AGU GC31I-1152

The Bay Miwok Migration and the Pacific Decadal Oscillation: Insights from Bayesian Phase Modelling and Radiocarbon Event Count Ensemble Models

Mark E. Hall, PhD, RPA

Mark.Hall2@hdrinc.com

HDR

10615 Professional Circle, Suite 200

Reno, NV 89521

Introduction

One topic of interest for archaeologists and anthropologists is the resilience and adaptive response of complex hunter-gatherers to climate changes of the past. One of the purposes of this presentation is to examine the role of climate on cultural groups in the San Francisco Bay Area/Delta region over the past 1500 years.

While California archaeology has been traditionally focused on chronological issues, the chronologies are often based on cross-dating of artifact types and/or utilizing just the medians of calibrated radiocarbon dates. This presentation re-analyzes a set of recent radiocarbon determinations from the Hotchkiss Mound (CCO-138) and Simone Mound (CCO-139) sites (see Bartelink and Eerkens 2019). The Hotchkiss site is seen by archaeologists as being a site occupied by the Bay Miwok, while the neighboring Simone mound is a site associated with the earlier inhabitants of the region, ancestors of the Costanoan tribes. The reanalysis will utilize Bayesian phase modelling, radiocarbon event count (REC) ensemble modelling (see Carleton 2020), and Bayesian negative binomial (NB) regression of the RECs.

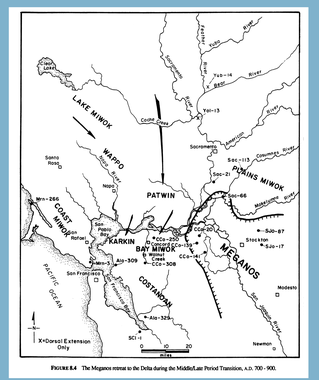


FIGURE 8.4 The Meganos retreat to the Delta during the Middle/Late Period Transition, a.D. 700 - 900.

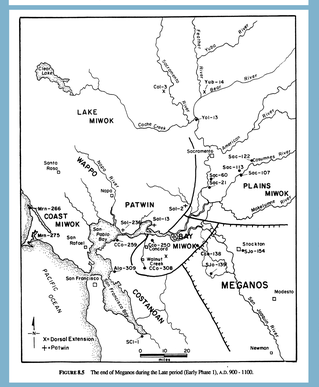


FIGURE 8.5 The end of Meganos during the Late period (Early Phase 1), a.D. 900 - 1100.

Above maps from Bennyhoff 1994b.

Archaeological Background

The Hotchkiss and Simone mounds are located in Contra Costa County, California near the town of Oakley. The sites are in the delta region of the San Francisco Bay, where the Sacramento and San Joaquin rivers merge. While the area today is dry and contains a variety of grasses and scrub vegetation, in the past when these two mounds were occupied, the area was a freshwater marsh dominated by tule, sedges and other rhizomes. Fauna in the area would have included freshwater mussels, salmon, tule elk, beaver and grizzly bears. Atchley (1994:11-13) and Evans (2014:14-15) contains a more detailed summary of the past flora and fauna of the site area.

Based on earlier radiocarbon dates and the taxonomic artifact dating scheme for the San Francisco Bay area, it is known that these sites were occupied over the last 1500 years. The past 1500 years have been characterized cycles of wet and dry periods with heavy influence by the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). Two major climatic events occur during this period: 1) the Little Ice Age (LIA) from 550 to 250 BP; and 2) the Medieval Climatic Anomaly (MCA) from 1150 to 600 BP. For the San Francisco Bay area, the LIA sees cooler temperatures and increased freshwater flow into the Bay. In the MCA, river flows into the bay are decreased and the salinity of the bay increased.

Archaeological excavations were conducted at the sites throughout the 20th century. Based on the earlier radiocarbon dates, toolkit assemblages, diagnostic artifact types, the Simone mound dates to the Middle/Late Transition Phase, dated circa 1250 to 1050 BP, for the Cosumnes District (Bennyhoff 1994a:74; Bennyhoff 1994b:86,87). The Simone mound site has been considered by archaeologists to be part of the Meganos cultural complex and potentially ancestral to modern-day Costanoan/Ohlone tribal groups. The Hotchkiss mound is assigned to the Late Horizon Phase, dated circa 1050 to 150 BP. At this time period, the bow and arrow, and simple harpoons, are introduced into the San Francisco Bay area—these and other cultural features are believed to come from the north from Patwin speaking groups. Archaeologists believe that the occupation at the Hotchkiss mound was by the Bay Miwok. The term Bay Miwok is used to designate both a California Native American group consisting of 7 tribes and their associated Penutian language. Geographically their territory covers Contra Costa and northern Alameda Counties. Archaeologists believe the Bay Miwok migrated into the California delta region from the Sacramento River valley due to the southward movements of Patwin speaking tribal groups.

Methodology

For this study, all calculations were performed utilizing a variety of packages from the R system (R Core Team 2022).

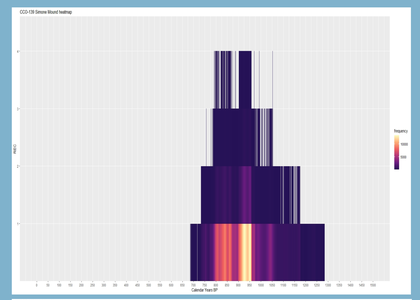
The creation of mixed calibration curves, reflecting a combined terrestrial-aquatic diet, and radiocarbon date calibration were performed in IntCal (Blaauw 2022).

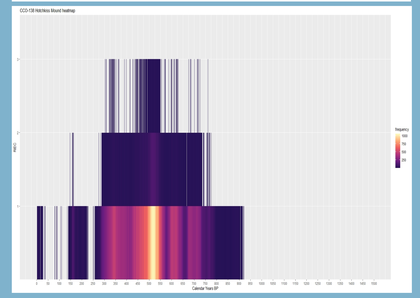
Bayesian calibration and phase boundary modelling was performed using the package nimbleCarbon (Crema and Di Napoli 2022). The start and end date for the occupation of each site mound was calculated using informative, uniform priors, Naylor-Smith-Buck-Christiansen priors (see Phillippe and Anne 2018), and log-normal priors (see Kidd 2019). The occupations were also assumed to possibly overlap. The full code is available from Mark.Hall2@hdrinc.com. The posterior distributions were checked by a variety of diagnostic tests. The use of different priors resulted in similar 95% Highest Posterior Density (HPD) regions.

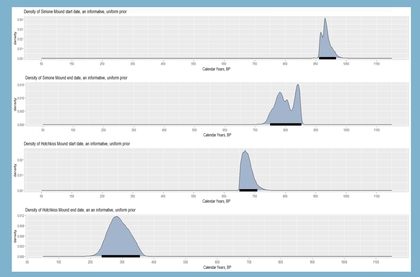
While a calibrated radiocarbon date may span hundreds of years, the reality of it, especially if a short lived sample like a seed, is that it is a single point in time--the calibrated density is just a map of the probabilities for the true date. Figure 3 in Carleton (2020) illustrates this issue using two dates.

By randomly sampling the calibrated radiocarbon densities, we can create large radiocarbon event-count sequences. Carleton terms a collection of these event-count sequences as a Radiocarbon Event Count Ensemble (RECE). The RECE is a point-wise estimate that can be used to look at through time changes in the number of events and account for chronological uncertainty. By using heatmaps, we can see the number of events in any given year. Since we have count data, we can use regression methods to look at a variety of climatic proxies to see their impact on the dated sequence of events (see for example Stewart et. al. 2022).

The RECE model was created using the Chronup package (Carleton 2022).







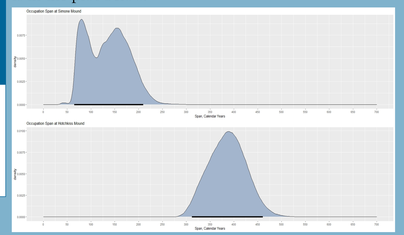
Site	Informative, Uniform Prior (95% HPD)	NSBC Prior (95% HPD)	Log-normal Prior (95% HPD)
Simone Mound start	962-1017 BP	961-1016 BP	964-1021 BP
Simone Mound end	799-902 BP	798-901 BP	792-894 BP
Hotchkiss Mound start	700-759 BP	700-759 BP	700-759 BP
Hotchkiss Mound end	285-406 BP	286-406 BP	286-407 BP

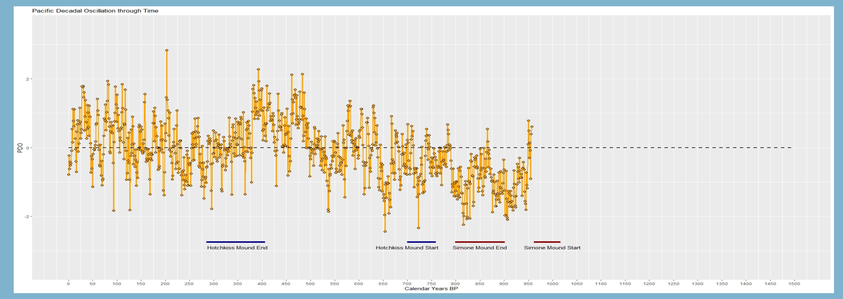
Results and Discussion

The figures on the left are heatmaps of the count-time pairings for the radiocarbon dates from the Simone and Hotchkiss mounds. The brighter/warmer colors indicate a higher probability of an event (in this case a death since all the dates come from human remains); so circa 790 BP to 975 is a time period with moderate to high probability of use of the Simone Mound. It bears noting, if these burials are representative of the Middle/Late Transition period, then the dating scheme (see Bennyhoff 1994a) is too early. Looking at the heatmap, there is a low probability of use between 1250 BP to 1050 BP. Also of note, there is a low probability of multiple events in any given year. The Simone mound saw use in the MCA, and interestingly enough, when there is a short moist period in the MCA from circa 780 to 740 BP (see Stine 1994), there is a low probability of the use of the Simone mound at that time.

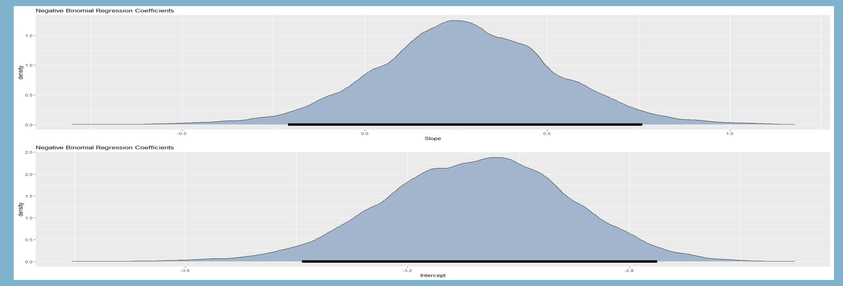
In the case of the Hotchkiss Mound, the heatmap indicates a moderate to high probability of site use from approximately 725 BP through 300 BP. Use starts at the end of the MCA, and has its highest probability of use in the Little Ice Age (LIA) (see Matthews and Briffa 2005).

The results of the phase modelling are also shown on the lower left. While the Simone Mound may have an artifact assemblage typical of Middle/Late Transition Phase, the 95% HPD beginning and end dates place it younger than in Bennyhoff's chronology (1994a). In regards to the Hotchkiss Mound, based on the 95% HPDs, it was occupied after a hiatus occurred at the Simone Mound. While the 95% HPD beginning and ending dates place it in the Emergent Period, the span of use at the site is longer than in Bennyhoff's chronology. The span of use of each site is in the plot below.





The above plot shows the PDO as reconstructed by McDonald and Case (2005) with the 95% HPD regions for the beginning and end dates of each site. It is interesting to note that the Simone Mound was occupied primarily when the PDO was negative. Negative PDOs in this part of California generally are characterized by drought. While the Hotchkiss Mound may have begun to be occupied during a period of drought, most of the occupation occurred during a time of positive PDO, when the climate would have been wet.



Bayesian binomial regression was performed using Chronup on the RECE model for the Hotchkiss Mound and the PDO. (Details of the process available on request to the author.) The regression coefficient for the model is skewed towards positive values, but the 95% HPD contains zero—this indicates the possibility there ***is not*** a correlation between the PDO and occupation at the Hotchkiss Mound.

Conclusions

The phase boundary modelling and RECE models indicate that the Simone and Hotchkiss mounds were not contemporaneously occupied, despite being adjacent to each other. The Bay Miwok mitigation may have occurred into a landscape that was unoccupied or very sparsely occupied. Bayesian negative binomial regression indicates that while the slope is positively skewed, the 95% HPD region of the slope contains zero and indicates that there is no correlation between the PDO and the RECE counts.

Bibliography

Aitchley, Sara M. (1994) *A Burial Analyses of the Hotchkiss Site (CCO-138).* Master Thesis, Sonoma State University.

Bennyhoff, James A. (1994a). Central California Augustine: Implications for Northern California Archaeology. In *Toward a New Taxonomic Framework for Central California Archaeology: Essays by James A. Bennyhoff and David A. Fredrickson*, edited by Richard E. Hughes, 65–74. Berkeley, CA: Contributions of the University of California Archaeological Research Facility No. 52. https://escholarship.org/uc/item/26144166 .

Bennyhoff, James A. (1994b). Variation within the Meganos Culture. In *Toward a New Taxonomic Framework for Central California Archaeology: Essays by James A. Bennyhoff and David A. Fredrickson*, edited by Richard E. Hughes, 65–74. Berkeley, CA: Contributions of the University of California Archaeological Research Facility No. 52. https://escholarship.org/uc/item/26144166 .

Blaauw, Martin. (2022) IntCal: Radiocarbon Calibration Curves. https://cran.r-project.org/web/packages/IntCal/index.html

Carleton, W. Christopher (2021) Evaluating Bayesian Radiocarbon-dated Event Count (REC) models for the study of long-term human and environmental processes. *Journal of Quaternary Science* 36(1): 110-123, DOI: 10.1002/jqs.3256 . https://onlinelibrary.wiley.com/doi/full/10.1002/jqs.3256

Carleton, W. Christopher. Chronup. https://github.com/wccarleton/chronup

Crema, Enrico and Di Napoli (2022) nimbleCarbon: Bayesian Analyses of Radiocarbon Dates with NIMBLE. https://CRAN.R-project.org/package=nimbleCarbon

Eerkens, Jelmer W. and Eric J. Bartelink (2019) New Radiocarbon Dates from CA-CCO-138 (Hotchkiss Mound) and CA-CCO-139 (Simone Mound) and Insights into Mounds, Settlement Patterns, and Culture History in the California Delta. *California Archaeology* 11(1):45-63.

Evans, Sally R. (2014) *Auditory Exostosis: A Marker of Behavior in Pre-Contact Populations from the San Francisco Region of California.* Master Thesis, Sonoma State University.

Kidd, R. S. (2019) Modelling Unstratified Burials via Bayesian Analysis with Log-normal Interval Priors. *Radiocarbon* 61(4):939-952.

Matthews, John A., and Keith R. Briffa (2005) The 'Little Ice Age': re-evaluation of an evolving concept. *Geografiska Annaler: Series A, Physical Geography* 87(1): 17-36. https://doi.org/10.1111/j.0435-3676.2005.00242.x

MacDonald, G.M., and R.A. Case (2005) Variations in the Pacific Decadal Oscillation over the past millennium. *Geophysical Research Letters*, 32(8). doi: 10.1029/2005GL022478 .

Phillippe, Lanos and Phillippe Anne (2018) Event date model: A Robust Bayesian tool for Chronology Building. *Communications for Statistical Applications and Methods* 25(2):131-157.

R Core Team (2022). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Stewart, Matthew, W. Christopher Carleton, and Huw S. Groucutt (2021) Climate change, not human population growth, correlates with Late Quaternary megafauna declines in North America, *Nature Communications* 12, 965, https://www.nature.com/articles/s41467-021-21201-8#Sec6

Stine, Scott (1994) Extreme and Persistant Drought in California and Patagonia during Mediaeval time. *Nature* 369: 546-549