

ISOTOPIC EVIDENCE FOR CHANGING RESIDENCE PATTERNS THROUGH THE MIDDLE TO LATE HOLOCENE IN CENTRAL CALIFORNIA

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Most studies of settlement systems focus on group-level patterns. Although informative, such studies ignore or obscure the role of individual actions and social systems in population-level phenomena. This study focuses on oxygen isotope ratios of individuals from two prehistoric populations from the San Francisco Bay and Central Valley. Postmarital residence patterns, and possible underlying kinship systems, inferred from these isotope ratios are used to address changing patterns of mobility between sexes – across both space and time. Results are compared to isotopic evidence for changing diets to determine how ecological conditions may have influenced residence patterns and kinship structures.

Kinship systems represent an adaptive solution to social and environmental pressures. Changes in technology, population, and resource availability are among the potential factors contributing to the selection of postmarital residence patterns. Previous studies suggest population increase and resource intensification as major patterns in California prehistory. Isotopic analysis of burials provides a potential means of identifying how residence patterns have changed, and what may have influenced these changes. In this proof-of-concept study, we compare changes in residence patterns in the isotopically distinguishable San Francisco Bay and lower Sacramento River Valley. A shift to patrilocality in the San Francisco Bay region supports the hypothesis that increasing population and conflict shaped ethnographically documented kinship and residence systems.

BACKGROUND

The San Francisco Bay area is home to the largest freshwater estuary in California. This nutrient-rich water system is fed by the Sacramento-San Joaquin rivers which drain the Central Valley from the Sierra to Mt. Shasta. The Bay Area is composed of a mosaic of freshwater and saltwater marshes, grasslands, and woodland vegetation communities. The lower Sacramento River valley, bounded by the Pacific Coastal Range and the Sierra Nevada foothills, is a fertile area of riparian woodland, perennial grassland, and freshwater marshes which experienced significant seasonal flooding.

The time frame we focus on concerns occupations from the mid to late Holocene, divided into the three traditional time periods commonly applied to California archaeology: the Early period, 5350-3150 B.P.; the Middle period, 2160-940 B.P.; and the Late period, 740-180 BP (Groza 2002; all dates are calendar years before A.D. 1950). Although there were notable subsistence changes through time, evidence for a broad-spectrum foraging pattern including acorns, small seeds, hunting, and fishing is present throughout this sequence.

This article expands on work conducted by Bartelink (2006, 2009), who collected isotopic data on human skeletal remains to support the observations of various zooarchaeological studies (Broughton 1997) that suggest diet breadth expanded significantly during the late Holocene. Resource intensification during this period has been linked to increasing population density and a decrease in the highest-ranked resources. Through the use of skeletal analysis and isotopic dietary reconstruction, Bartelink (2006) was able to show that diet breadth was broad and expanded through time.

The sites from the lower Sacramento Valley include: Blossom Mound (CA-SJO-68), McGillivray 1 Mound (SJO-142), Brazil Mound (SAC-43), Hicks 1 mound (SAC-60), Cardinal Mound (SJO-154), and Johnson Mound (SAC-06). The sites from the San Francisco Bay region include: West Berkeley Village (ALA-307), Emeryville Shellmound (ALA-309), the Patterson Mound (ALA-328), and Ryan Mound (ALA-329). Site locations are shown in Figure 1.

The Blossom Mound is a Windmill site located on the banks of the Mokelumne River. The site is interpreted as both a village midden site and a cemetery, and is the oldest known burial site in the lower Sacramento River. The McGillivray 1 Mound is a Windmill site located on the Mokelumne River. The site appears to be a cemetery with no associate village found, but one could be deeply buried. The Brazil Mound is a Middle- and Late-period cemetery and village site on the Sacramento River with evidence of year-round occupation. The Hicks 1 Mound is a Middle-period and Late-period phase 2 cemetery site on the banks of the Sacramento River. The Cardinal Mound is a burial mound dated to the terminal Middle period and Late period phase 1a, located near the Calaveras and San Joaquin rivers. The Johnson Mound is a Late-period village site with evidence of year-round occupation, located on the Cosumnes River. West Berkeley Village is an Early-period shell mound with both a cemetery and a village component. Emeryville Shellmound is a Middle- and Late-period village site with associated burials. The Patterson and Ryan mounds are Middle- and Late-period sites with mortuary components and poorly understood seasonal occupation. A summary of the burials sampled from each site is found in Table 1.

METHODS

Oxygen has two stable isotopes, ^{16}O and ^{18}O , which are both present in a consistent ratio in seawater. The heavier isotope, ^{18}O , fractionates differentially from the lighter ^{16}O during evaporation and condensation, such that rainwater is always less enriched in ^{18}O compared to seawater and becomes progressively less enriched in rain falling farther from the coast. Plants and animals in a region express $\delta^{18}\text{O}$ values that reflect the oxygen fractionation for rainwater in the area. The oxygen from human bone apatite reflects the last several years of an individual's local water intake. In California, oxygen fractionation produces an east/west gradient that makes it possible to identify individuals living in, but not native to, a location (Figure 2). We analyzed $\delta^{18}\text{O}$ results for 118 individuals. We performed a Bayesian multivariate regression and ANOVA analysis of time period, region, and sex in predicting $\delta^{18}\text{O}$ values, to isolate possible trends in residence and mobility.

RESULTS

Based on predicted values of $\delta^{18}\text{O}$ in rainfall of -10.59 to -9.84 at Sacramento Valley sites and -7.02 to -6.97 at San Francisco Bay sites, expected spacing of $\delta^{18}\text{O}$ values between regions is 3.19. Observed mean differences less than that suggest migration or marital residence movement between the two regions.

Summaries of variation and of change in mean oxygen isotope values measured from burials are presented in Figures 3 and 4, respectively. In the Central Valley residence patterns appear to shift after the Early period from relatively endogamous residence to a more patrilocal society, with females migrating to the valley from more coastal locations. In the San Francisco Bay region, the Early period starts out more matrilineal, with males migrating from more inland locations. In the Middle period, there is a switch in residency patterns to a more patrilocal society, in which females are migrating from more inland locations. In the Late period, both men and women appear to be coming from the coast, suggesting a less exogamous marriage pattern.

Based on ANOVA analysis, the perceived interaction between sex, region, and period is significant within the data. AICc model comparison of a Bayesian regression analysis divides posterior weight between a model that includes the variables age, sex, and region and a model that includes these three variables along with their three-way interaction. Period appears to be the most important predictor of $\delta^{18}\text{O}$ values within regions.

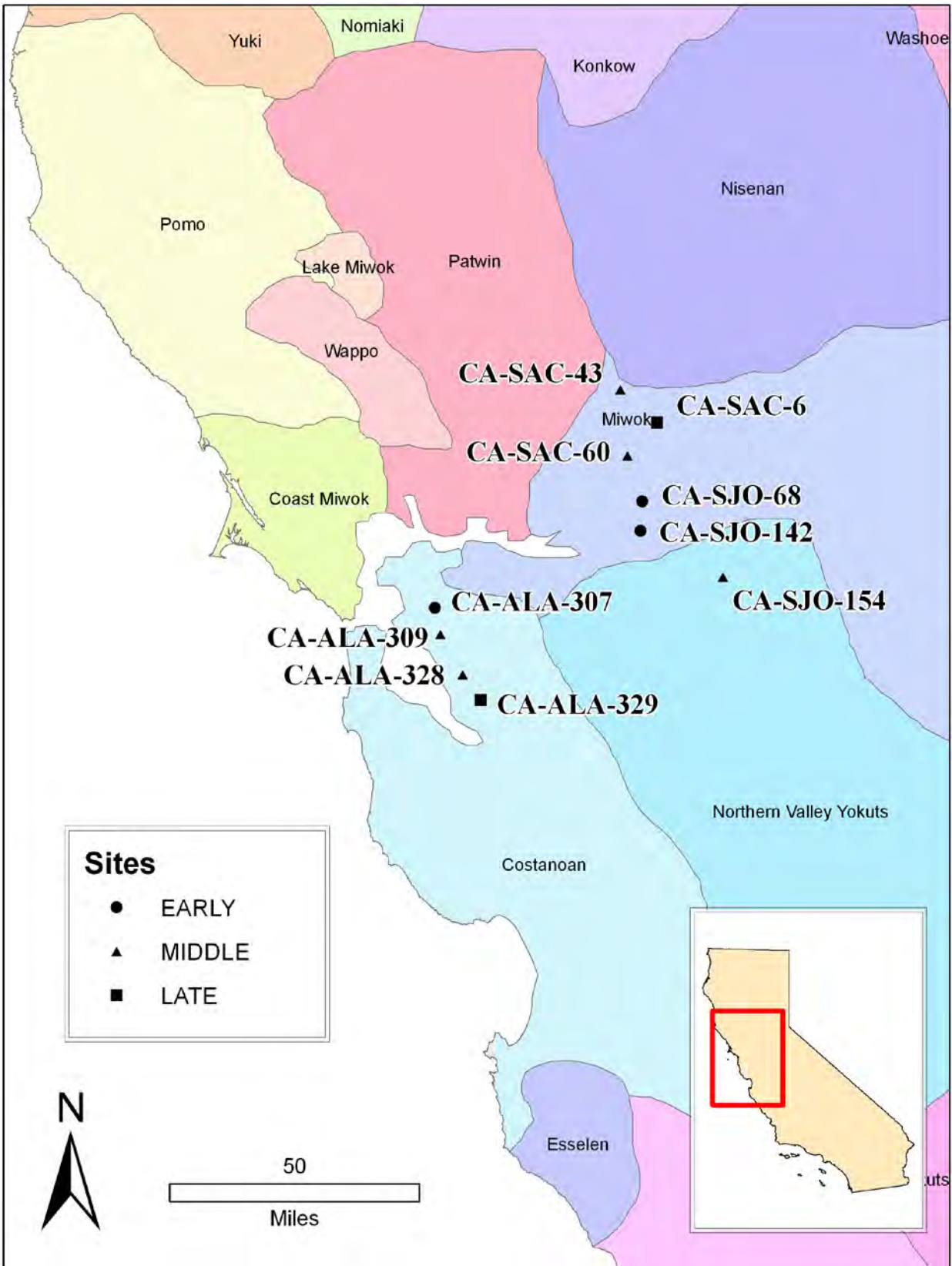


Figure 1. Location of sites that were analyzed by Bartelink (2006) and utilized in this study.

Table 1. A breakdown of burials sampled at each site by sex and temporal component.

SITE	PERIOD	MALE	FEMALE
SJO-142	Early	6	5
SJO-68	Early	7	6
SJO-56	Early	1	--
SAC-43	Middle	3	5
SAC-60	Middle	1	1
SJO-154	Middle	1	2
SAC-43	Late	1	1
SAC-60	Late	3	2
SAC-06	Late	6	5
ALA-307	Early	9	9
ALA-309	Middle	6	4
ALA-329	Middle	1	3
ALA-328	Middle	3	5
ALA-309	Late	3	--
ALA-329	Late	5	3

SUMMARY OF FINDINGS

- The Early period is characterized by endogamy in the Central Valley and matrilocality in the Bay region.
- Near San Francisco Bay, the Middle period is marked by a transformation from matrilocality to patrilocal.
- From the Middle period forward, residence in the Central Valley is strongly patrilocal.
- The San Francisco Bay region appears more endogamous in the Late period.

DISCUSSION

Previous stable isotope dietary reconstruction of each of the individuals in this study demonstrates that each region had distinct dietary patterns over time (Bartelink 2006). There were no significant temporal differences in diet over time for Sacramento Valley individuals. In contrast, the San Francisco Bay individuals show a significant change in resource use between the Early period and the Middle and Late periods. All of the San Francisco Bay individuals had a diet of terrestrial and marine resources, but it appears that after the Early period individuals shifted away from higher-trophic-level foods and focused more on gathered resources, including plants and shellfish.

For the same time periods that Bartelink (2006, 2009) suggests an intensification of resource use and expansion of diet breadth in the San Francisco Bay area, Wohlgemuth (2004) uses macrobotanical analysis to infer that there was an increase in small seed exploitation in the Central Valley. An increase in gathered resource use suggests that there was also an increase in the importance of women's work. Shifts in the importance of women's work could result in increased benefits for matrilocality. However, increased intensification of plant resources may also be connected with increasing population, social circumscription, and associated intergroup conflict. Pressure from intergroup conflict could favor patrilocal (Figure 5).

At ethnographic contact, all California Indian groups practiced postmarital residence and kinship that fit within a spectrum of strict patrilocal and patilineal decent to ambilocal residence with bilateral decent. Isotopic evidence from the Late period is consistent with this range of behavior. Burials from the Early period at San Francisco Bay, however, suggest that matrilocality may have once been present. The

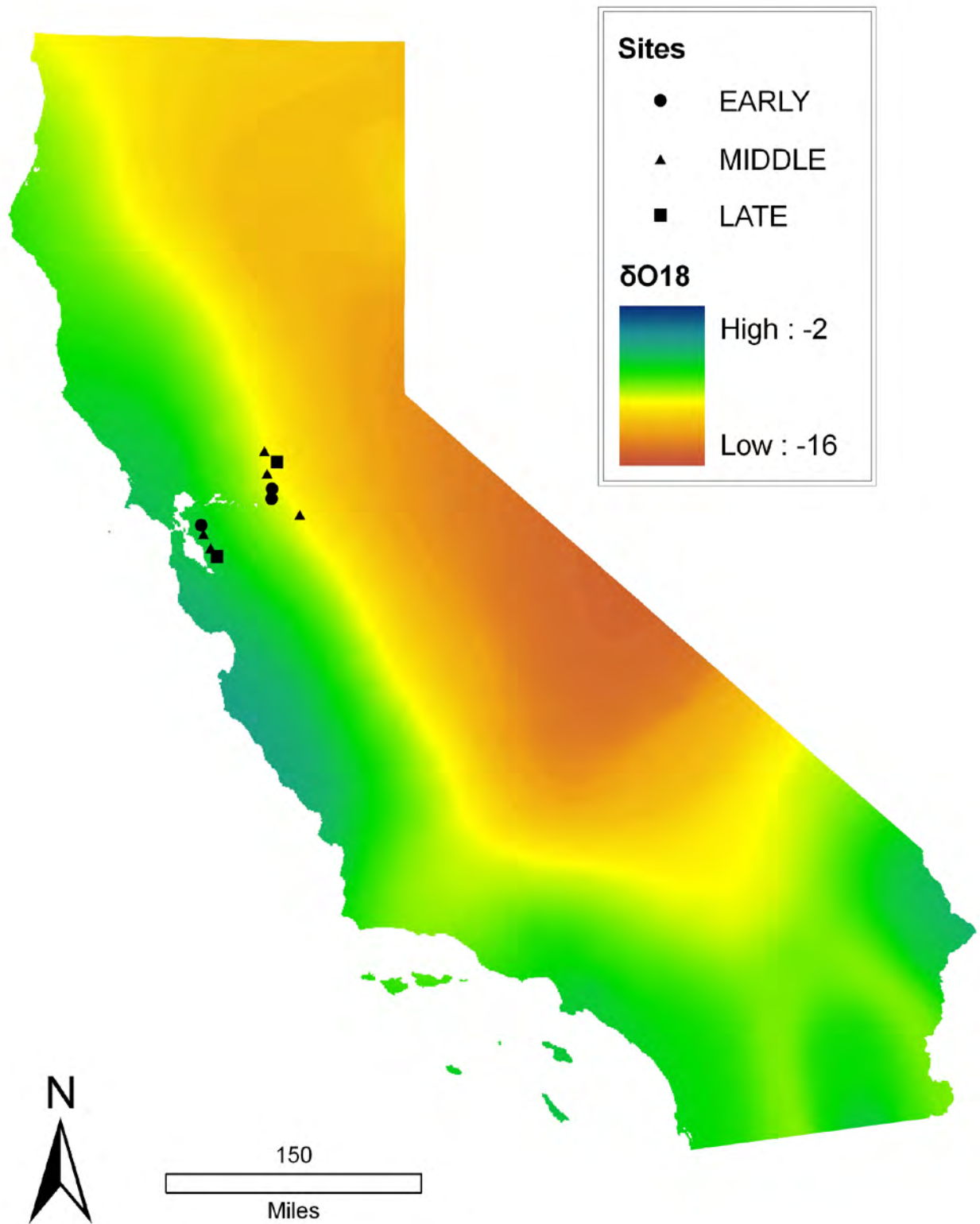


Figure 2. The location of sites in relation to $\delta^{18}O$ values for local rainfall predicted by Kendall and Coplen (2001).

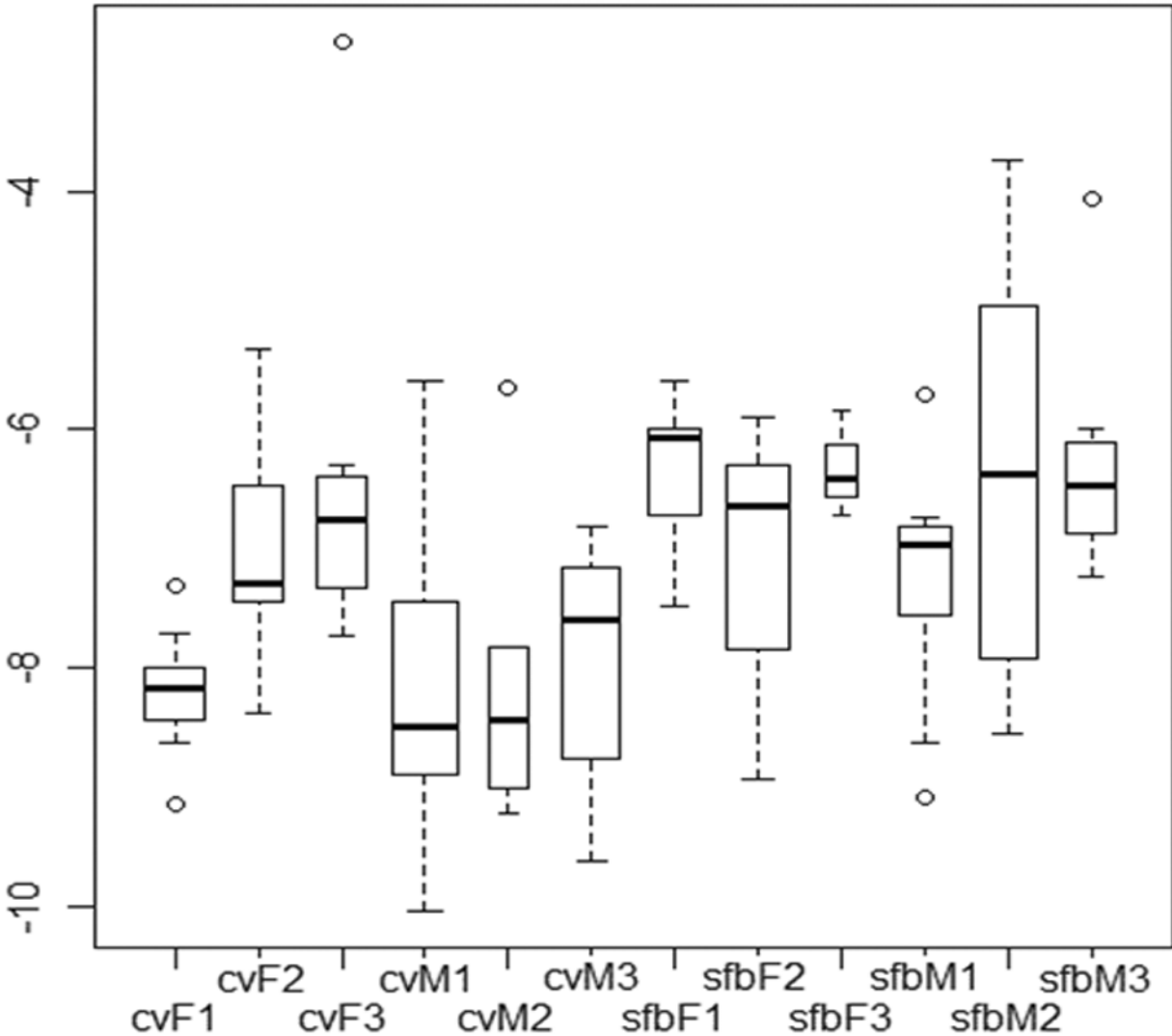


Figure 3. A box plot describing the data in terms of $\delta^{18}O$ for each of the regions divided into time periods (Early = 1, Middle = 2, Late = 3) and time periods divided by sex (M = males, F = females). The lines and boxes describe the confidence interval for the mean; the areas of the boxes are proportional to sample size.

ethnographic preference for patrilocalty suggests that population-driven conflict was likely more important than resource intensification in shaping kinship systems.

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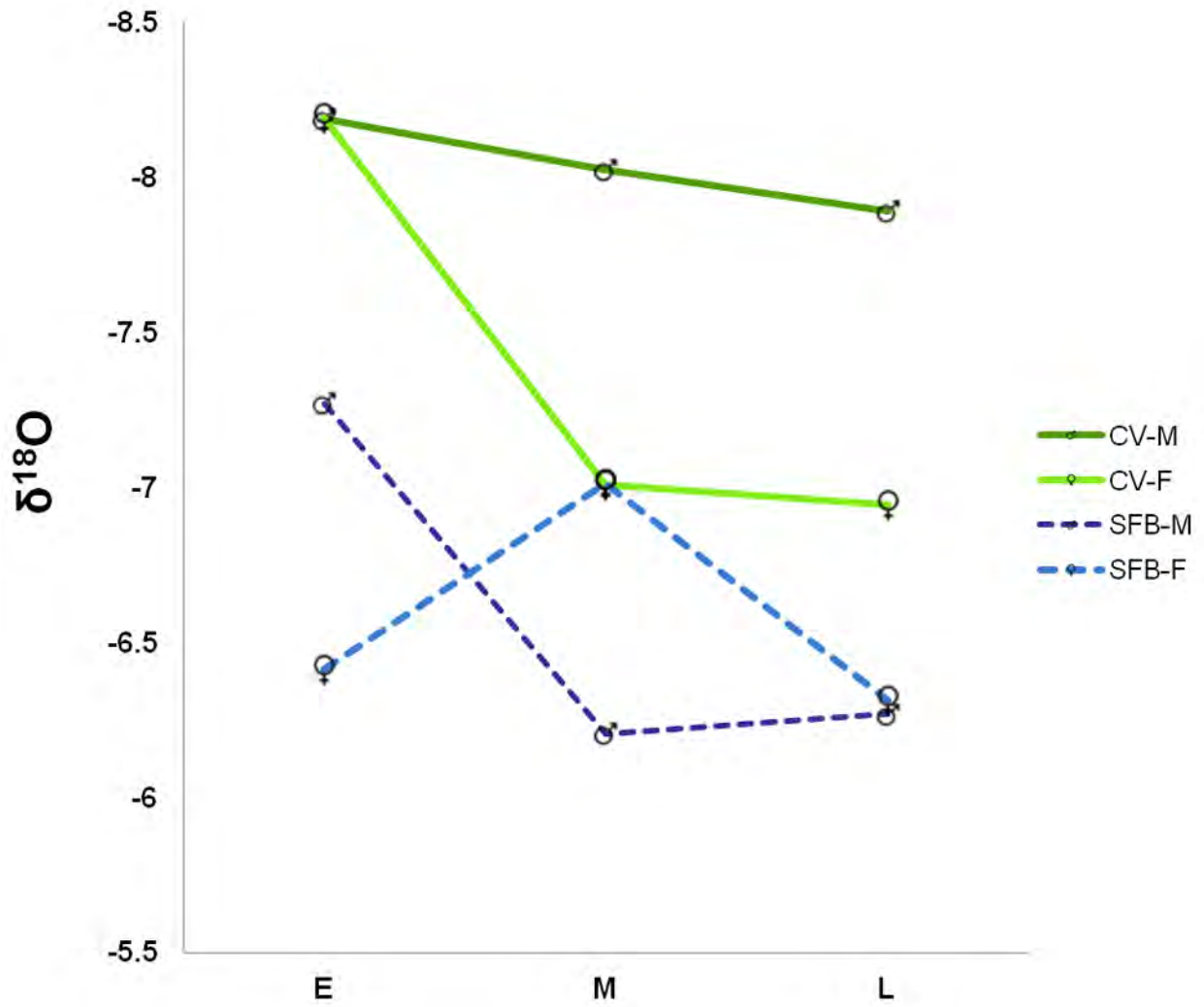


Figure 4. The above plots demonstrate the trends in the data for $\delta^{18}O$. Trends of mean change through time between periods and sexes using the $\delta^{18}O$ values without confidence intervals to more clearly demonstrate changes.

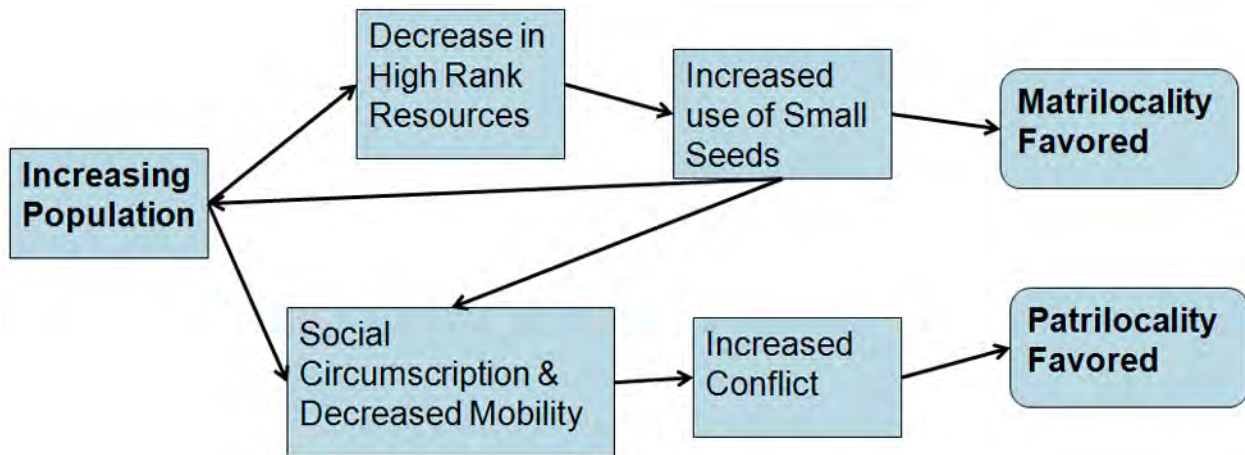


Figure 5. A summary of interactions between population density and postmarital residence pattern.

REFERENCES CITED

Bartelink, Eric John

2006 Resource Intensification in Pre-Contact Central California: A Bioarchaeological Perspective on Diet and Health Patterns among Hunter-Gatherers from the Lower Sacramento Valley and San Francisco Bay. Unpublished Ph.D. dissertation, Department of Anthropology, Texas A&M University.

2009 Late Holocene Dietary Change in the San Francisco Bay Area: Stable Isotope Evidence for an Expansion in Diet Breadth. *California Archaeology* 1:227-252.

Broughton, Jack M.

1997 Widening Diet Breadth, Declining Foraging Efficiency, and Prehistoric Pressure: Ichthyofaunal Evidence from the Emeryville Shellmound, California. *Antiquity* 71:274.

Groza, Randall G.

2002 An AMS Chronology for Central California Olivella Shell Beads. Unpublished Master's thesis, Department of Anthropology, California State University, San Francisco.

Kendall, Carol, and Tyler B. Coplen

2001 Distribution of Oxygen-18 and Deuterium in River Waters across the United States. *Hydrological Processes* 15:1363-1393.

Wohlgemuth, Eric

2004 The Course of Plant Intensification in Native Central California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Davis.