175 +/-80	485-59	272
SCL-732	WSU-4611/ House floor 1	Charcoal	225 +/-70	515-59	287
SCL-732	WSU-4567/ House floor 1	Charcoal	245 +/-60	519-59	289
SCL-732	WSU-4605/ Animal burial 1	Charcoal	285 +/-80	569-59	314
SCL-732	WSU-4607/ Feature 2	Charcoal	425 +/-80	681-359	520
SCL-732	WSU-4563/	Animal	1980 +/-90	2351-1779	2065

	Burial 6	bone			
SCL-732	WSU-4566/ Burial 59	Animal bone	1990 +/-90	2355-1783	2069
SCL-732	WSU-4565/ Burial 39	Animal bone	2015 +/-60	2207-1883	2045
SCL-732	WSU-4555/ Burial 19	Animal bone	2190 +/-80	2409-2013	2211
SCL-732	WSU-4535/ Burial 35	Animal bone	2220 +/-70	2419-2099	2259
SCL-732	WSU-4554/ Burial 9	Animal bone	2220 +/-190	2809-1801	2305
SCL-732	WSU-4553/ Burial 96	Charcoal	2035 +/-90	2364-1879	2122
SCL-732	WSU-4541/ Burial 87	Charcoal	2095 +/-90	2399-1939	2169
SCL-732	WSU-4549/ Burial 54	Charcoal	2115 +/-90	2399-1949	2174
SCL-732	WSU-4557/ Burial 100	Animal bone	2420 +/-320	3383-1779	2581
SCL-732	WSU-4556/ Burial 88	Animal bone	2450 +/-305	3383-1801	2592
SCL-732	WSU-4560/ Burial 69	*Mytilus edulis*	2680 +/-70	2369-1959	2164
SCL-732	WSU-4552/ Burial 90	Charcoal	2295 +/-60	2517-1799	2158
SCL-732	WSU-4558/ Burial 17	*Mytilus edulis*	2710 +/-60	2369-2009	2189
SCL-732	WSU-4559/ Burial 56	*Mytilus edulis*	2750 +/-80	2409-1999	2204
SCL-732	WSU-4540/ Burial 66	Charcoal	2735 +/-180	3419-2419	2919
SCL-755	WRC-3146/ Burial 1	Human bone	1385 +/-47	1414-1323	1369
SCL-755	WRC-3167/ Burial 2	Human bone	1273 +/-49	1359-1119	1239
SCL-755	WRC-3173/ Burial 3	Human bone	1399 +/-59	1459-1319	1389
SCL-755	WRC-3216/ Burial 3	*Olivella* A1 beads	2229 +/-86	1849-1399	1624
SMA-77	UCR-0957/Burials 24 and 25	Charcoal	2645 +/-150	3221-2409	2815
SMA-77	UCR-0956/Burials 24 and 25	Charcoal	2715 +/-150	3221-2422	2822
SMA-77	UCR-0958/Burials 24 and 25	*Ostrea lurida*	3310 +/-150	3319-2539	2929
SMA-77	UCR-0959/ Burial 36	Human bone	3000 +/-70	3439-3022	3231
SMA-77	L-0187A/Burials 23-25 , 37-38	Charcoal	2965 +/-350	4120-2389	3255

SMA-77	UCR-0953/ Burial 19	Human bone	3080 +/-90	3584-3062	3323
SMA-77	I-07591/Pit 4 upper lens	*Ostrea lurida*	3460 +/-85	3369-2859	3114
SMA-77	UCR-0960/ Burial 36	Charcoal	3075 +/-160	3734-2909	3322
SMA-77	UCR-0955/ Burial 36	Human bone	3150 +/-160	3866-2984	3425
SMA-77	UCR-0954/ Burial 19	Charcoal	3215 +/-240	4144-2850	3497
SMA-77	I-07592/ Pit 4 lower lens	*Ostrea lurida*	3675 +/-85	3599-3149	3374
SMA-77	L-0187B/Burials 24-25, pit 4	Charcoal	3415 +/-300	3886-3635	3761
SMA-77	UCR-0951/ Burial 36	*Ostrea lurida*	3870 +/-150	3999-3259	3629
SMA-115	WSU-3104/ U-7N/6W 120-130 cm	*Mytilus californianus*	1115 +/-130	779-349	564
SMA-134	Beta-74111/U-12-14E 20-30 cm	*Mytilus californianus*	1310 +/-50	779-599	689
SMA-134	Beta-74112/U-15-17E 20-30 cm	*Mytilus californianus*	1330 +/-60	829-599	714
SMA-134	Beta-74110/U-14-15E 20-30 cm	*Mytilus californianus*	1320 +/-70	829-579	704
SMA-134	Beta-74109/U-14-15E 20-30 cm	*Mytilus californianus*	1410 +/-60	939-689	814
SMA-134	Beta-74113/U-15-17E 20-30 cm	*Mytilus californianus*	1410 +/-60	939-689	814
SMA-218	WSU-3425/ U-3 20-30 cm	*Mytilus californianus*	3290 +/-75	3089-2769	2929
SMA-244	WSU-3424/ U-4 20-40 cm	Charcoal	650 +/-70	774-589	682
SCR-132	WSU-3231/Feature 1 30-40 cm	*Haliotis cracherodii*	2310 +/-50	1379-1149	1264
SMA-97	WSU-3232/ U-4 20-30 cm	*Haliotis rufescens*	1450 +/-70	979-699	839
SCR-93	WSU-3450/ U-1 10-20 cm	Mixed shell	2170 +/-70	1739-1369	1554
SCR-93	WSU-3450/ U-1 40-50 cm	*Mytilus californianus*	2370 +/-70	1959-1589	1774
SCR-93	WSU-3450/U-1 0-10 cm	Charcoal	2070 +/-105	2399-1879	2139
SCR-93	WSU-3450/U-1 100-110 cm	*Mytilus california*	3130 +/-90	2909-2419	2664

		nus			
SCR-93	WSU-3450/ Feature 2 105-110 cm	Charcoal	2740 +/-75	3197-2799	2998
SCR-93	WSU-3450/ Feature 1	Mixed shell	3240 +/-75	3019-2729	2874
SCR-93	WSU-3450/U-1 160-170 cm	Mixed shell	3620 +/-110	3149-2589	2869
SCR-93	WSU-3450/U-1 90-100 cm	*Mytilus californianus*	4110 +/-60	4109-3719	3914
SCL-128	UC-Riverside /Burial 3	Human bone	1359 +/-100	1443-1105	1274
SCL-128	UC-Riverside / Burial 9	Human bone	1409 +/-110	1591-1135	1363
SCL-674	Beta-128989/ Burial 2	Charcoal	330 +/-60	569-344	457
SCL-674	Beta-127665/ Burial 51	Charcoal	620 +/-40	719-594	657
SCL-674	Beta-128997/ Burial 76	Charcoal	810 +/-40	839-729	784
SCL-674	Beta-128990/ Burial 117	Charcoal	980 +/-60	1039-814	927
SCL-674	Beta-132034/ Burial 118	Charcoal	1820 +/-60	1944-1644	1794
SCL-674	Beta-128996/ Burial 134/141	*Mytilus spp.*	2500 +/-60	2109-1774	1942
SCL-674	Beta-128991/ Burial 150/165	*Mytilus spp.*	2530 +/-70	2174-1784	1979
SCL-674	Beta-128993/ Burial 154	Charcoal	1980 +/-80	2189-1784	1987
SCL-674	Beta-132032/ Burial 187	Charcoal	2020 +/-70	2199-1889	2044
SCL-674	Beta-129004/ Burial 166	*Mytilus spp.*	2570 +/-70	2209-1854	2032
SCL-674	Beta-129001/ Burial 199	*Mytilus spp.*	2620 +/-70	2334-1904	2119
SCL-674	Beta-132033/ Burial 206/216	Charcoal	2140 +/-40	2332-2022	2177
SCL-674	Beta-128995/ Burial 204	Charcoal	2120 +/-60	2374-2004	2189
SCL-674	Beta-129002/ Burial 205	Charcoal	2140 +/-50	2374-2054	2214
SCL-674	Beta-128998/ Burial 208	Charcoal	2160 +/-50	2384-2064	2224

SCL-478 from Wiberg 2002, SCL-128 from Winter 1978, SCL-674 from Grady et al. 2001, SCL-38, SCL-137, SCL-690, CL-732, SCL-755, SMA-115, SMA-77, SMA-115, SMA-134, SMA-218, SMA-244, SMA-97, SCR-38, from Hylkema 2002 and SCR-93 from Hylkema 2002 and Byrne 2002.

4.2.2 Site Occupation of Entire Sample. In an effort to find patterns of occupation over time, the 109 mean dates are tabulated according to 100-year increments (Table 2). This particular analytical method comes with a caveat. It is possible, and in fact probable, that a greater number of radiocarbon dates does not represent a larger population. More radiocarbon dates may simply be a result of more funding available for a thorough archaeological analysis, as stated in Section 3.3.

Table 2. Quantities of Radiocarbon Dates in 100-Year Increments.

Years BP	**Qty of Mean RC Dates**
0-100	0
100-200	0
200-300	3
300-400	2
400-500	1
500-600	2
600-700	5
700-800	4
800-900	9
900-1000	2
1000-1100	2
1100-1200	1
1200-1300	3
1300-1400	3
1400-1500	0
1500-1600	1
1600-1700	1
1700-1800	2
1800-1900	0
1900-2000	3
2000-2100	8

2100-2200	17
2200-2300	8
2300-2400	3
2400-2500	3
2500-2600	3
2600-2700	1
2700-2800	0
2800-2900	6
2900-3000	4
3000-3100	1
3100-3200	1
3200-3300	2
3300-3400	3
3400-3500	2
3500-3600	0
3600-3700	1
3700-3800	1
3800-3900	0
3900-4000	1
4000-4100	0
4100-4200	0
4200-4300	0
4300-4400	0
Total	**109**

Figure 15 presents the quantities of mean radiocarbon through time in 100-year increments represented as a line graph. The time period marking the MCA is noted as well.

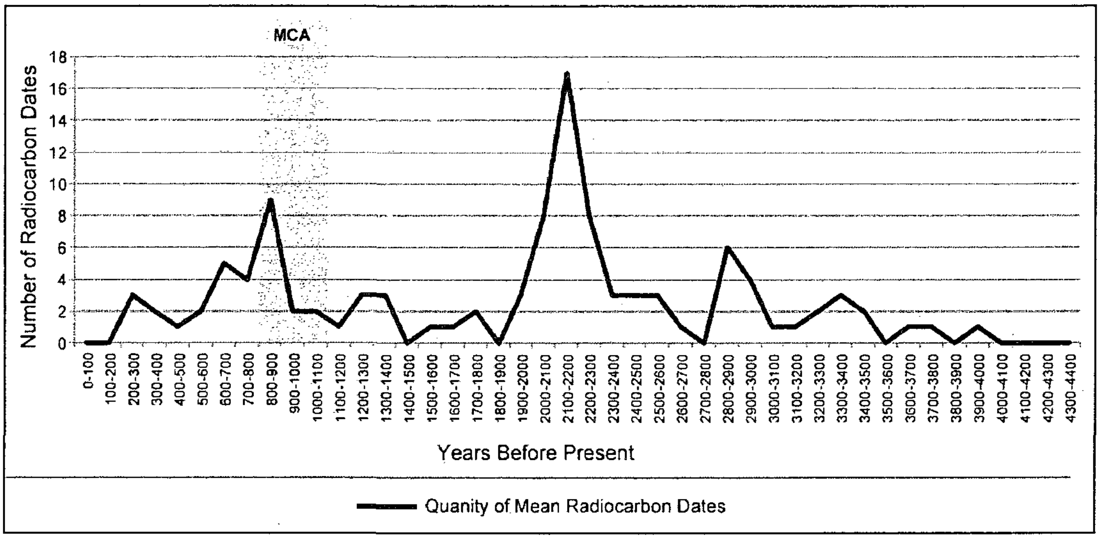


Figure 15. Line Graph of Radiocarbon Date Quantities.

4.2.3 Site Occupation by Ecozone. Did prehistoric populations prefer living along the coast or inland? Do their preferences change over time? In an effort to determine if occupational locations changed over the four chronological periods, Table 3 quantifies the numbers of sites during each chronological period and ecozone. Notice that the quantities of coastal sites remain consistent throughout time.

Table 3. Quantities of Occupied Sites by Chronological Period.

Chronological Period	Quantity of Occupied Sites	Quantity of Coastal Sites	Quantity of Inland Sites
Early	6	2	4
Middle	9	2	7
Middle/Late	4	2	2
Late	5	2	3

The data in Table 3 is graphed below (Figure 15) in a histogram to illustrate site occupation over time in relation to their ecozones. The greatest number of sites ocuupied is by far the inland sites of the Middle Period. During the Middle/Late Transition, the time of the MCA, an equal proportion of inland and coastal sites are occupied.

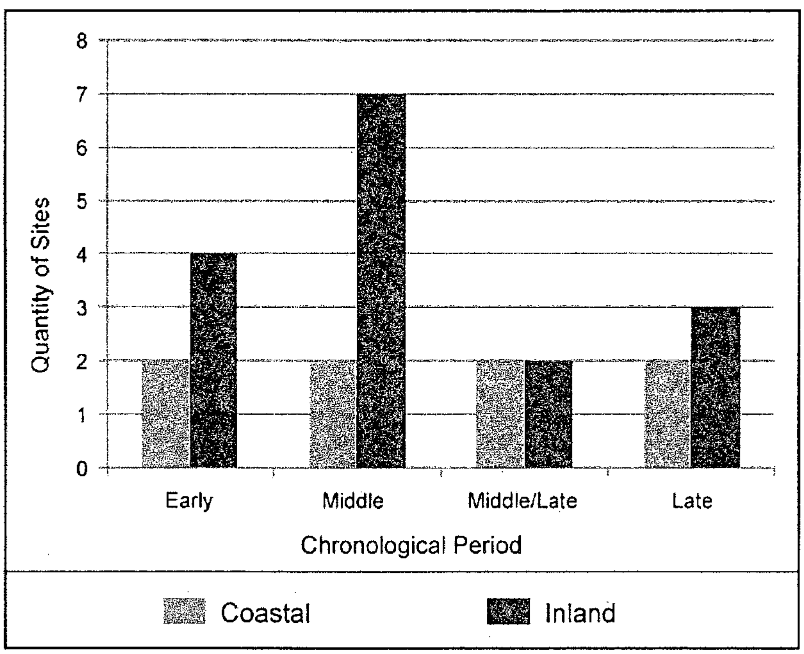


Figure 16. Histogram of Site Occupation over Time.

To determine whether prehistoric populations are utilizing different parts of the landscape using a finer scale than chronological periods, the quantities of archaeological sites are tabulated along with their corresponding ecozones in 100-year increments (Table 5).

Table 4. Quantities of Sites by Ecozone Separated into 100-Year Increments.

Years Before Present	Qty. Inland Sites	Qty. Coastal Sites	Total Qty. Sites
0-100	0	0	0
100-200	0	0	0
200-300	3	0	3
300-400	2	0	2
400-500	1	0	1
500-600	1	1	2
600-700	2	2	4
700-800	1	1	2
800-900	1	2	3
900-1000	2	0	2
1000-1100	1	0	1
1100-1200	1	0	1
1200-1300	2	1	3
1300-1400	2	0	2
1400-1500	0	0	0
1500-1600	0	1	1
1600-1700	1	0	1
1700-1800	1	1	1
1800-1900	0	0	0
1900-2000	1	0	1
2000-2100	2	0	2
2100-2200	4	1	5
2200-2300	3	0	3
2300-2400	2	0	2
2400-2500	2	0	2
2500-2600	2	0	2
2600-2700	0	1	1

2700-2800	0	0	0
2800-2900	3	1	4
2900-3000	2	2	4
3000-3100	1	0	1
3100-3200	1	0	1
3200-3300	1	0	1
3300-3400	1	0	1
3400-3500	1	0	1
3500-3600	0	0	0
3600-3700	1	0	1
3700-3800	1	0	1
3800-3900	0	0	0
3900-4000	0	1	1

The quantities of sites on the coast are compared to those from inland with a shaded area marking the time span of the MCA (Figure 17). The pattern shows more inland sites are consistently occupied over time. The only exception is in the beginning of the Early Period between 3900 - 4000 B.P.

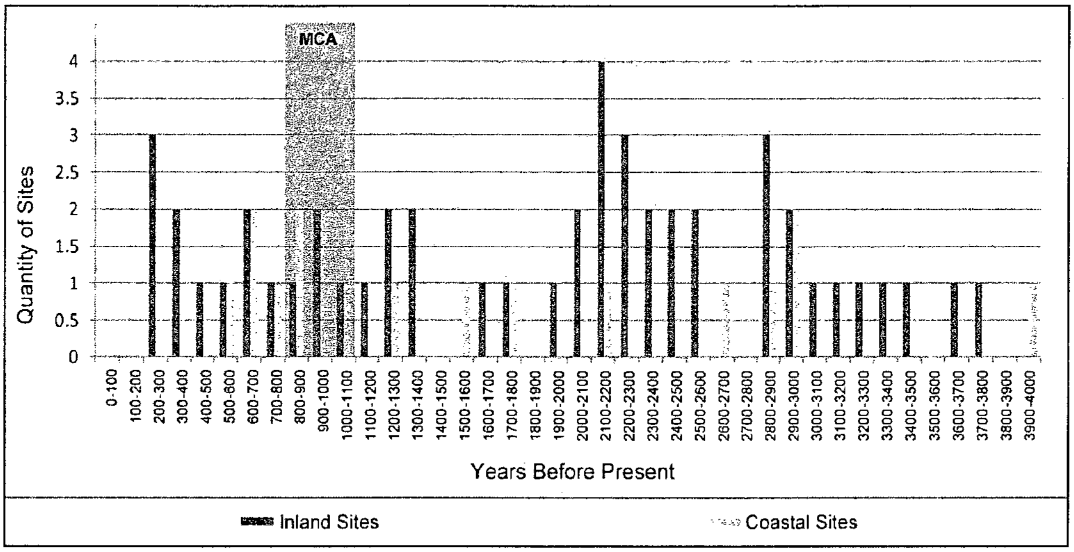


Figure 17. Quantities of Inland and Coastal Site Occupied in 100-Year Increments.

The final analysis of settlement distribution over time incorporates cartographic methods. GIS is used to plot sites on four maps with each map representing a temporal period examined in this thesis. The GIS layers consist of county boundaries, ecozones, and site occupation separated into chronological periods. The four maps were created in ArcMap 9.3, and then imported to Illustrator 10.0.3 to improve the graphic qualities of text, labels, and legend elements (Figure 18).

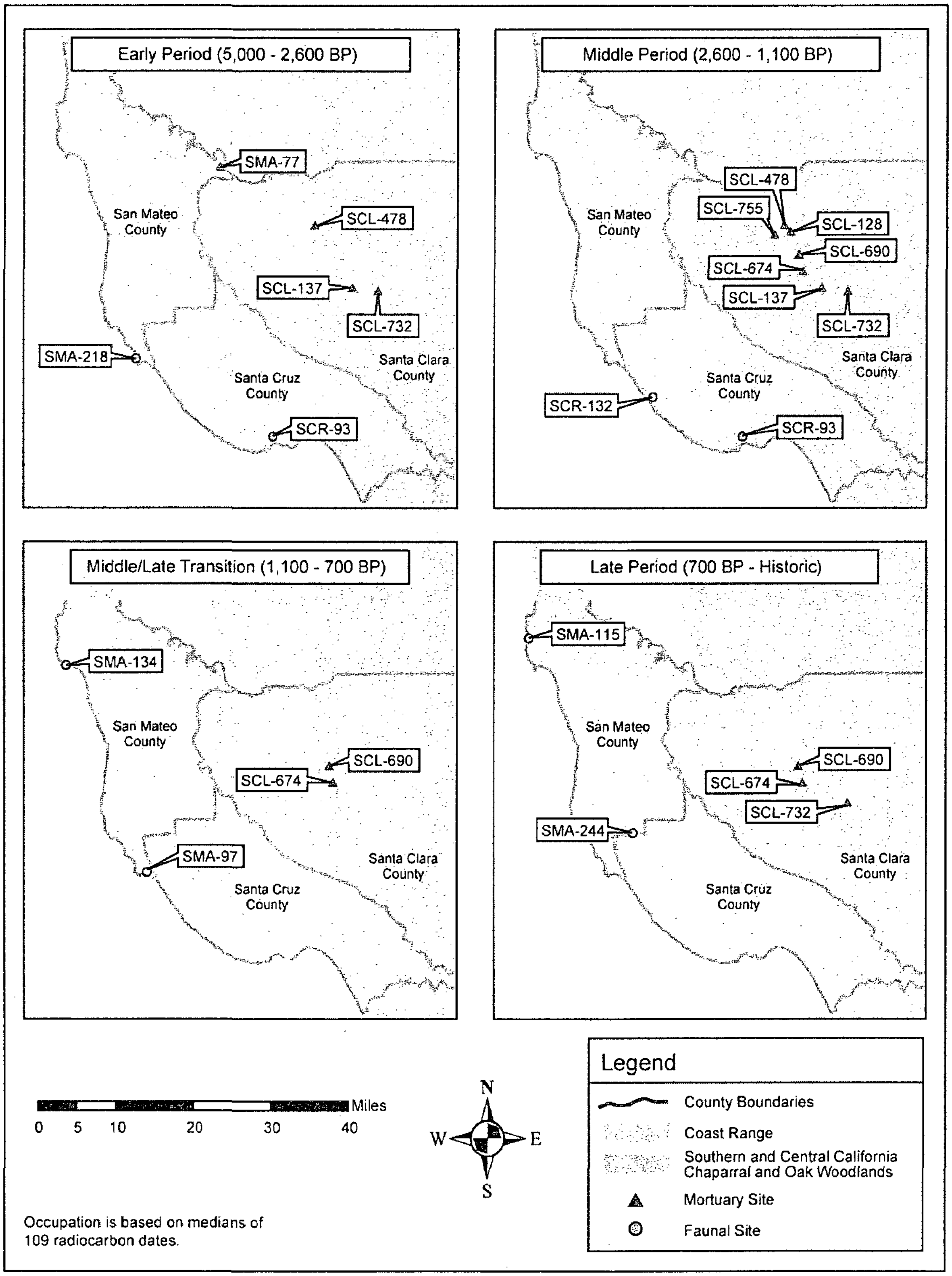


Figure 18. Occupation of Sites Through Time.

The maps clearly show a preference for inland occupation throughout most time periods. The Middle/Late Transition map is the only exception with an even ratio of coastal and inland sites. The same period is also differentiated from the others by having the lowest number of total sites occupied. Although the histogram in Figure 16 presents the same data, the results are better represented through the use of cartography.

4.3 *Hunting Strategies*

The following section discusses the data from the seven sites examined for the faunal analyses. First I present all of the data, and then I arrange the data differently to look for patterns in size of prey choice and whether the taxa come from marine or terrestrial sources. Lastly, intensification is analyzed. All of the faunal data was originally published by Hylkema (2000); however, this thesis reevaluates the data by culling specific sites and separating them into different time periods. I also create charts and graphs to better illustrate and interpret the data. The sites are listed below in their respective time periods:

Early Period: CA-SMA-218

Middle Period: CA-SCR-132 and CA-SCR-93

Middle Late Transition Period: CA-SMA-134 and CA-SMA-97

Late Period: CA-SMA-244 and CA-SMA-115

Table 5 below provides a complete listing of all faunal material found in the seven sampled sites. Volumes excavated are represented as cubic meters (m^3). The number of identified specimens (NISP) is indicated over the weight, represented as grams. The seven sites are arranged chronologically from Early to Late Periods.

Table 5. Faunal Material Analyzed for this Thesis.

Taxa	**NISP over weight (grams) of faunal material**							
	Early Period	Middle Period		Middle/Late Transition		Late Period		
	Site (volume excavated as m^3)							
Common Name Scientific Name	SMA-218 m3=3.8	SCR-132 m3=4.0	SCR-93 m3=2.9	SMA-134 m3=20.2	SMA-97 m3=4.2	SMA-244 m3=2.75	SMA-115 m3=5.5	
	NISP/ Weight (g)	NISP/ Weight (g)	NISP/ Weight (g)	NISP/ Weight (g)	NISP/ Weight (g)	NISP/ Weight (g)	NISP/ Weight (g)	**Totals**
Grizzly Bear Ursus horribilus	2 19.9	-	-	-	-	-	-	2 19.9
Tule Elk *Cervus nannodes*	3 2.2	-	3 36.3	-	2 23.2	11 105.4	5 69.5	24 236.6
Black-tailed deer *Odocoileus hemionus*	20 131.4	12 62.1	41 220	11 105.4	24 313.8	17 69.6	10 99.3	135 1001.6
Large herbivore Artiodactyla	-	-	-	-	1 2.8	-	9 74.6	10 77.4
Dog/coyote Canidae	-	2 2.0	-	1 2.6	3 5.3	-	2 23.1	8 33.0
Rabbit Leporidae	26 16.3	2 0.6	15 16.9	-	27 38.3	11 7.7	8 3.4	89 83.2
Bobcat *Lynx rufus*	-	-	-	-	-	1 1.0	5 3.9	6 4.9
Squirrel Sciuridae	-	2 0.4	-	-	-	-	-	2 0.4
Gopher Geomyidae	30 10.8	15 12.2	-	-	-	2 0.6	-	47 23.6
Skunk/Weasel Mephitidae	-	-	-	-	2 3.3	2 2.7	-	4 6.0
Sea Otter *Enhydra lutris*	5 6.4	3 5.0	6 1.3	65 187.4	8 18.3	1 11.8	55 347.4	143 577.6
Seals/Sea lions Pinnipedia	142 755.8	6 117.0	3 2.2	57 407.9	40 368.2	1 1.4	32 206.6	281 1859.1
Birds Aves	21 26.3	3 0.8	4 8.8	36 34.2	26 10.2	3 1.6	42 71.7	135 153.6
Fish Pisces	46 10.5	8 1.5	396 37.8	360 94.1	90 29.1	40 13.4	-	940 186.4
Total faunal NISP over grams	295 979.6	53 201.6	468 323.3	530 831.6	223 812.5	89 215.2	168 899.5	1826 4263.3

4.3.1 Prey Choices. The first analysis is to determine the size of prey selected as well as dietary breadth over time. These two types of analyses were not analyzed in the Southern California Model, but can be useful in determining human behavior with respect to prey choices. Size of prey determines the effort required to catch the resource and increases in dietary breadth may be indicative of resource depression and/or abundance. Using David Hurst Thomas' (1969) guidelines for quantifying faunal material, the taxa from the seven coastal sites have been separated into the following categories:

Large mammals (weighing over 25 kg):
- Grizzly bears
- Tule elk
- Mule deer
- Other artiodactlys (large herbivores)
- Pinnipeds

Medium mammals (weighing between 5-25 kg):
- Sea otters
- Canids (dogs/coyotes)
- Bobcats

Small Mammals (weighing less than 5 kg):
- Mephitids (Skunks/Weasles)
- Squirrels
- Leporids (rabbits/hares)
- Rodents (gophers)

Birds

Fish

Table 6 presents categorized summed weights (grams) of faunal material using the guidelines above. The weights are separated into chronological periods. Although the table clearly shows the greatest bone weights in the large mammal category, it must be understood that one elk bone may weigh more than 200 squirrel bones. The weight percentages are to be examined as changes over time and not to be compared to other categories within the same time period.

Table 6. Categorized Taxa by Chronological Period.

Taxonomic Categories	**Weight (g)/Percentage of Faunal Remains by Chronological Period**			
	Early	**Middle**	**Middle/Late**	**Late**
Small Mammals	27.1g/2.7%	30.1g/5.7%	4.6g/2.5	15.8g/1.7%
Medium Mammals	6.4g/0.7%	8.3g/1.6%	213.6g/13.0%	387.2g/42.6%
Large Mammals	909.3g/92.8%	437.5g/83.4%	1221.3g/74.3%	418.9g/46.1%
Birds	26.3g/2.7%	9.6g/1.8%	44.4g/2.7%	73.3g/8.1%
Fish	10.5g/1.1%	39.3g/7.5%	123.2g/7.5%	13.4g/1.5%
Total Weight (g)/Percentage	**979.6g/100%**	**524.8g/100%**	**1607.1g/100%**	**908.6g/100%**

To provide the reader with a better visual representation of the data above, Figure 19 presents the percentages of faunal remains as pie charts.

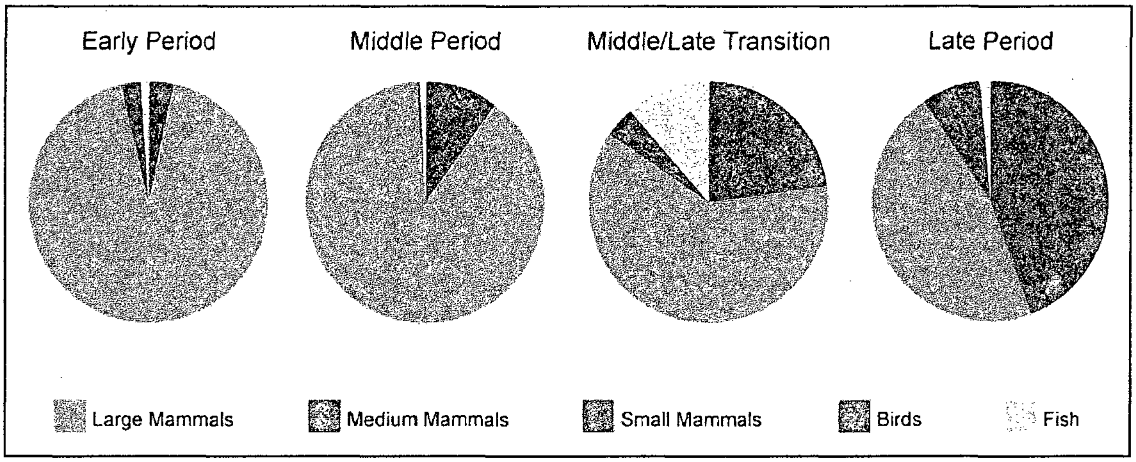


Figure 19. Pie Charts of Categorized Faunal Taxa over Time.

The charts indicate large mammals were consistently a significant portion of the archaeological faunal assemblage, but, as stated previously, the weight percentages are to be examined as changes over time and not to be compared to other categories within the same time period. Medium mammals play more of a prominent role in the Middle/Late Transition than in previous years, but the percentage continues to increase into the Late Period. Also, diet breadth appears to have increased dramatically during the Middle/Late Transition and continues through the Late Period, as evidenced by the higher percentages of taxa other than large mammals. Finally, it appears that fish are the most abundant in the faunal assemblage during the drought years of the Middle/Late Transition.

4.3.2 Terrestrial Versus Marine. Dietary choices between terrestrial and marine prey are examined in the second analysis. Taxa for this analysis are categorized below.

Terrestrial taxa:

- Grizzly bears
- Tule elk
- Mule deer
- Other artiodactlys (large herbivores)
- Mephitids (Skunks/Weasles)
- Squirrels
- Leporids (rabbits/hares)
- Rodents (gophers)
- Canids (dogs/coyotes)
- Bobcats
- Birds

Marine taxa:

- Pinnipeds
- Sea Otters
- Fish

Table 7 compares the percentages of terrestrial to marine taxa. Percentages are calculated as weight (grams) and separated into chronological periods. The data shows higher amounts of terrestrial fauna during the Middle and Late Periods. Marine resources, on the other hand, are the most significant part of Early Period and Middle/Late Transition faunal assemblages.

Table 7. Percentages by Weight (g) of Terrestrial and Marine Taxa over Time.

Taxonomic Categories	**Percentage of Faunal Material by Chronological Period**			
	Early	**Middle**	**Middle/Late**	**Late**
Terrestrial	21.1%	66.2%	26.5	83.6%
Marine	78.9%	33.8%	73.5%	16.4%
Total Percentage	**100%**	**100%**	**100%**	**100%**

Actual bone weights of marine versus terrestrial resources are presented in Table 8 to provide the reader with another view of the same data. The data is then represented as a line graph on a log 10 base scale since the weights vary as much as 630 grams. This type of graph is used identify the points at which the types of fauna eclipse each other (Figure 20).

Table 8. Total Weight (g) of Terrestrial and Marine Taxa over Time

Taxonomic Categories	**Faunal Weight (grams) by Chronological Period**			
	Early	**Middle**	**Middle/Late**	**Late**
Terrestrial	206.5	359.7	44.4	934.6
Marine	772.9	183.7	123.2	183.7
Total Weight (g)	**979.4**	**543.4**	**176.6**	**1118.3**

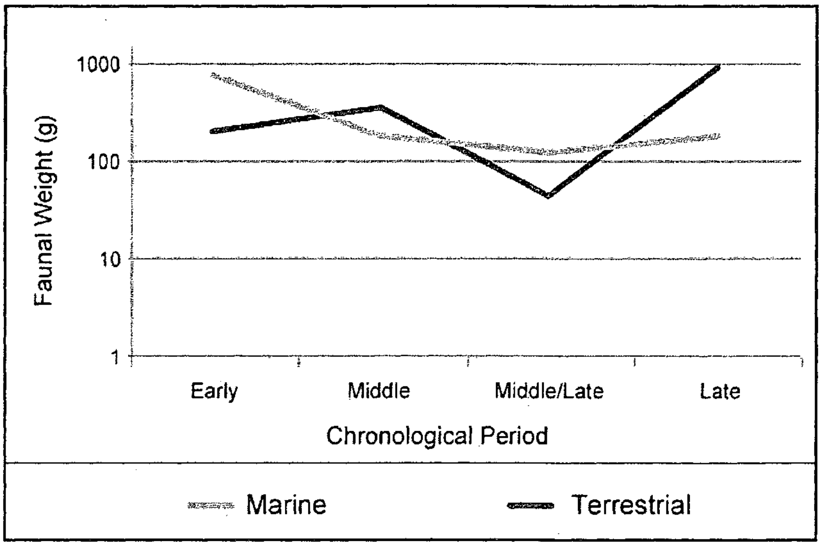


Figure 20. Line Graph of Terrestrial and Marine Taxa Over Time.

The graph makes it easier to see the significant differences in marine and terrestrial taxa, especially during the Middle/Late Transition period. While the increase in marine taxa is very drastic between the Middle and Late Periods when looking at percentages, the actual bone weights do not reflect the same differences. Terrestrial and marine fauna both have the least amount of bone weight during the Middle/Late Transition with terrestrial taxa significantly lower during this period than any other period.

4.3.3 Intensification. Intensification of resources is measured here by the number of radiocarbon dates from the faunal sites and an index of weight divided by volume excavated (m3) divided by 100. Radiocarbon dates are used here as a proxy for population with a caveat that the number of dates may not actually represent the number of people occupying a site. Greater numbers of dates may simply be the product of more funds available to acquire dates. Table 9 lists the data according to chronological period.

Table 9. Faunal Weights Compared to Quantities of Radiocarbon Dates over Time.

Time Period	Qty. of Dates	Weight of fauna (g)	Volume excavated (m^3)	Weight/Volume Index
Early	23	979.6	3.8	2.577895
Middle	57	524.8	3.3	1.590303
Middle/Late	15	1644.1	24.4	0.673811
Late	14	908.6	8.25	1.101333

The data from the table above is graphed in Figure 21 and may be interpreted as follows: the closer the lines are the greater the degree of intensity.

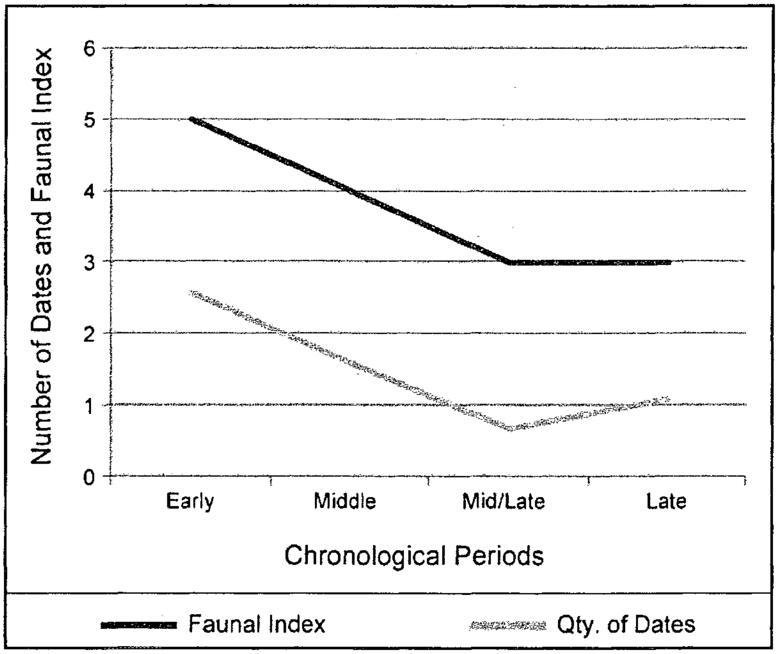


Figure 21. Line Graph of Population and Faunal Index over Time.

The graph above (Figure 21) demonstrates only a minimal degree of intensification during the Late Period. The Middle/Late Transition Period does not reflect intensification. Once again, this graph must not be examined by itself due to the fact that radiocarbon dates are used as a proxy for population. The information is simply used as another tool to examine faunal intensity and must be examined along with the other types of faunal data presented earlier in this section.

4.4 *Social Stress*

Skeletal stress studies from the study area include: Gerow's 1968 analysis of the University Village Complex (CA-SMA-77), representing the Early Period; analyses of the Santa Clara Mission Site (CA-SCL-755) by Lorna Pierce (Skowroneck and Pierce 2006), the Snell Site, CA-SCL-137 by Robert Jurmain (Cartier et al. 1987; Hylkema 2002) and of the Three Wolves Site by Jurmain (Cambra et al. 1996), representing the Middle Period; Robert Jurmain and Kenneth R. Bethard's analysis of the Tamien Station remains, CA-SCL-690, representing the Middle/Late Transition (Hylkema 2006); and the Rubino Site, CA-SCL-674, with remains analyzed by Grady et al. (2001) ranging from the Middle through Late Periods. Chronological periods and their associated sites are listed in Table 10.

Table 10. Chronological Periods and Mortuary Site Occupation.

Early Period	Middle Period	Middle/Late Transition	Late Period
SMA-77	SCL-128 SCL-137 SCL-478 SCL-674 SCL-732 SCL-755	SCL-690 SCL-674	SCL-674

4.4.1 Mortuary Sites. The next section gives a brief overview of each mortuary site. The circumstances of excavation are reviewed as well as the state of skeletal preservation, and highlights of data relevant to this thesis. The sites are discussed with emphasis on the types of trauma and malnutrition noted within the burial samples. Individual cases are noted in each site section. The state of bone preservation is also described.

4.4.1.1 *CA-SMA-77*. Also called the "University Village Site," CA-SMA-77 dates to the Early Period based on a radiocarbon date from charcoal taken eight years after Gerow's 1968 report on the site's excavation (Wallace and Lathrap 1975). Human remains were in poor condition with a total of 32 adults over the age of 20 and four sub-adults between 18 and 20 years of age. No trauma or nutritional stress was observed in the sample population (Gerow 1968).

4.4.1.2 *CA-SCL-137*. CA-SCL-137, "The Snell Site," was excavated as a part of the Guadalupe Corridor Transportation Project from 1982 to 1991. It was one of 13 mortuary sites encountered during this CRM project funded by the Santa Clara Transportation Agency. The site dates to 3091-2104 BP, the Early and Middle Periods, with five of the seven radiocarbon samples yielding dates from 2439 - 2104 B.P. (Hylkema 2002). The 87 sets of human remains analyzed for this thesis all date to the Middle Period and include three individuals who have experienced projectile trauma, and five individuals with fractured long bones. Signs of malnutrition are also evidenced by two cases of cribra orbitalia (Cartier et al. 1993:67; Cartier et al. 1987:53).

4.4.1.3 *CA-SCL-732*. CA-SCL-732, also called "Kaphan Umux/Three Wolves" was excavated under the direction of Ohlone Families Consulting Services, the archaeological consulting firm of the Muwekma Ohlone Tribe, according to state and federal regulations for a CRM project in south San Jose. It is a multi-component site with corrected median radiocarbon dates from the Early, Middle, and the Late Periods. Due to the fact that there are no radiocarbon dates from the Middle/Late Transition, the site appears to have been temporarily abandoned. The human remains were in a state of poor preservation. Out of 100 burials, none are complete, 17 are incomplete and 86 are extremely fragmentary (Cambra et al.:4.4). These evaluations are based on the criteria below:

> Complete: at least six long bones or immature diaphyses denotes completely intact

Incomplete: at least six long bones complete, but perhaps preserved in pieces

Fragmentary: less than six long bones complete (Hylkema 2006:189)

From the 17 incomplete burials, 15 were dated to the Middle Period, one to the Early, and one set of remains are of unknown age due to the sample being contaminated (Cambra et al. 1996:10.1-10.2). Since the date of the oldest burial lays outside of my sample acceptance criteria, this thesis uses only the data from the Middle Period burials, which date from 1680 - 2420 B.P. Of the sample, two individuals exhibit healed fractures in long bones and two show possible cranial injuries. There is no evidence of projectile trauma in the sample (ibid: 4.18). Nutritional stress indicators such as stature, Harris lines, and cribra orbitalia are not mentioned in the osteological examination.

4.4.1.4 *CA-SCL-755*. CA-SCL-755 is a Middle period site dating from 2400 - 1200 B.P. situated at the present-day University of Santa Clara (Skowronek and Pierce 2006:67). Ten individuals are examined in the report, of which only six were able to be sexed (all females). No evidence of trauma was found in the sample; however, Harris lines on one teen-age individual indicate nutritional stress. Overall, the sample is a healthy population with the exception of the aforementioned teen-ager and Burial 1, an individual who suffered from chronic maxillary sinusitis unrelated to nutritional stress or trauma.

4.4.1.5 *CA-SCL-478.* CA-SCL-478, also known as "The Skyport Plaza Site," was excavated in accordance with state and federal regulations as a CRM project for Spieker Properties who were developing office buildings, retail shops, and a parking structure near the San Jose Airport in 2000. Fifteen radiocarbon dates from charcoal yielded 14 dates from 2505 - 2015 B.P. placing the site in the early Middle Period. Wiberg notes the relative lack of artifacts associated with the burials and suggests the site was primarily a cemetery and not used for residential purposes (Wiberg 2002:10-2). A total of 90 individuals were excavated; most were interred alone, but there were also five dual and one triple internment. Out of the nine total number of burials associated with projectile point trauma, three of them were in paired graves and two of the triple grave burials were associated with projectile points "…most exhibiting basal damage consistent with impact scars -

and/or post-mortem dismemberment of arms and legs" (ibid: 10-8). Post-mortem dismemberment (trophy-taking) is indicated by missing extremities and cutmarks on surviving bones (ibid: 10-10) and are found on six burials. Wiberg notes that the dismembered individuals were also buried in mass graves and/or were associated with projectile points within the skeleton. Burial 61 (also in a dual grave) and Burial 77 displayed lesions associated with trauma, while four other burials (19, 37, 38, and 77) have evidence of healed fractures. Burials 70, 71, and 73 exhibited perimortem skull fractures, while Burial 70 also displayed a perimortem fracture of the left ilium (ibid:10-1-10 through 10-15). There is no indication in the report about nutritional stress analysis and cribra orbitalia is not mentioned at all.

4.4.1.6 *CA-SCL-674*. "The Rubino Site," CA-SCL-674, was excavated in 1998 and 1999 in accordance to state and federal regulations for a CRM project in south San Jose. It has been dated from the Middle through the Late Period (2224 - 457 B.P.). Although most of the burials (11 out of 15) date to the Middle period, two individuals date to the

Middle/Late Transition Period and two date to the Late Period (Grady et al. 2001:527).

The Middle Period burials show a significant amount of trauma. Five of the 11 Middle Period individuals exhibited perimortem cut marks and chop marks on longbones corresponding hands or forearms missing, five had lesions associated with trauma, four had skull fractures, and one individual had unhealed projectile point trauma to the ilium (Grady et al. 2001). Another indicator of warfare or violence is the fact that seven of the 11 were interned in mass graves; 10 of the 11 were males between the ages of 18-45 years of age (Wiberg 2002:10-25). Harris lines were not observed during the pathological investigation due to the unavailability of radiological equipment (Grady et al. 2001:35), and there is no indication of cribra orbitalia.

Of the two individuals dated to the Middle/Late Transition Period, one had a healed fracture and the other was directly associated with a projectile point which was likely the cause of death. There is no indication of cribra orbitalia. Of the two individuals dated to the Late Period, one has no signs of trauma or malnutrition, while the other has both: a healed nasal fracture, an ulnar parry fracture, and cribra orbitalia.

4.4.1.7 *CA-SCL-690.* CA-SCL-690, also called the "Tamien Station Site," dates precisely to the Middle/Late Transition. The site was a cannery in historic times demolished to construct a transportation terminal, a federally-funded project which had to comply with Section 106 of the National Historic Preservation Act of 1966 (NHPA). The treatment plan outlined mitigation procedures, research questions, and also made provisions in the event human remains were discovered. The excavations yielded not only human remains, but evidence of a large village.

The most likely number of individuals examined was determined to be between 121 and 130 due to the fragmentary nature of most of the remains. This report averages the number to 126 individuals. The human remains were in fair to good condition with a total of 22 complete burials, 26 incomplete and 94 considered fragmentary. The criteria for these categories are identical to those used for CA-SCL-732, noted above. There is no indication of height for this population nor is there a discussion of nutritional stress; however, there is ample evidence of trauma:

> Healed fractures are evident or strongly suggested in 18 long bones, including the clavicle…, yielding an

overall frequency of involvement of 6.8% [Jurmain in Hylkema 2006:206-208].

Jurmain notes that the injuries are consistent with aggression, such as attempting to break a fall or warding off blows, also known as "parry fractures." Further indicators of trauma include three individuals with ununited fractures of the ulnae (Burials 85/85A and 98) and radius (Burial 22A), which are the result of unhealed fractures. Healed fractures in the hands, feet, ribs, and neck are evidenced in seven other individuals (ibid.). Obsidian projectile points are directly associated with the osteological damage of the remains of three individuals, while a fourth had an obsidian point in the rib cage without any damage to bone (ibid.:209). No cranial injuries are reported.

4.4.1.8 *CA-SCL-128*. "The Holiday Inn Site," CA-SCL-128, is a multi-component site dating from the Middle Period through historic times. In the process of constructing a Holiday Inn garage, burials were encountered. The salvage project of 1977 was the first to have resulted from the City of San Jose's Burial Ordinance (#18219) although some burials had previously been excavated during the 1973 investigations. The Native American cemetery dates to the Middle Period based on radiocarbon dates from some burials and diagnostic bead ornaments from others. A total of 16 burials (from both the 1973 investigations and the 1977 salvage project) are examined with the remains being in fragmentary to fairly complete condition in addition to disassociated bones screened from backfill (Winter 1978:72-87). The total minimum number of individuals represented in the sample has been determined to be 39 (ibid: 93). From the burials, two individuals were identified as having cribra orbitalia (Burials 1973-3 and 1977-1). Acute trauma evidenced by healed fractures is noted in "several" bones screened from backfill and unassociated with specific burials (ibid: 84).

Cremations are not analyzed in this thesis; however, it is worthy to note that the practice of burning the dead could be a reason why there are fewer burials to report from the Middle/Late Transition. As pointed out by Gallegos (2002:35), it is an effective method of handling large numbers of deaths caused by disease, malnutrition, or even warfare.

4.4.2 Trauma. The categories of trauma cited in the Southern California Model were usually not provided in the site reports from this study area. Instead, trauma here is measured by quantities of burials with lesions associated with injury, healed and unhealed fractures, projectile point trauma, and post-mortem dismemberment. These categories were chosen because they were the most consistent observations throughout the sampled mortuary analyses. Table 11 lists indicators of trauma according to chronological periods.

Table 11. Skeletal Trauma by Chronological Period.

Period (Sample Size)	**Lesions**		**Healed fractures**		**Unhealed fractures**		**Projectile injury**		**Post-mortem dismemberment**	
	Qty.	**%**	**Qty.**	**%**	**Qty.**	**%**	**Qty.**	**%**	**Qty.**	**%**
Early (n=32)	0	0%	0	0%	0	0	0	0%	0	0
Middle (n=345)	10	3%	9	3%	19	6%	13	4%	14	4%
Middle/Late (n=128)	1	1%	8	6%	21	16%	5	4%	0	0%
Late (n=2)	1	50 %	0	0%	2	100 %	0	0%	0	0%
Totals	12		17		42		18		14	

The same information is graphed in Figure 22 below. Since the sample is so small for the number of burials in the Late period (n=2), it is difficult to discern a pattern in the other periods. The Early Period shows no signs of trauma at all. To prevent confusion, the Early Period sample has been eliminated from Figure 22.

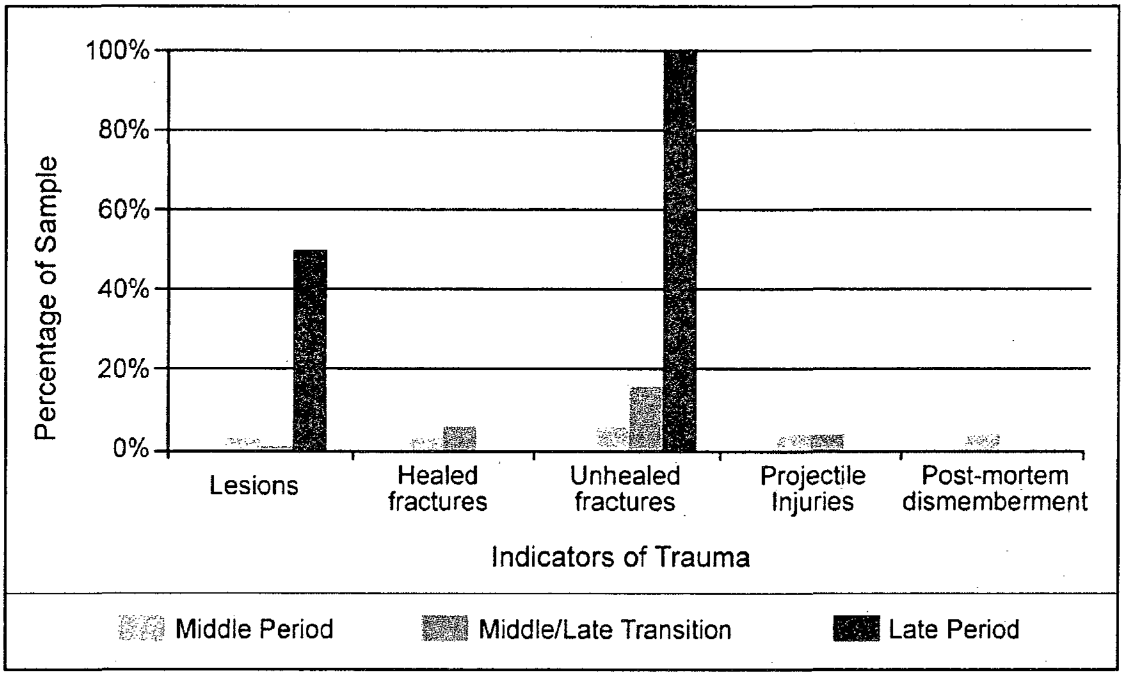


Figure 22. Bar Graph of Percentages of Trauma over Time.

When the data from the Late Period is removed, it becomes easier to identify patterns in the other data (Figure 23). While the Early Period burial data do not reflect any trauma, the Middle and Middle/Late Transition Periods exhibit substantial amounts (at least 4%) of unhealed fractures and projectile injuries. Although post-mortem dismemberment reaches 4% in the Middle Period sample, evidence for the same is not recorded during any other period. While the percentage of lesions is the highest during the Middle Period, healed fractures are the highest during the Middle/Late Transition.

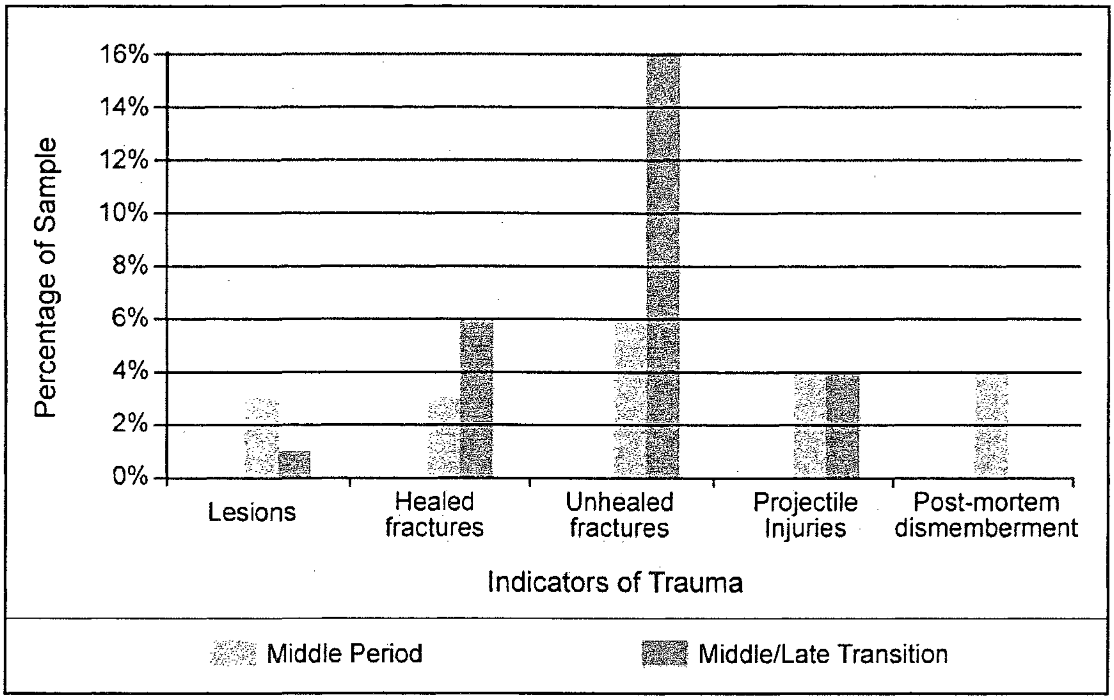


Figure 23. Bar Graph of Percentages of Trauma over Time without the Late Period.

Indicators of nutritional stress presented here are not identical to those represented in the Southern California study due to a lack of data. For example, out of the eight sites examined, only one site (CA-SCL-755) included data regarding stature. The reasons for the gaps in the data range from lack of budget to poor skeletal preservation. For the purposes of this thesis, characteristics that are described in most of the reports are used. In nearly every report gathered for this analysis, there are details about cribra orbitalia indicative of nutritional stress. The following section quantifies the information regarding cribra orbitalia.

Table 12 presents quantities of burials with cribra orbitalia, a sign of iron-deficiency, arranged by chronological periods. Once again, the sample is so small for the number of burials in the Late period (n=2) that the one burial with cribra orbitalia is an inflated percentage. It is worthy to note that there are no incidences of cribra orbitalia in the Early Period or the Middle/Late Transition.

Table 12. Incidences of Cribra Orbitalia over Time.

Period (Sample Size)	Cribra oribtalia	
	Quantity	Percentage
Early (n=2)	0	0%
Middle (n=345)	4	1%
Middle/Late (n=128)	0	0%
Late (n=2)	1	50%
Totals	5	-

5. STUDY FINDINGS AND CONCLUSIONS

The Southern California Model presented by Raab and Larson (1997) is one of many such studies conducted recently in which paleoenvironmental and archaeological data are compared to find cultural trends possibly related to climatic events (Arnold 1992; Bourke et al. 2007; deMenocal 2000; Field 2004; Gamble 2005; Gardner 2006; Jones et al. 1999; Kennett and Kennett 2003; Sutton et al. 2007). The paleoenvironmental data from the model demonstrate prolonged droughts in the Santa Barbara region lasting 250 years. The archaeological data suggest Native Californians responded to these changes with an intensification marine resources and disrupted settlement patterns, at least on the Channel Islands. Furthermore, the Southern California Model indicates other consequences for people including poorer health and greater incidents of trauma among individuals during the Middle/Late Transition.

In this section I present the results of a test of the Southern California Model in the San Francisco Bay Area followed by a discussion of the model in Northern and Southern California. Specifically, I will examine the possible reasons for differences between my results and those of the Southern California Model with regards to new paleoenvironmental records demonstrating different SSTs and archaeological data showing disparities in diet, skeletal stress, and settlement patterns.

5.1 *Results*

Paleoenvironmental data from several studies has documented droughts in the study area during the Middle/Late Transition representing the MCA (Byrne et al. 2001; Kennett and Kennett 2000; Stine 1994). The archaeological evidence shows virtually no resource intensification during the Middle/Late Transition, however, percentages of fish remains are higher during the MCA than any other time period. Skeletal data shows the highest quantities of healed and unhealed fractures during the Middle/Late Transition, but overall patterns of violence during this period are comparable to those of the Middle Period. Cribra orbitalia, signifying malnutrition, was not found in the Middle/Late Transition sampled observed in this thesis.

5.2 *Discussion*

This section is a discussion of SST, pollen, and tree-ring data with comparisons to the Southern California Model beginning with paleoenvironmental data. Archaeological results of from the study area are also discussed. These include radiocarbon dates, settlement patterns, dietary analyses, violence, and malnutrition. The results are finally compared to the Southern California Model.

5.2.1 Fossils in Core Samples for Marine Paleotemperature. A recent more refined record of SSTs demonstrates the errors of the previous record used in the Southern California Model. Although the sample was taken in the Santa Barbara region 200 miles south of this study area and only 25 miles southeast of the Pisias (1978) core, the record directly contradicts the Southern California Model's SST trend line. The fact that SSTs were actually cooler than normal during the MCA lends support to the Southern California Model's suggestion that marine productivity was high. It also corroborates the high fish percentages found in the faunal assembles of the Middle/Late Transition in this study area, as will be discussed later. If SSTs had been as high as those suggested by the Southern California

Model, the off-shore kelp forests would have been decimated, creating a depressed environment with little chance of intensification of resources.

5.2.2 Pollen Evidence for Decreased Rainfall. Data from a pollen core sample at Rush Ranch 40 miles northeast of this study area indicate decreased stream flows and increased salinity (Figures 12 and 13). The results are very similar to salinity compositions provided by Davis' (1993) analysis of a core from the San Joaquin Marsh within the Southern California Model area. Davis demonstrated high percentages of salt-water plants during the Middle/Late Transition Period. These findings indicate decreased precipitation in both study areas during the same time period and support the existence of the anomaly along coastal California between 1,100 - 700 B.P.

5.2.3 Dendrochronology Evidence for Decreased Rainfall. Figure 14 clearly demonstrates prolonged drought conditions from approximately 1320-925 B.P. (Stine 1994:547). Although the Southern California Model combines Stine's (1994) data with those from the Transverse Ranges in Santa Barbara County, it is safe to assume that the pattern of low precipitation during the Middle/Late Period is a fair representation of reality. The dendrochronological and pollen results from both study areas are in agreement. It is apparent that California experienced a dramatic decrease in rainfall at the same time.

5.2.4 Radiocarbon Dates. Radiocarbon dates were not evaluated at all in the Southern California Model and are only used here to identify patterns of occupation and to graph resource intensification. The bar graph showing occupation over 100-year intervals (Figure 15) illustrates that the number of radiocarbon dates taken from Middle Period sites is higher than any other time period. The graph is not meant to imply populations were greater during the Middle Period, however, as radiocarbon dates are not being used as a proxy for population in this thesis, with the exception of the analysis of faunal intensification. Table 1 reveals the spike in quantities is due to the fact that more dates were acquired for CA-SCL-732, the Three Wolves Site, than any other site and that most of them centered between 2000 - 2300 B.P. The graph merely illustrates the fact that we have very few radiocarbon dates from other time periods.

5.2.5 Settlement. Settlement pattern evaluations in this thesis indicate a lower number of sites during the Middle/Late Transition. Table 3 reveals a decrease in the number of occupied sites during the MCA. Coastal sites, however, remain consistent throughout time with occupation remaining at 2 sites per time period. It appears from Table 3 and Figure 18 that the Middle Period within the inland ecozone of chaparral and oak woodlands had more sites occupied than any other period. The decrease in the number of sites during the Middle/Late Transition may certainly be attributed to water shortages, as suggested by True (1990) in the Southern California Model. However, the decrease may also be the result of overpopulation, social conflict (war), or even terrestrial resource depression.

5.2.6 Hunting Strategies. When the faunal material from the study area is separated into size and resource area categories, there appears to be a greater reliance on marine resources during the MCA, specifically with regards to fish (Figures 19 and 20). Fish remains are the highest during the Middle/Late Transition than any other period. The pie charts representing taxa size (Figure 19) should be approached with caution, however, because percentages of large mammal may appear to decrease when other taxa increase. Likewise, the bar graphs of marine versus terrestrial taxa do not consider that terrestrial fauna would likely be affected by drought conditions as grasses dry and large herbivores are driven to moister regions, perhaps towards the Santa Cruz Mountains. The drastic increase in marine taxa may be a direct result of fewer terrestrial resources due to drier conditions.

The Figure 19 pie charts also indicate large mammals were consistently a significant portion of the coastal diet, but the percentage decreases over time. Although the result may be due to greater population pressure, it also lends support to Glassow's interpretation of the Early Period in which he believes gender roles were developed; women stayed in residential encampments gathering and processing resources while men pursued tool manufacture, maintenance, and hunting activities (Glassow 1996). If gender roles were not as developed as Glassow suggests, there would be higher percentages of other sizes of taxa. Women and children do not hunt large mammals. Instead they gather plant resources and smaller taxa such as fish, birds, and small mammals.

The same pie charts (Figure 19) indicate diet breadth increases over time. The increase may be due to drought conditions, but may also be the result of technological innovations, such as the bow and arrow, which appears in coastal archaeological assemblages during the Middle/Late Transition. The bow and arrow is very effective for killing smaller and faster prey, such as medium and small mammals. Less dangerous to hunt, it is predictable that smaller taxa are represented in higher numbers after the introduction of the bow and arrow.

Figure 20 indicates a greater reliance upon marine resources during the MCA. Using the most recent SST data (Kennett and Kennett 2000), we now know that ocean temperatures were cooler during the Middle/Late Transition. This fact is supported by the abundance of marine remains in the faunal assemblages during this time. Kelp forests thrive in cooler waters and would have supplied Native Californians with an abundance of marine resources during the MCA.

Sea otters appear in Figure 19 as medium mammals, a category that increases dramatically from the Middle Period to the Middle/Late Transition, and continues increasing through the Late Period. Examining the raw data in Table

1, it is apparent that sea otter is a substantial part of the coastal diet; but the resource has other uses as well. Trading pelts may have been an activity pursued by coastal populations. Although the evidence for such is not present in this thesis, it should be considered in future research as a method for coastal peoples to gain prestige and wealth.

Although this thesis graphs resource intensification, I have used radiocarbon dates as a proxy for population. The results, therefore, should be approached with caution (Figure 21). The graph does not show intensification of resources until the Late Period, not during the Middle/Late Transition suggested in the Southern California Model. Raab and Larson do not quantify the statement "marine subsistence productivity peaked" but cite other reports from within the Southern California Model area (Raab and Larson 1997:326). Based on information from coastal sites in the southern San Francisco Area, it does not appear that populations are collecting more food during the MCA than any other time. This finding directly contradicts Raab and Larson's (1997) assessment and supports the null hypothesis; that is, there is no significant difference in intensification during the droughts of the MCA.

5.2.7 Social Stress. This section discusses the results of mortuary analysis in the study area and includes a comparison to the Southern California Model. It must be noted, however, that some of the samples were in extremely poor states of preservation. For example, the burials of the Early Period mortuary site CA-SMA-77 were mostly fragmented while there are very few burials from both Early and Late Periods. Results of analysis from the two time periods may be skewed due the small amount of data.

Skeletal stress indicators show more healed and unhealed fractures during the MCA than any other period. The pattern of violence, however, is a continuation from the Middle Period which shows an equal percentage of projectile injuries as well as another gruesome indicator of violence, post-mortem dismemberment.

Contrary to the Southern California Model, this study area does not support a significant increase in violence during the Middle/Late Transition. Instead, there appears to be a continued pattern of violent activity which began during the Middle Period. Based on this information, it is unlikely that the MCA played a significant role in warfare within this study area. Other factors must be considered for future study, such as population increases and/or the immigration of other groups. The Middle Period is considered the time when Penutian groups arrived in the San Francisco Bay Area.

Malnutrition is evaluated in this study by the occurrence of cribra orbitalia, which is absent during the Middle/Late Transition and indicative of a healthy population. Cribra is not quantified in the Southern California Model; however, the authors discuss the high incidences of the disease on Channel Island populations during the MCA (Raab and Larson 1997:328). Raab and Larson reprint data (reproduced here as Figure 8) in which nutrition is measured by stature.

The data from this study area regarding nutritional deficiencies during the Middle/Late Transition contradicts the Southern California Model. Instead of seeing more incidences of cribra orbitalia during the MCA, the greatest number of cases occurs during the Middle Period in this study area. The lack of cribra cases during the Middle/Late Transition is, in fact, indicative of healthy individuals. Based on this information, it is unlikely that the MCA played a significant role in the nutritional health of Native California populations in the southern San Francisco Bay.

5.3 *Conclusion*

The results of this thesis show that prehistoric populations of the San Francisco Bay Area do not follow the pattern exhibited in the Southern California Model. The prolonged droughts of the MCA do not appear to have had any significant negative effects on the behavioral patterns of the people in the study area. The evidence presented here supports the notion that adaptations to prolonged drought are quite diverse within California and that no single model may be applied successfully to all populations. Due to the varied ecozones and linguistically diverse populations in California, it is a safe assumption that the MCA not only had different environmental effects, but also resulted in a variety of cultural responses.

My research supports Gamble's (2005) assessment that social stress, disease, and resource diversification may be the result of many other variables rather than climatic change alone. Although environmental stress may play a role in cultural adaptation, it should not be considered the primary driving force in every situation. For the people of the Channel Islands, the MCA would likely have had more devastating effects due to the lack of sufficient water sources, but the same notion should not be attributed to all other populations throughout California.

Future research in adaptations to drought should consider technological advances, i.e. the bow and arrow and asphaltum-lined water bottles, and make an attempt at understanding historical circumstances such as population movements. This thesis demonstrates that drought is not the only explanation for social crises.

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7.0 APPENDICES

7.1 GIS Layer Metadata

Ecozone and county layers were provided on-line by the U.S. Environmental Protection Agency. The file was imported as an Arc/Info coverage and was projected from an Albers Equal Area projection (parameters: units=meters, 1st parallel=29 30 0.000, 2nd parallel=45 30 0.000, central meridian=-96 0 0.000, latitude of origin=23 0 0.000, false easting = 0.000, false northing=0.000, datum=NAD27, spheroid=clarke1866) to Geographic Coordinate System NAD83 (units dd).

The following information provides the values for Level3 and Level3_Name attributes:

ECO Ecoregion Name 1 Coast Range 2 Puget Lowland 3 Willamette Valley 4 Cascades 5 Sierra Nevada 6 Southern and Central California Chaparral and Oak Woodlands 7 Central California Valley 8 Southern California Mountains

7.2 *GIS Layer Tables*

County Layer Table from

http://seamless.usgs.gov/website/seamless/index.htm

(accessed January 10, 2009)

COUNTYP020	STATE	COUNTY	FIPS	STATE_FIPS	SQUARE_MIL
3637	CA	San Mateo County	06081	06	454.810
3697	CA	Santa Clara County	06085	06	1295.200
3870	CA	Monterey County	06053	06	3321.912
3429	CA	Marin County	06041	06	528.561
3501	CA	Contra Costa County	06013	06	732.051
3510	CA	Stanislaus County	06099	06	1512.320
3601	CA	San Francisco County	06075	06	46.890
3775	CA	Santa Cruz County	06087	06	450.514
3582	CA	Marin County	06041	06	528.561
3655	CA	Merced County	06047	06	1967.764
3431	CA	San Joaquin County	06077	06	1421.611
3571	CA	Alameda County	06001	06	748.344
3852	CA	San Benito County	06069	06	1390.726
3591	CA	San Francisco County	06075	06	46.890
3604	CA	Alameda County	06001	06	748.344

County Layer Table from:

http://seamless.usgs.gov/website/seamless/index.htm

(accessed January 10, 2009)

USECO GEO	LEVEL3	ECO	ECO_Name
378	1	1	Coast Range
242	7	7	Central California Valley
366	6	6	Southern and Central California Chaparral and Oak Woodlands
234	6	6	Southern and Central California Chaparral and Oak Woodlands
360	6	6	Southern and Central California Chaparral and Oak Woodlands

Site locations without UTM coordinates were designated located based upon mapped information available. The coordinates for the Southern California data were located using MapTek Terrain Navigator Pro Version 6.01. The locations are accurate to within 1800 feet. UTMS were recording using NAD27, Zone 10.

Site	Easting	Northing	Elev ft
SCL-732	609115	4122500	220
SCL-755	593906	4134079	23
SCL-137	603798	4123183	160
SCL-690	598947	4130015	110
SMA-77	576321	4147912	19
SMA-134	544654	4150603	15
SMA-97	561320	4108009	45
SMA-218	559099	4108451	25
SMA-115	543119	4156144	25
SMA-244	564343	4116102	1225
SCR-132	568812	4100610	20
SCL-478	595934	4136028	45
SCL-128	597160	4134708	16
SCL-674	599804	4126628	143
SCR-93	587502	4092459	50