Demographic Artifacts of the Radiocarbon Calibration Curve: Implications for Identifying Mechanisms of Social Transformation

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INTRODUCTION

Archaeologists working on the Northern Channel Islands of California have use changing frequency of radiocarbon-dated components through time as a proxy for demographic change (e.g., Arnold 1992; Erlandson et al. 2001; Glassow 1999). Fluctuations in the number of dated components have been interpreted as demographic changes in response to climatic instability, introduction of disease, or social transformation (Arnold 1992; Erlandson et al. 2001; Kennett and Kennett 2000; Kennett 2005), assuming a correlation between the number of dated components and population size (see Rick 1997). Figure 1 depicts the distribution of dated components derived from the recently updated Northern Channels Islands Radiocarbon Database, which suggests gradually increasing population through the Holocene until a sharp rise and large fluctuations after 1600 cal BP. Component frequency is depressed during the unstable climate of the Medieval Climatic Anomaly (MCA; Stine 1994), rebounds thereafter, only to decline around the arrival of the Spanish. To what extent are these shifts caused by fluctuations in the calibration curve? Here we model the regular creation of datable archaeological carbon to explore the effect of variable atmospheric ^{14}C production calibrated component frequencies, focusing on the last 2000 cal BP. We show that some periods are likely to systematically over- or underestimate the number components present when intercepts are used to organize ^{14}C databases for demographic analyses.

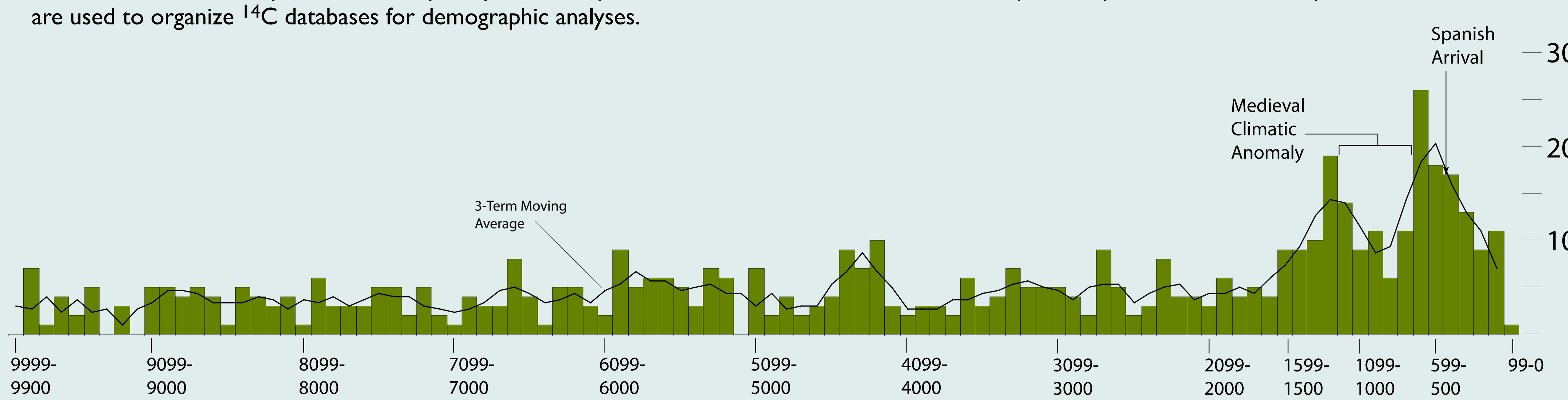

Figure 1. Northern Channel Islands Calibrated ^{14}C Component Frequencies, 10000 - 0 cal BP.

MODELING THE EFFECTS OF AVERAGING INTERCEPTS

Artifacts of the calibration curve should be identifiable by modeling constant introduction of datable carbon into the archaeological and assuming equal preservation and recovery, and calibrating with the Intcal98 curve. This is simulated with calendar intercepts at each decade depicted with vertical lines in Figure 2. Single intercepts correspond directly to a cal BP date. In many cases, the apparent age in ^{14}C years corresponds to several possible actual ages, resulting in multiple intercepts with the curve. Note that this is the stage where archaeologists typically enter the chronometric process - having obtained a conventional ^{14}C age on a sample. Calibrating the resulting ^{14}C age produces multiple intercepts, which are then averaged. As can be seen, reversals in the calibration curve produce more multiple intercepts, which tend to concentrate the averaged intercepts. Certain time periods are more likely to be represented than others if intercepts are used to organize a large database.

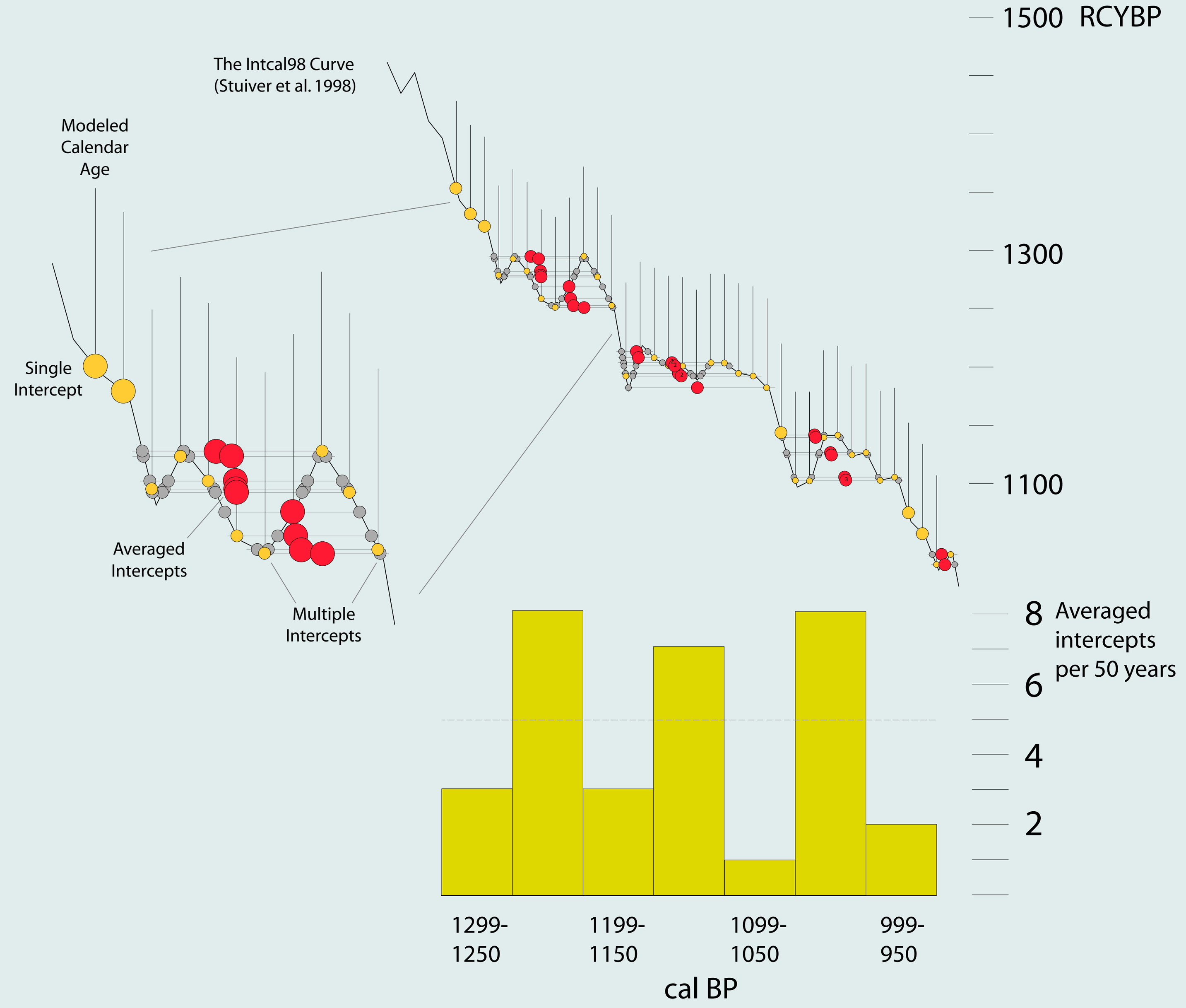

Figure 2. Model detail at 1299-950 cal BP assuming one component per decade. Averaged intercept frequencies vary from actual frequency (5 per 50 years) considerably in this period.

BIASES DURING THE LAST 2000 YEARS

Averaged intercepts are modeled on the Intcal98 calibration curve (Stuiver et al. 1998) assuming regular introduction, preservation and recovery of datable carbon into the record. Average intercept frequency per 50-cal-year period is summarized in the histogram below.

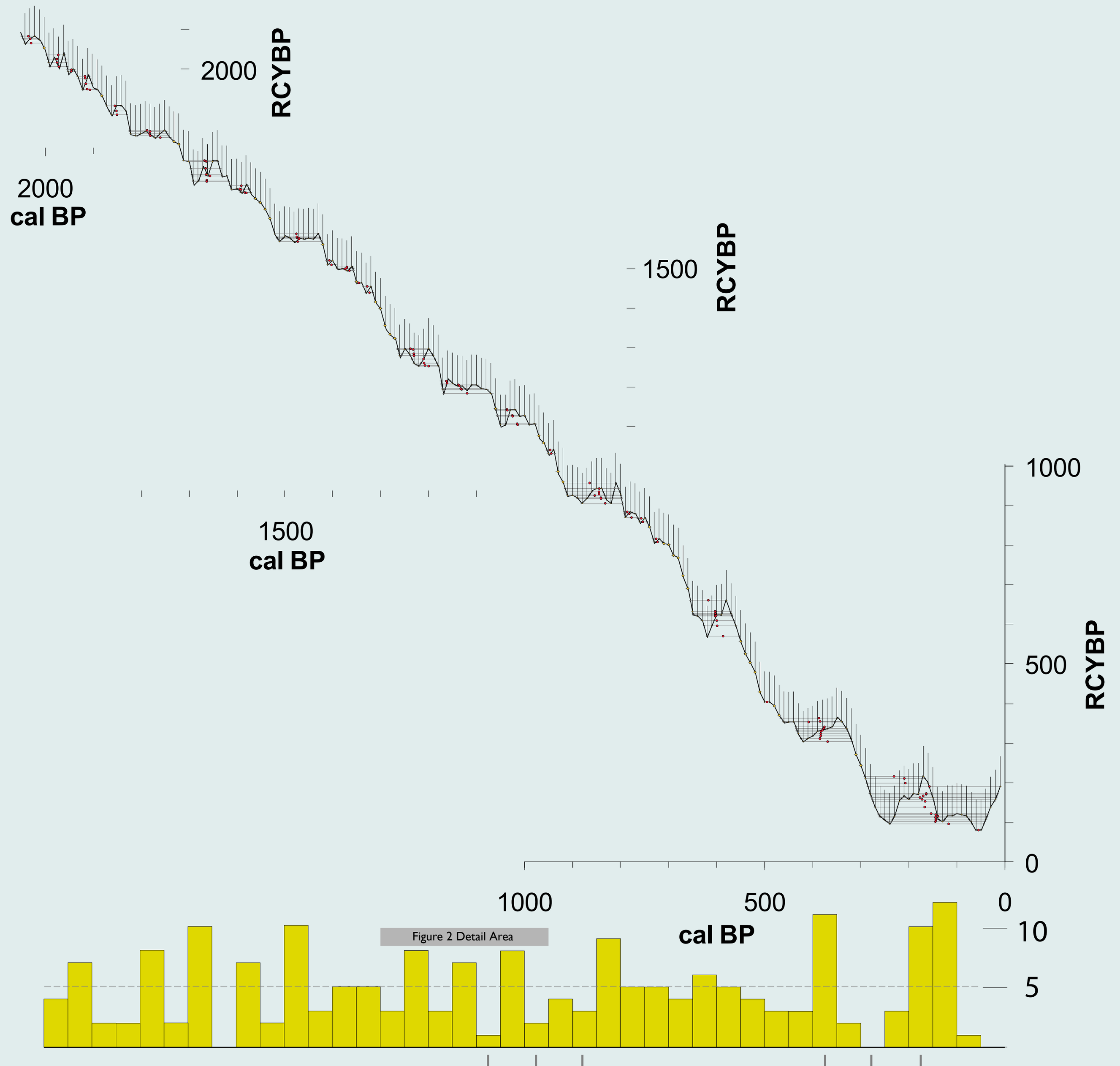

Figure 3. Modeled averaged intercept frequency 2000-0 cal BP assuming one component per decade, 50-year increments.

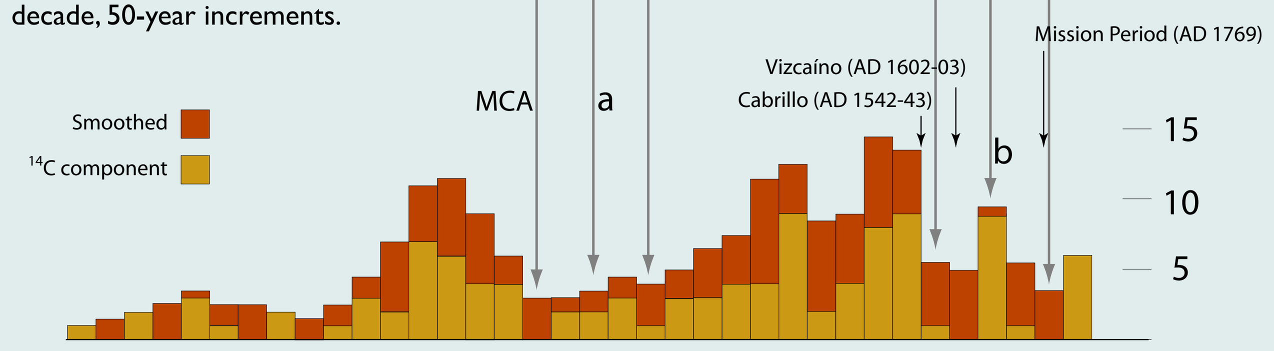

Figure 4. Northern Channel Islands calibrated ^{14}C component frequencies on short lived samples only, cal AD 50 - 1850, adapted from Erlandson et al. (2001:Figure 4).

Organizing radiocarbon dates by averaging intercepts (or using midpoints) is problematic in several parts of the last 2000 cal BP, as seen in Figure 3. The period from ca. 2000-850 cal BP is most variable, when sequential 50-year periods overestimate the number of components by up to 2 times and underestimate by half. Comparison with an earlier plot of short-lived, high-precision dates (Erlandson et al. 2001) suggests that depressed component frequency during the MCA may be partly due to biases in averaged intercept frequency (a). After 500 cal BP modeled and observed component frequencies are out of synch: periods expected to be overrepresented show declines, and vice versa (b).

COMPARISON TO THE CURRENT CHANNEL ISLANDS ^{14}C DATABASE

The previous model plot (Figure 3) shows that short-term fluctuations in radiocarbon production can create false trends (or obscure real trends) in component frequency when dates are organized by averaged intercept. Attempting to increase chronological resolution by measuring component frequency in 50-year increments exacerbates the problem. Model data are replotted in 100-year increments below.

Fluctuations from 2000-850 cal BP are reduced at this scale, though components are under-represented at 1950-1750 cal BP and 1100-900 cal BP, and 500-0 cal BP remains erratic.

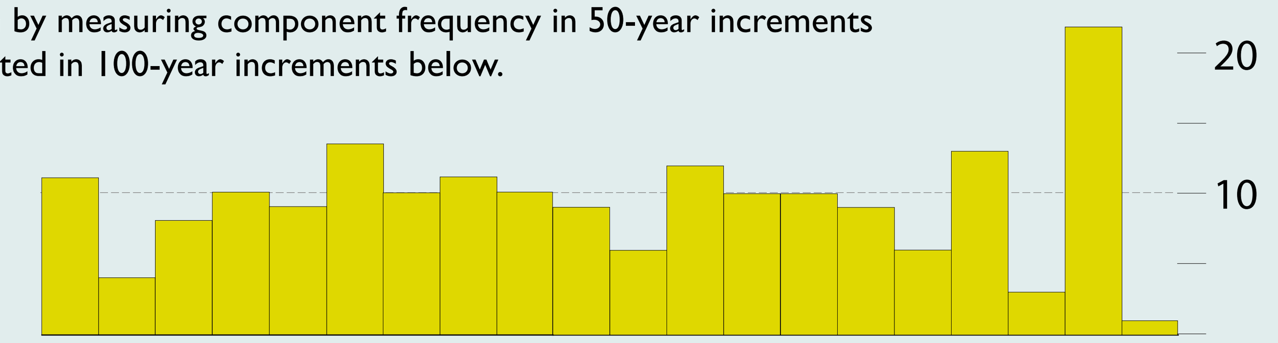

Figure 5. Modeled averaged intercept frequency 2000-0 cal BP assuming one component per decade, 100-year increments.

The current distribution of dated components reflects trends similar to those described by Erlandson et al. (2001): increasing after 1500 cal BP, reduced component frequency during the MCA, a peak ca. 700 - 400 cal BP, and a decline following the arrival of the Spanish. Notably, the Middle/Late Transition (800-650 cal BP) is marked by a sharp increase in dated components, rather than a decline as proposed by Arnold (1992).

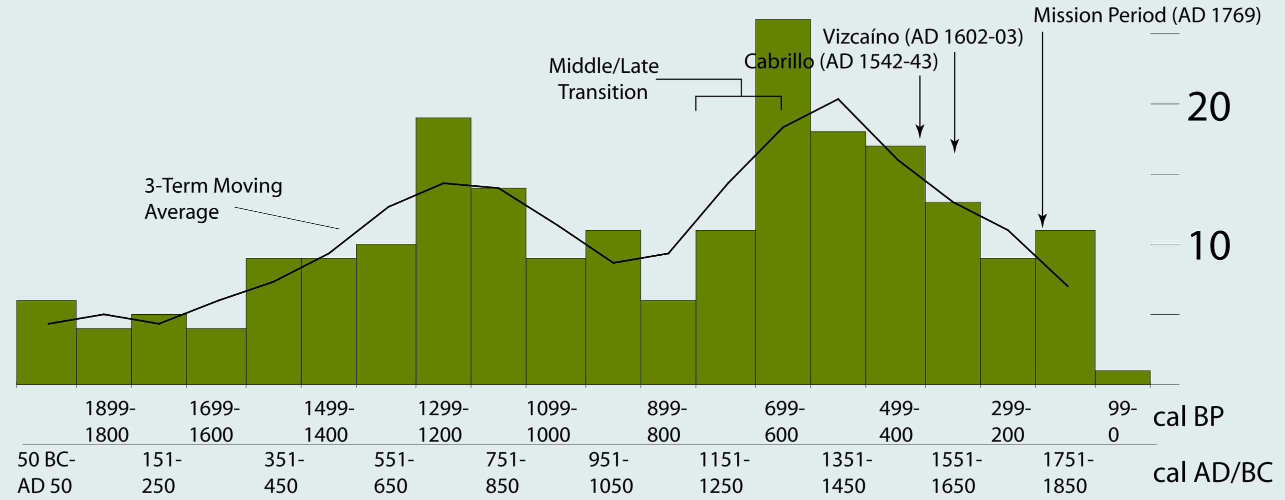

Figure 6. Northern Channel Islands calibrated ^{14}C component frequencies, cal 2000-0 BP.

Having estimated the biases in each century, perhaps the component frequencies in Figure 6 could be corrected. Figure 7 depicts the data transformed proportionate to the modeled frequency. The basic trends remain, though component declines in the MCA appear as late as 900 cal BP. Dramatic changes in the Protohistoric period coincide with the arrival of the Spanish. This could indicate that the impact of European disease brought by Cabrillo and Vizcaíno was *even greater* than Erlandson et al. (2001) estimated, as was the population rebound preceding the Mission Period.

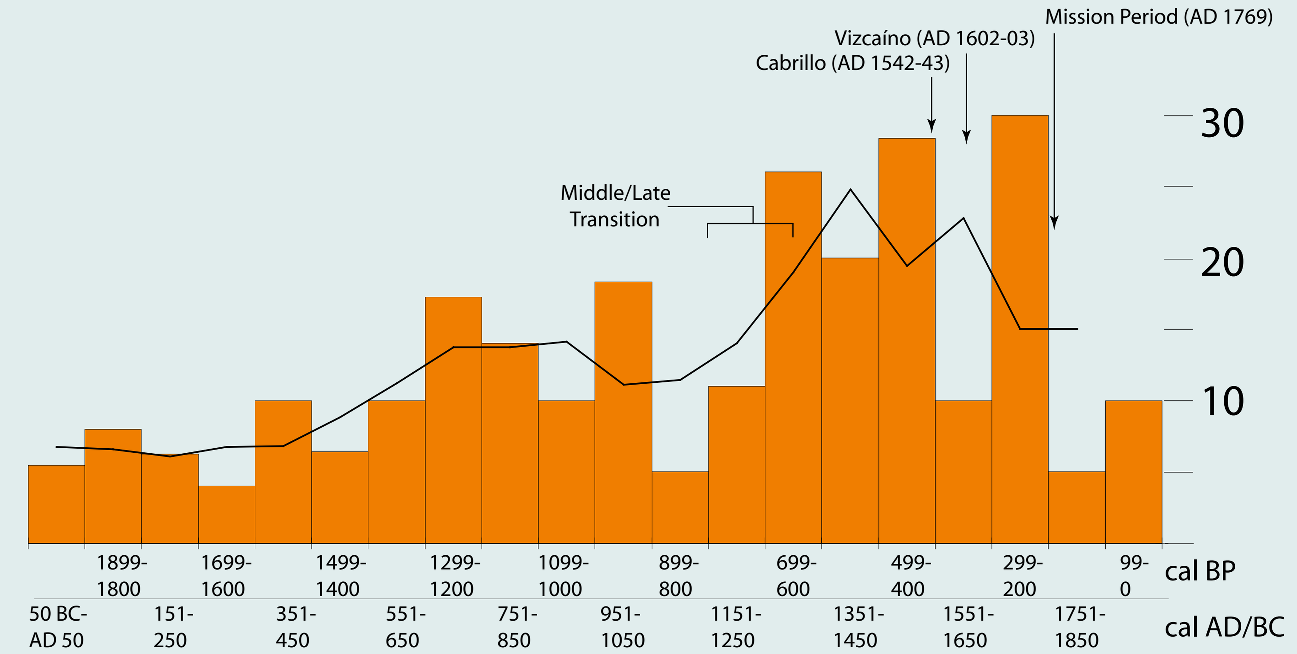

Figure 7. Northern Channel Islands calibrated ^{14}C component frequencies, cal 2000-0 BP.

This manipulation should be viewed with some caution, however. The wide swings in the component frequency during the Late and Protohistoric periods could reflect demographic shifts in response to environmental change, economic intensification, or introduction of European disease. But, where the model shows wide departures from the expected frequency of ^{14}C components, a correction will magnify the errors inherent in the use of dates as demographic proxies (e.g., it is unlikely that there should actually be 10 components dating in the last century cal BP on the Northern Channel Islands). We may be more confident that additional errors are not added at periods where the expected frequency is observed, for example, during the Middle-Late Transition, when the number of dated component rises sharply after an apparent decline during the MCA. At coarser time scales (e.g., 200-year increments), short-term fluctuations in the calibration curve will produce fewer demographic artifacts. Further, the less convoluted nature of marine calibration curve suggests that marine carbonates may provide less problematic high-resolution dating.

REFERENCES CITED J.E. Arnold (1992) *American Antiquity* 57(1):60-84; J.M. Erlandson, T.C. Rick, D.J. Kennett and P.L. Walker (2001) *Pacific Coast Archaeological Society Quarterly* 37(3):11-26; M.A. Glassow (1999) *Journal of California and Great Basin Anthropology* 21(1): 45-66.; D.J. Kennett (2005) *The Island Chumash: Behavioral Ecology of a Maritime People*, UC Press; D.J. Kennett and J.P. Kennett (2000) *American Antiquity* 65(2):379-395; J.W. Rick (1987) *American Antiquity* 52(1): 55-73; S. Stine, (1994) *Nature* 369:546-549; M. Stuiver, P.J. Reimer, E. Bard, J.W. Beck, G.S. Burr, K.A. Hughen, B. Kromer, F.G. McCormac, J. van der Plicht and M. Spurk (1998) *Radiocarbon* 40:1041-1083.

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