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

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Introduction

One topic of interest for archaeologists and anthropologists is the resilience and adaptive response of complex human societies 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 the dating of artifact types and/or utilizing just the medians of calibrated radiocarbon dates. This presentation re-analyses a set of recent radiocarbon determinations from the Hotchkiss Mound (CCO-138) and Simone Mound (CCO-139) sites (see Bartelink and Eerkens 2019). This presentation is based on the assumption that these sites were occupied over the last 1500 years. The past 1500 years have been characterized by climate oscillations (see for example Stewart et al. 2022). 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 time changes through the number of events and account for chronological uncertainty. By using beam spaced event counts, we can determine the number of events in any given year. Since we have count data, we can use regression methods to look at a variety of climate proxies to see their impact on the dated sequence of events (see for example Stine, Scott 1994). The RECE model was created using the Chrypto package (Carleton 2020).

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 muskells, tule elk, beaver and grizzly bears. Atchley (1994:11-13) and Evans (2014:1-13) contain a more detailed summary of the past flora and fauna of the site area.

Based on earlier radiocarbon dates and the taphonomic 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 by well-defined cycles of wet and dry periods with heavy influence by the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). Two major climate events during this period: 1) the Little Ice Age (LIA) (1150 to 1950 BP) and 2) the Medieval Climatic Anomaly (MCA) (1150 to 1600 BP). For the San Francisco Delta, the LIA was cooler temperatures and increased freshwater flow into the Bay. In the MCA, river flows into the bay are decreased and the salinity increased, allowing for additional riverine and estuarine habitats; so circa 790 BP to 975 is a time period with moderate to high probability of use of the Simone Mound. It is important to note that in this time period, there is a low probability of multiple events in any given year. The Simone mound was used in the MCA, and interestingly enough, when there is a short period of time, there is a low probability of multiple events in any given year. The Simone mound was occupied primarily when the LIA occurred, and there is a low probability of use of the Simone mound at that time. In the case of the Hotchkiss Mound, the heatmap indicates a time span to high probability of site use from approximately 725 BP through 100 BP. Use starts at the end of the LIA, and has its highest probability of use in the Little Ice Age (LIA) (see Matthews and Boppa 2015).

The results of the heatmap analysis and results as shown on the forest 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 Bennyhoff’s chronology (1994a). In the case of 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 for the Hotchkiss Mound place it in the Emigration Period, the span of use of the site is longer than Bennyhoff’s chronology. The span of use of each site is in the plot below.

Methodology

For this study, all calculations were performed utilizing a variety of packages from the R system (R Core Team 2020).

The creation of mixed calibration curves, reflecting a combined temporal-distribution plot, and radiocarbon date calibration were performed in IntCal (Blaauw 2021). Bayesian calibration and phase boundary modelling was performed using the package nimaCarbon (Cromer and Di Napoli 2020). The start and end-date for the residence of each site was calculated using information, uniform priors, Neander-Smith-Berk-Christian (see Phillips 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.E.Hall@hdr.com. The posterior distributions were checked by a variety of diagnostic tools. 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 soil, 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 true usage of radiocarbon data.

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 time changes through the number of events and account for chronological uncertainty. By using beam spaced event counts, we can determine the number of events in any given year. Since we have count data, we can use regression methods to look at a variety of climate proxies to see their impact on the dated sequence of events (see for example Stine, Scott 2002). The RECE model was created using the Chrypto package (Carleton 2020).

Results and Discussion

The figures on the left are heatmaps of the count timings for the radiocarbon data from the Simone and Hotchkiss mounds. The bright/cooler colors indicate a higher probability of an event (in this case a death) and darker colors 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 is important to note that in this time period, there is a low probability of multiple events in any given year. The Simone mound was used in the MCA, and interestingly enough, when there is a short period of time, there is a low probability of multiple events in any given year. The Simone mound was occupied primarily when the LIA occurred, and there is a low probability of use of the Simone mound at that time. In the case of the Hotchkiss Mound, the heatmap indicates a time span to high probability of site use from approximately 725 BP through 100 BP. Use starts at the end of the LIA, and has its highest probability of use in the Little Ice Age (LIA) (see Matthews and Boppa 2015).

The results of the phase modelling are also shown on the forest 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 Bennyhoff’s chronology (1994a). In the case of 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 for the Hotchkiss Mound place it in the Emigration Period, the span of use of the site is longer than Bennyhoff’s chronology. The span of use of each site is in the plot below.

Bayesian binomial regression was performed using Chrypto on the RECE model for the Hotchkiss Mound and the PDIs (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—which indicates the possibility that there is no 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 migration may have occurred into a landscape that was unoccupied or very sparsely occupied. Bayesian binomial regression indicates that while the steps 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.

References