Patterns of paleomobility in the ancient Antilles: an isotopic approach
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Citation
Laffoon, J. E. (2012, October 31). *Patterns of paleomobility in the ancient Antilles: an isotopic approach*. Retrieved from https://hdl.handle.net/1887/20072

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Issue Date: 2012-10-31

CHAPTER 7 DISCUSSION

7.1 Introduction

In the previous chapter I presented the results of multiple isotope analyses of plants, animals, and human remains. In this chapter I discuss these results in terms of how they are utilized to identify and interpret patterns of human mobility in the Caribbean. This chapter begins with a discussion of the results of Sr isotope analyses of animal and plant remains to assess the spatial patterns of biosphere $^{87}Sr/^{86}Sr$ variation throughout the Caribbean region. The following section focuses on discussions of multiple isotope analyses of human remains from a number of sites throughout the Caribbean beginning with an assessment of various methods for determining local ranges of $^{87}Sr/^{86}Sr$ and the differences these methods provide in terms of the determination of locals and nonlocals. Next, I present the estimated local $^{87}Sr/^{86}Sr$ ranges and a comparison of the range of human and biosphere $^{87}Sr/^{86}Sr$ results for each site/population. In this section, I also discuss which individuals were identified as nonlocals and assessments of their possible origins. This discussion is followed by a comparative analyses of patterns of mobility vis-à-vis a number of other relevant parameters including demography, chronology, body modification practices, mortuary treatment, and dietary patterns. Finally I discuss the results of carbon and oxygen isotope analyses of a subset of the human sample population and the implications of these results for identifying nonlocals, inferring mobility, and determining the possible origins of specific nonlocal individuals.

7.2 Spatial Variability of Biosphere $^{87}Sr/^{86}Sr$ in the Caribbean

Various faunal and floral samples were collected and analyzed for Sr isotope ratios primarily to assess the range of biosphere $^{87}Sr/^{86}Sr$ variation for the site locations included in this study and to map $^{87}Sr/^{86}Sr$ variation in the Caribbean biosphere for the purpose of interpreting human Sr isotope data and investigating the geographic origins of nonlocal humans (Laffoon et al. 2012a). The animal samples comprise a mixture of modern and archaeological faunal remains, mostly land snails and rodents while the plant samples are all modern and are primarily various species of grasses. Both the animal and plant samples should reflect the local bioavailable Sr pool.

This data set establishes that there is not a simple, direct correlation between measured biosphere $^{87}Sr/^{86}Sr$ and the $^{87}Sr/^{86}Sr$ predicted based on the underlying geology. This poor correlation is likely the result of a number of factors including; multiple influxes of non-geological Sr into terrestrial Caribbean ecosystems with significant but variable contributions of marine and atmospheric Sr from marine aerosols or sea spray, and variations in the weathering and solubility of different soil components and mineralogy. We conclude that local biosphere $^{87}Sr/^{86}Sr$ cannot be directly inferred from associated geology in this region. However, our data set clearly establishes that estimations of local terrestrial biosphere $^{87}Sr/^{86}Sr$ can be derived from Sr isotope measurements of local plant and animal samples.

Despite large differences between predicted and observed *absolute* Sr isotope values, there is clear spatial patterning of biosphere $^{87}Sr/^{86}Sr$ in the Caribbean based on associated geology (Figures 30 and 31). These maps display the predicted biosphere $^{87}Sr/^{86}Sr$ for the circum-Caribbean region and eastern Caribbean respectively and are based on a multi-source predictive model that accounts for variable inputs, concentrations and compositions of Sr from bedrock weathering, precipitation, and dryfall based on the work of Bataille and colleagues (in press). This model agrees well with the empirical dataset of biosphere $^{87}Sr/^{86}Sr$ variation for the Caribbean region presented in this present study. In general, there are distinct differences in the means and ranges of $^{87}Sr/^{86}Sr$ between certain subregions with relatively little overlap in $^{87}Sr/^{86}Sr$ ranges, particularly between the two subregions from Trinidad and Venezuela and the remainder of the subregions from the Antilles proper. In contrast, substantial overlap exists between some subregions within the Antilles, in particular between areas of older limestone and those of volcanic geologies.

In terms of assessing ancient mobility within the insular Caribbean or Antilles (*sensu stricto*), despite some degree of overlap between volcanic and limestone areas, the isotopic identification of mobility is possible at certain scales. Although the Sr isotope ranges for entire archipelagos or some island groups are rather large, when broken down by associated geology there is much less overlap on a case by case basis. For example Tobago has a very large range (0.70475 to 0.71026) of biosphere ^{87}Sr/^{86}Sr owing to its rather complex and variable geology. This suggests that intra-island mobility between different areas of this island should be identifiable but that inter-island mobility from most areas of the Antilles to Tobago would be difficult to detect. The same overall trend holds for the Greater Antilles, where there is relatively little overlap in ^{87}Sr/^{86}Sr ranges between coastal alluvial deposits and limestone hills on the one hand, and the interior regions composed of mosaics of volcanic, intrusive, and metamorphic zones on the other. The implication of this pattern is that for the Greater Antilles, intra-island mobility between the interior and the coast (or *vice versa*) is potentially identifiable via Sr isotope analysis.

In terms of intra-archipelagic mobility, even within a single archipelago there are some clear distinctions in the ranges of biosphere ^{87}Sr/^{86}Sr between certain islands. For example, despite broad geological similarities between all of the islands of the Volcanic Caribbees, some of the islands display little or no overlap with other islands or groups of islands. Specifically, there is a general trend towards more elevated ^{87}Sr/^{86}Sr ratios in geological samples within the Volcanic Caribbees going from south to north, probably as the result of greater degrees of crustal contamination in the northern islands relative to the southern ones during the development of this island arc (Davidson 1983, 1987). This same general south to north trend is also apparent in the biosphere ^{87}Sr/^{86}Sr ranges within the Volcanic Caribbees (see Appendix A), with the exceptions of Martinique and St. Lucia. More specifically, there is little or no overlap in biosphere ^{87}Sr/^{86}Sr ranges between the southernmost islands of St. Vincent and Grenada and many of the volcanic islands to the north including Saba, St. Eustatius, Les Saintes, and St. Lucia. This pattern suggests that in many cases it is possible to identify inter-island mobility even between islands of broadly similar geologies. Furthermore, the lack of overlap in ^{87}Sr/^{86}Sr ranges between the Volcanic Caribbees and the Limestone Caribbees is a promising result for the exploration of mobility between these two archipelagos. In fact, biosphere ^{87}Sr/^{86}Sr results from areas dominated by marine limestone deposition most closely matched the expectations based on underlying geology. This result is not overly surprising in that the most likely cause of differences between biosphere values and geological ^{87}Sr/^{86}Sr ratios in coastal and island environments is the additional input of marine Sr. As geologically young limestone possesses similar ratios to that of modern seawater, little difference exists between the ^{87}Sr/^{86}Sr ratios of terrestrial and marine inputs in these regions.

Trinidad and Venezuela possess areas underlain by metamorphic rocks. As expected, these areas contain elevated ^{87}Sr/^{86}Sr relative to the overall biosphere ^{87}Sr/^{86}Sr range for the insular Caribbean. Sedimentary deposits of Tertiary marine strata and Quaternary alluvium from southern Trinidad and coastal Venezuela are also generally elevated in ^{87}Sr/^{86}Sr relative to the insular Caribbean. These patterns are of special importance for investigations of prehistoric mobility in the Caribbean, as northern mainland South America and Trinidad are widely believed to be areas of potential origin(s) for various migrations into the Antilles based on a large body of archaeological evidence (Rouse 1986, 1992). As such, migrants originating from Trinidad, Venezuela, (or from the Guiana Shield Region) should be identifiable as immigrants via Sr isotope analyses. In summary, these results indicate that baseline biosphere ^{87}Sr/^{86}Sr data are essential for archaeological applications of strontium isotope analysis to provenance studies in the Antilles.

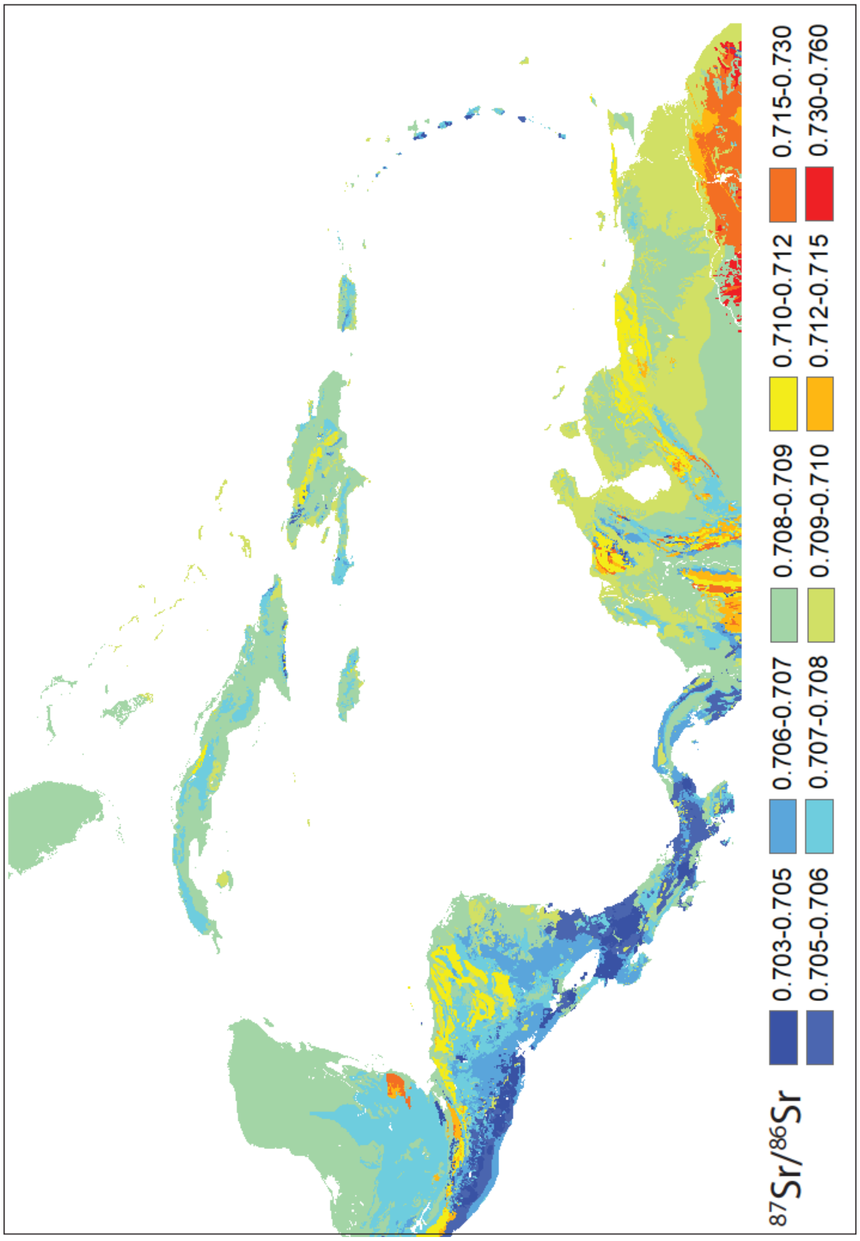


Figure 30 **Map of modeled biosphere $^{87}Sr/^{86}Sr$ variation in the Circum-Caribbean.**

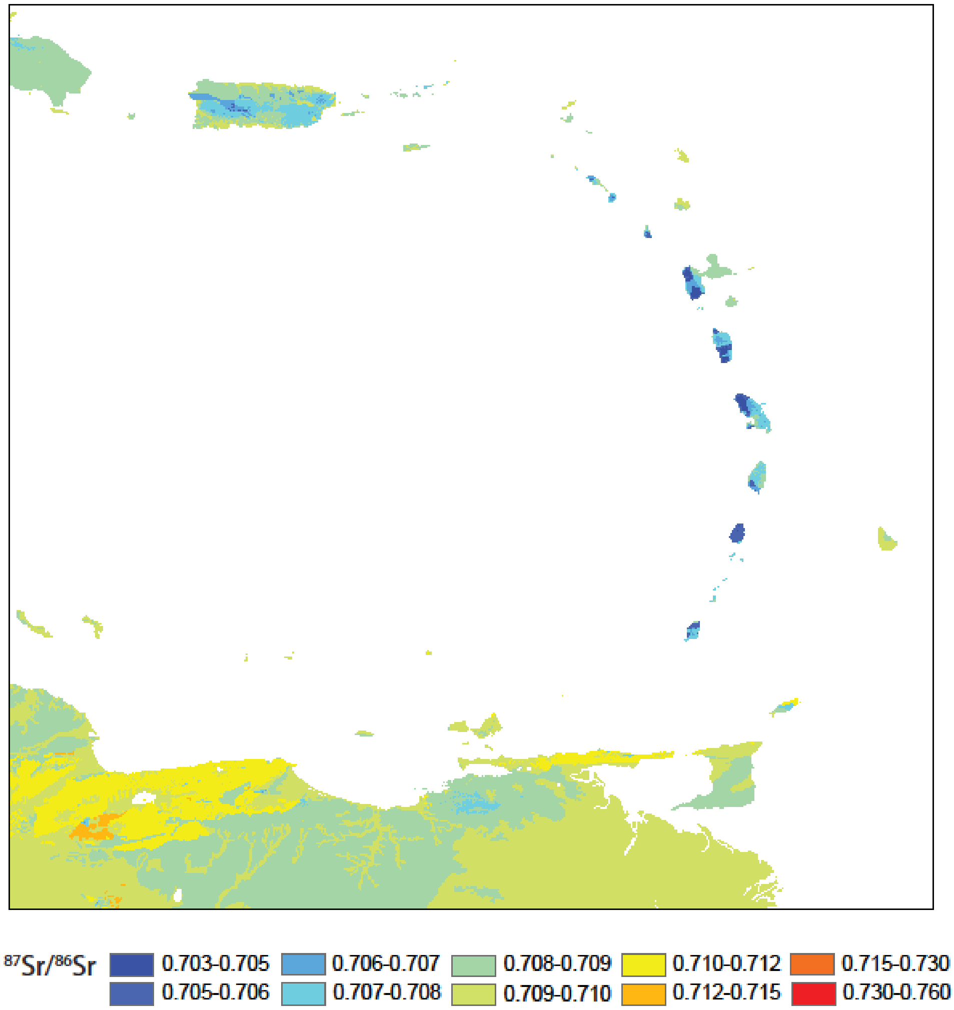


Figure 31 Map of modeled biosphere ^{87}Sr/^{86}Sr variation in the Eastern Caribbean.

Note: Maps adapted from figure 5B in Bataille et al. (in press).

7.2 Interpreting Human Strontium Isotope Results

In this section, I discuss the analysis of the strontium isotope data from the human sample populations in this study. I begin with a discussion of various methods for estimating local $^{87}Sr/^{86}Sr$ ranges and the potentially variable results that these produce in terms of the estimated local ranges and subsequently of the number and proportion of populations that are identified as either local or nonlocal. Next, I present the approaches that were ultimately used in this study to estimate the local Sr isotope ranges and the identification of local and nonlocal individuals. In this section I also describe the statistical measures that were employed in the analysis of the isotope data.

7.2.1 Comparison of different methods for estimating local Sr isotope ranges

Various methods have been employed to identify nonlocal individuals via strontium isotope analysis of human dental enamel. These include but are not limited to: 1) comparisons with geological expectations; 2) comparisons with bone Sr ratios from the same individual, 3) comparisons with the range of Sr isotope ratios of human teeth from the same population, 4) comparisons with the range of biosphere Sr isotope ratios (e.g., from local plants and/or animals); 5) statistical assessments of human Sr isotope data; or 6) a combination of these approaches. The choice of approach is not only dependent on the context of the archaeological assemblage but also on the availability of comparative data sets. Furthermore, and perhaps most importantly, different approaches often produce widely disparate results, not only in terms of the range of local isotope ranges but also, by consequence, in the identification of which individuals are local and which are nonlocal within a given population. In other words, certain individuals may possess Sr isotope signals that are extremes or statistical outliers relative to comparative populations and thus are identified as nonlocals regardless of which approach is utilized. On the other hand, for many populations there are often one or several individuals with $^{87}Sr/^{86}Sr$ ratios that are neither typical nor extreme relative to others (Price et al. 2002). In these cases, the choice of approach for assessing and interpreting the range and distribution of local isotope variation can greatly influence which individuals are identified as nonlocals and which as locals.

These different methods for estimating local Sr isotope ranges produced vastly different results in terms of the number and proportions of locals/nonlocals within these populations. For the sake of consistency, I would prefer to consistently apply a single system to all of the populations, unfortunately this is not possible. For example, one of the more commonly used methods, comparisons with the range of $^{87}Sr/^{86}Sr$ signals from local plants and animals (the biosphere approach), is limited in cases where these types of samples are unavailable or limited in number. Likewise, statistical assessments of Sr isotope data of human populations alone are also limited in many cases owing to very small sample sizes. Thus, no single method for assessing the range of local variation is appropriate for all of the sample populations in this study. The quantity and quality of the different data sets, the sample materials from which they derive, and the distribution of the $^{87}Sr/^{86}Sr$ ratios for different data sets are highly variable. These circumstances have forced me to use somewhat different methods for estimating the local ranges for some populations. I have tried to use methods that incorporate as much available data as possible and that are appropriate for the nature of the available data set for each population.

Ideally, the most robust approach would incorporate large sample sets of biosphere data obtained from different sample materials (plants and animals) of different species representing varying catchment areas. Additionally, biosphere data obtained directly from the site location should be complemented with similar data obtained from samples from the surrounding area to provide some indication of the spatial extent of the estimated local range. Furthermore, the integration of theoretical models of spatial variation with available empirical data sets should permit fairly robust predictions of Sr isotope variation for un-sampled areas and provide some indication of where sampling density and intensity needs to be increased (Bataille and Bowen 2012).

7.2.2 Methods applied to the identification of nonlocal humans

The primary method for identifying locals versus nonlocals that I have applied to most of the populations in this study is based on a modification of the statistical approach proposed by Booden and colleagues (2008) [see also (Wright 2005)]. For sites from which comparative biosphere samples have been analyzed for Sr isotope composition, these data have been pooled with the human $^{87}Sr/^{86}Sr$ data into a single sample population. Descriptive statistical analyses of these pooled samples were then conducted using SPSS Student Version 18.0 (Statistical Package for the Social Sciences). Outliers were identified after each iteration of the data analysis using the stem and leaf method. These outliers were subsequently removed from the sample population and the trimmed data set was reanalyzed. Outliers were removed after each subsequent iteration of this process until the distribution of the trimmed sample population possessed convergent mean and median values, low skewness relative to the standard error of skewness, and the distribution of the data approached a normal distribution (i.e., the null hypothesis of a normal distribution was not rejected via a Shapiro-Wilk test for normality).

The results of the iterative statistical analyses were then compared to the dispersion and range of $^{87}Sr/^{86}Sr$ ratios for the 'local' human population and to the absolute range of biosphere $^{87}Sr/^{86}Sr$ ratios for the site itself and the larger region or island. Descriptions of the application of this statistical method and the results thereof are presented individually for each sample population in the following sections. In some cases, variations of this approach were applied depending on the availability, quantity, and quality of comparative data and the dispersion and variance of the initial sample population.

One potential problem with this approach is that while a local population might be expected to possess normally distributed $^{87}Sr/^{86}Sr$ ratios, a normally distributed $^{87}Sr/^{86}Sr$ sample population does not necessarily indicate that a population is local. In other words, clustering of $^{87}Sr/^{86}Sr$ data could also result if the majority of sampled individuals in a given population were immigrants originating from the same (or isotopically similar) foreign location(s). That being said, this outcome is probably unlikely given the archaeological contexts of the populations in this study. Additionally, biosphere $^{87}Sr/^{86}Sr$ ratios provide an independent means of estimating and assessing local $^{87}Sr/^{86}Sr$ ranges. For most populations in this study, there is good agreement between the $^{87}Sr/^{86}Sr$ ratios of locally defined human populations and the biosphere $^{87}Sr/^{86}Sr$ data. These comparisons and exceptions to the general pattern are described in the following sections.

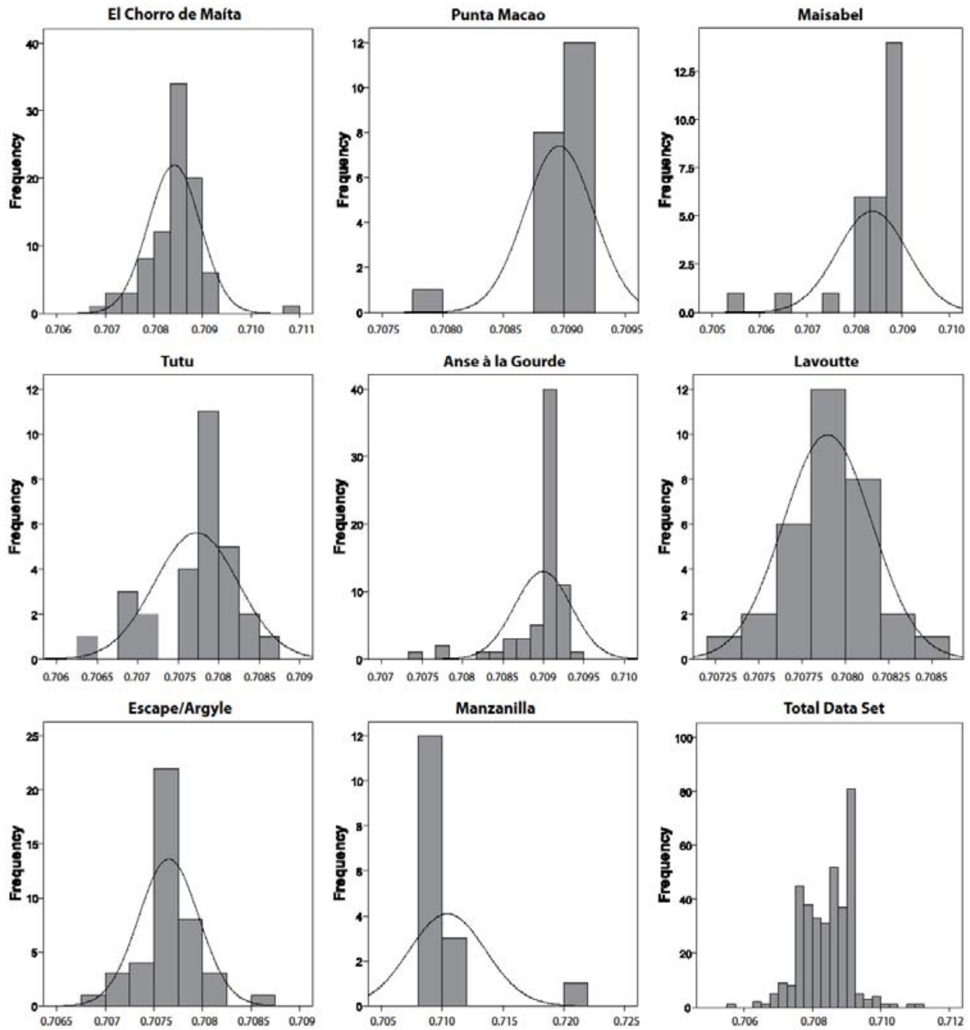
One caveat requires additional elaboration. While the probability of an individual possessing an extreme Sr isotope signature is theoretically quantifiable, this is not the case for local individuals. Although it may be more parsimonious to interpret a local isotopic value as resulting from local residence, this may not always be the case as natal origins from other (even distant) locations with similar baseline Sr isotope ratios are also plausible. As such, I have tended to equate local $^{87}Sr/^{86}Sr$ ratios with local residence although it is probably more appropriate to consider isotopically local individuals as possessing unknown origins. Alternatively, the nonlocal origins of certain individuals in this study are supported by independent lines of evidence including complementary carbon and oxygen isotope data and in several instances archaeological and bioarchaeological indicators of nonlocal, foreign, or exotic origins (see sections 7.4 and 7.5).

7.3 Local $^{87}Sr/^{86}Sr$ Range Estimates and Nonlocal Individuals

In this section I present and discuss the methods used to assess the local $^{87}Sr/^{86}Sr$ range for each of the populations in this study. I also present comparisons between the human $^{87}Sr/^{86}Sr$ data and biosphere $^{87}Sr/^{86}Sr$ data for each site and island. The results of descriptive statistical analyses of $^{87}Sr/^{86}Sr$ data are presented and an estimation of the number of nonlocals is given for each population. Possible geographic origins are also explored in relation to the nearest locations with similar biosphere $^{87}Sr/^{86}Sr$ ranges. The number and percentage of nonlocals amongst the different sample populations are presented in Table 8. Histograms of human $^{87}Sr/^{86}Sr$ data for the largest sample populations in this study are displayed in Figure 32. Descriptive statistics of the local trimmed populations after the removal of nonlocal outliers are presented in Table 9.

Table 8: Summary of nonlocals for the largest populations included in this study
Note: * indicates that Aruba sample population was pooled from multiple sites.

Site	Total (n)	Nonlocals (n)	Nonlocals (%)
Anse à la Gourde	68	17	25
Punta Macao	21	1	5
Maisabel	29	9	31
Tutu	29	7	24
Lavoutte	31	2	6
Escape/Argyle	42	12	29
Manzanilla	16	3	19
El Chorro de Maíta	88	22	25
Aruba*	9	1	11


El Chorro de Maíta

Punta Macao

Maisabel

Tutu

Anse à la Gourde

Lavoutte

Escape/Argyle

Manzanilla

Total Data Set

Figure 32 Histograms with normal distribution curves of human $^{87}Sr/^{86}Sr$ data.
Note: one individual from Manzanilla not displayed in the Total Data Set histogram at this scale.

Table 9: Descriptive statistics of the 'local' human $^{87}Sr/^{86}Sr$ data for each of the largest populations in this study.
Key: CM=El Chorro de Maíta; PM=Punta Macao; MB=Maisabel; TT=Tutu; AG=Anse à la Gourde; LV=Lavoutte; E/A=Escape/Argyle; MZ=Manzanilla

Statistic	**CM**	**PM**	**MB**	**TT**	**AG**	**LV**	**E/A**	**MZ**
Mean $^{87}Sr/^{86}Sr$	0.70851	0.70902	0.70873	0.70791	0.70913	0.70790	0.70763	0.70964
Stand. Dev.	0.00020	0.00007	0.00015	0.00021	0.00005	0.00020	0.00010	0.00046
Count	66	20	20	22	51	30	30	13
Median	0.70853	0.70903	0.70876	0.70788	0.70913	0.70790	0.70765	0.70971
Minimum	0.70806	0.70888	0.70838	0.70754	0.70900	0.70755	0.70742	0.70865
Maximum	0.70882	0.70916	0.70890	0.70828	0.70924	0.70825	0.70783	0.71041
Variance	4.0E-08	5.6E-09	2.3E-08	4.3E-08	2.8E-09	3.9E-08	1.0E-08	2.2E-07
Skewness	-0.56	-0.14	-0.96	0.07	-0.53	0.02	-0.35	-0.41
Skewness- SE	0.29	0.51	0.51	0.49	0.33	0.43	0.43	0.62
Kurtosis	-0.49	-0.40	0.17	-0.51	0.09	-0.94	-0.14	0.59
Kurtosis- SE	0.58	0.99	0.99	0.95	0.66	0.83	0.83	1.19

7.3.1 El Chorro de Maíta, Cueva de los Muertos, and Porteño del Mango- Cuba

Statistical analyses of the Sr isotope results from El Chorro de Maíta were conducted on pooled sample populations. First, human and faunal samples from this site were pooled and analyzed. Outliers identified after each iteration were removed and the subsequent trimmed data set was reanalyzed until no further outliers were apparent. After several iterations the resulting data set had convergent mean and median values, low skewness relative to its standard error, and was normally distributed (W=0.976, df=78, p=0.158) [where W is the test statistic; df is the degrees of freedom; and p is the probability value]. Sixteen nonlocals were identified via this method. In addition to this statistical assessment, I have identified six additional possible nonlocals amongst the Chorro de Maíta population. The justification for this is that the $^{87}Sr/^{86}Sr$ ratios of these six individuals are tightly clustered, and are all outside both the absolute range of faunal values for this site and outside the local range as determined by the mean of the total sample population ± two standard deviations. There is also a gap in values between the high end of the main cluster of ^{87}Sr/^{86}Sr ratios and the cluster represented by these six samples. As such, I tentatively identify these six individuals as nonlocals, in addition to the sixteen identified by the iterative statistical method that was applied to the other populations in this study, for a total of 22 nonlocals for this population (25%).

The statistical approach to the assessment of the pooled ^{87}Sr/^{86}Sr data set from El Chorro de Maíta provides an estimate of the local ^{87}Sr/^{86}Sr range of approximately 0.7080 to 0.7089. All 22 of the nonlocals are outside of this range and also outside of the range of ^{87}Sr/^{86}Sr ratios obtained from faunal remains from this site. The ^{87}Sr/^{86}Sr ratios amongst the nonlocals at the site of El Chorro de Maíta seem to cluster into at least four different groups (Figure 33). The first group consists of four samples that have ratios below 0.70725. There is a small gap in the range of measured ratios with none falling between ~0.70725 and 0.7075 and then a second group consisting of eleven individuals with ratios between ~0.7075 and 0.7080 that also is below the local range. A third group is represented by a tightly clustered group of values comprised of six individuals with ^{87}Sr/^{86}Sr ratios above the local range and that are all very similar to the modern seawater value of 0.7092. A fourth group consists of a single individual with a highly radiogenic ^{87}Sr/^{86}Sr value (0.711883). This highly enriched Sr isotope signature is outside the absolute range of ^{87}Sr/^{86}Sr ratios for the Antilles and is matched only by a few extremely radiogenic samples from Trinidad. Estimation of this individual's potential origin and the isotopic, archaeological, bioarchaeological evidence which it is based upon are discussed in section 7.6. With the exception of this single non-Antillean individual, the other three main groups of nonlocals at El Chorro de Maíta possess ^{87}Sr/^{86}Sr ratios that are within the absolute range of biosphere ^{87}Sr/^{86}Sr both for the island of Cuba and for the Antilles more generally.

Several human and faunal samples were also analyzed from the sites of Cueva de los Muertos (four humans, one snail) and Potreno del Mango (one human, one snail, and one hutía). All five of the human samples from the sites of Cueva de los Muertos and

Potreno del Mango appear to be local both relative to faunal remains from these sites and in comparison to the Chorro de Maíta local range estimate for these sites as well.

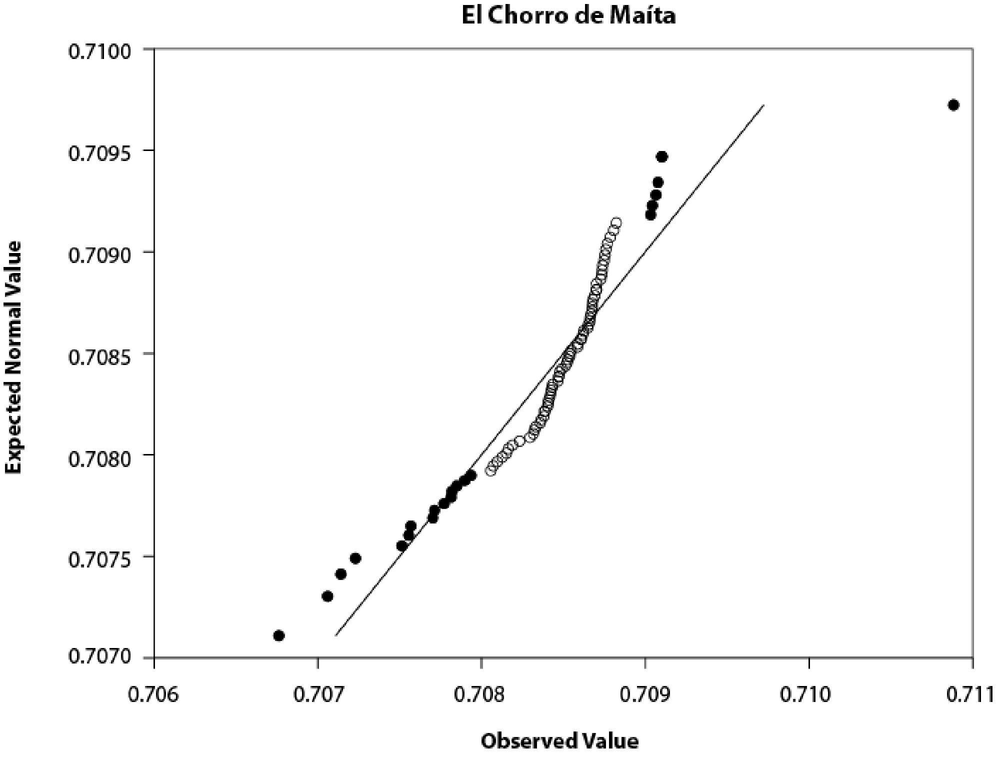


Figure 33 Normal probability Q-Q plot of human $^{87}Sr/^{86}Sr$ data from El Chorro de Maíta.
Key: filled circles indicate nonlocal (outlier and extreme) values, open circles indicate local values, line is parametric curve where y (expected normal value) = x (observed value).

7.3.2 Punta Macao and El Cabo- Dominican Republic

As is the case with several of the populations in this study, there are insufficient comparative biosphere samples with which to independently determine the local range of $^{87}Sr/^{86}Sr$ variation for the Punta Macao site. Therefore I have based the estimations of the local range and the identification of nonlocals within this population primarily on statistical analysis of the human $^{87}Sr/^{86}Sr$ data set. I pooled the single faunal $^{87}Sr/^{86}Sr$ value with those of the human population and performed basic statistical analyses on the pooled data set. This analysis identified one individual sample as an outlier which confirmed the assessment based on simple observation of the data. Removal of this single sample and reanalysis of the trimmed data set greatly reduced the dispersion of the data and produced similar mean and median values. The skewness of the sample was also greatly reduced to less than that of its standard error and results of a Shapiro-Wilk test (W=0.972, df=21, p=0.785) indicates that the trimmed sample has a normal distribution.

Using this statistical approach to the assessment of the pooled $^{87}Sr/^{86}Sr$ data set from Punta Macao provides an estimate of the local $^{87}Sr/^{86}Sr$ range of approximately 0.7088 to 0.7092. Despite the aforementioned danger of circularity when using human $^{87}Sr/^{86}Sr$ data to estimate the local range, there is some evidence, albeit limited in this case, to suggest that the normally distributed $^{87}Sr/^{86}Sr$ ratios at Punta Macao represents the local population. The single faunal $^{87}Sr/^{86}Sr$ value from this site is within the range of human values and the local range is in general agreement with geological expectations as the underlying bedrock is primarily Pliocene-Pleistocene reef limestone. Furthermore, the range of the local population at Punta Macao overlaps substantially with the values obtained from both human and faunal samples from the nearby site of El Cabo, which has a similar geological setting (see below).

Only one individual from the site of Punta Macao was identified as a nonlocal (~5%). This nonlocal has a depleted $^{87}Sr/^{86}Sr$ value (0.70776) relative to the local population at this site (Figure 34). Similar to the situation for Cuba, there are very few biosphere data for the Dominican Republic (or the island of Hispaniola), especially relative to the size of this island. In addition to the small number of samples from the far eastern peninsula of the Dominican Republic (Municipio Altagracia), four additional biosphere samples from different sites in the northeast coastal regions. Despite these limitations, the preliminary data permits an initial exploration of the potential geographic origin of the nonlocal individual from Punta Macao. Specifically, this individual's $^{87}Sr/^{86}Sr$ ratio is outside of the range of biosphere $^{87}Sr/^{86}Sr$ ratios obtained to date for the

Dominican Republic (~0.7082-.7092). The nearest location with similar, measured biosphere $^{87}Sr/^{86}Sr$ ratios in this study is Puerto Rico.

All four human samples and all four faunal samples from El Cabo possess comparable $^{87}Sr/^{86}Sr$ ratios that are tightly clustered around the value of seawater and match the associated geology (Pleistocene marine limestone). Thus all four humans at this site are considered local. Much of the far eastern peninsula of Hispaniola is underlain by a similar karstic terrain and so much of this region probably shares broadly similar baseline $^{87}Sr/^{86}Sr$ signals. As such, these four individuals could be nonlocal to the site but local to the region. The sole sample from the site of Bartolo is difficult to interpret owing to a lack of comparative data but the $^{87}Sr/^{86}Sr$ value (0.70922) of this individual is nearly identical to that of modern seawater (~0.7092) and very similar to the results from El Cabo and many of the local individuals from Punta Macao.

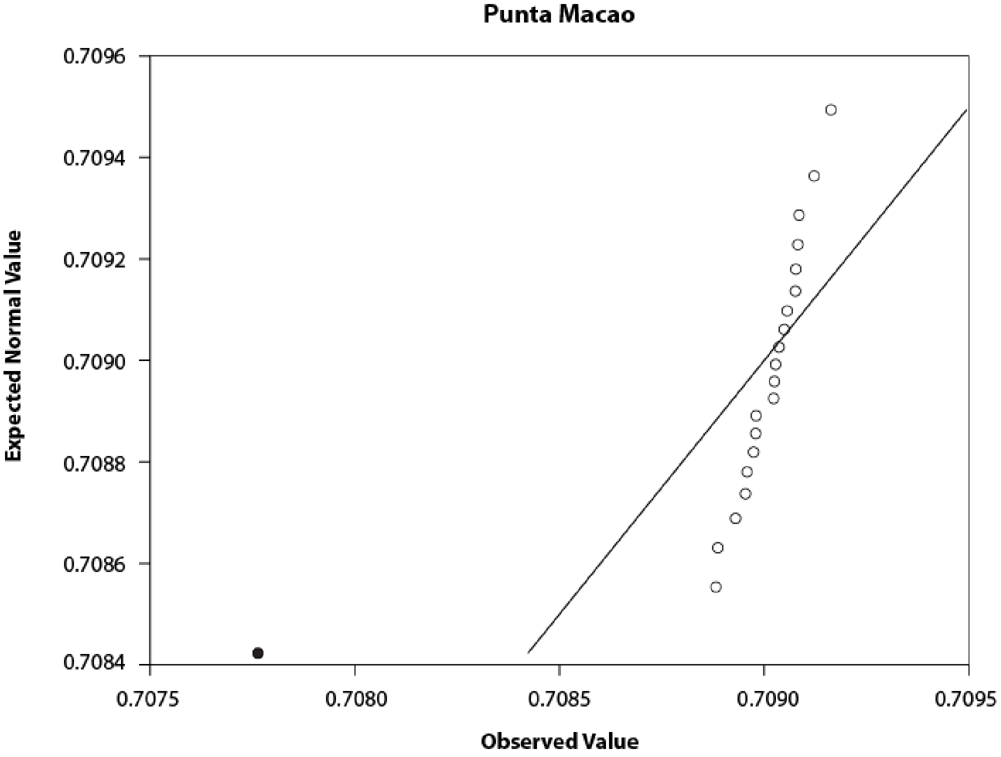


Figure 34 Normal probability Q-Q plot of human $^{87}Sr/^{86}Sr$ data from Punta Macao.
Key: symbols are the same as Figure 31.

7.3.3 Maisabel- Puerto Rico

The number of biosphere samples from Maisabel is larger than for most other sites in this study and should help to provide a better estimate of the local range of $^{87}Sr/^{86}Sr$ for this site. I have pooled both data sets into a single sample population for statistical analysis. The initial analysis indicated the presence of three outliers. These three individuals were removed from the sample population and the data was reanalyzed. Analysis of the trimmed data set did not identify outliers but the distribution was non-normal and bimodal with a skewness that was nearly double its standard error. The smaller mode included six samples with the lowest $^{87}Sr/^{86}Sr$ ratios which also fell outside the absolute range of biosphere values for this site. These six ratios were removed and another iteration of this process was conducted on the trimmed data set. This iteration revealed no more outliers and this trimmed data set possessed a convergent mean and median with a reduced skewness that was less than its standard error. The results of a Shapiro-Wilk test of this trimmed sample indicated a normal distribution (W=0.977, df=29, p=0.750).

Using this statistical approach to the assessment of the pooled $^{87}Sr/^{86}Sr$ data set from Maisabel provides an estimate of the local $^{87}Sr/^{86}Sr$ range of approximately 0.7083 to 0.7092. There is only a limited degree of overlap between the human and faunal data sets for this site with nearly half of the human values falling outside of the range of faunal $^{87}Sr/^{86}Sr$ ratios from Maisabel (~0.7087 to 0.7092) and a third falling outside this range if a single snail sample from a nearby location in Vega Baja is included in the biosphere range (0.7084). In total, nine nonlocals were identified amongst the human population from Maisabel (~31%) all of whom possess $^{87}Sr/^{86}Sr$ ratios that are outside of the range of faunal values from this site and are lower than the local population (Figure 35). The nonlocal $^{87}Sr/^{86}Sr$ ratios from Maisabel fall into two groups. The first consists of three individuals with highly variable but relatively low $^{87}Sr/^{86}Sr$ ratios that range between approximately 0.7056 and 0.7074. The second group is comprised of six individuals with $^{87}Sr/^{86}Sr$ ratios that cluster tightly between 0.70808 and 0.70819. Both groups of nonlocals are within the absolute range of biosphere $^{87}Sr/^{86}Sr$ for the island of Puerto Rico. Therefore, these individuals are nonlocal to the site of Maisabel but not necessarily to the entire island. In fact, Puerto Rico has one of the largest ranges of biosphere $^{87}Sr/^{86}Sr$ in this study, probably owing in part to the large differences in underlying geology between the interior and the coastal areas of the island.

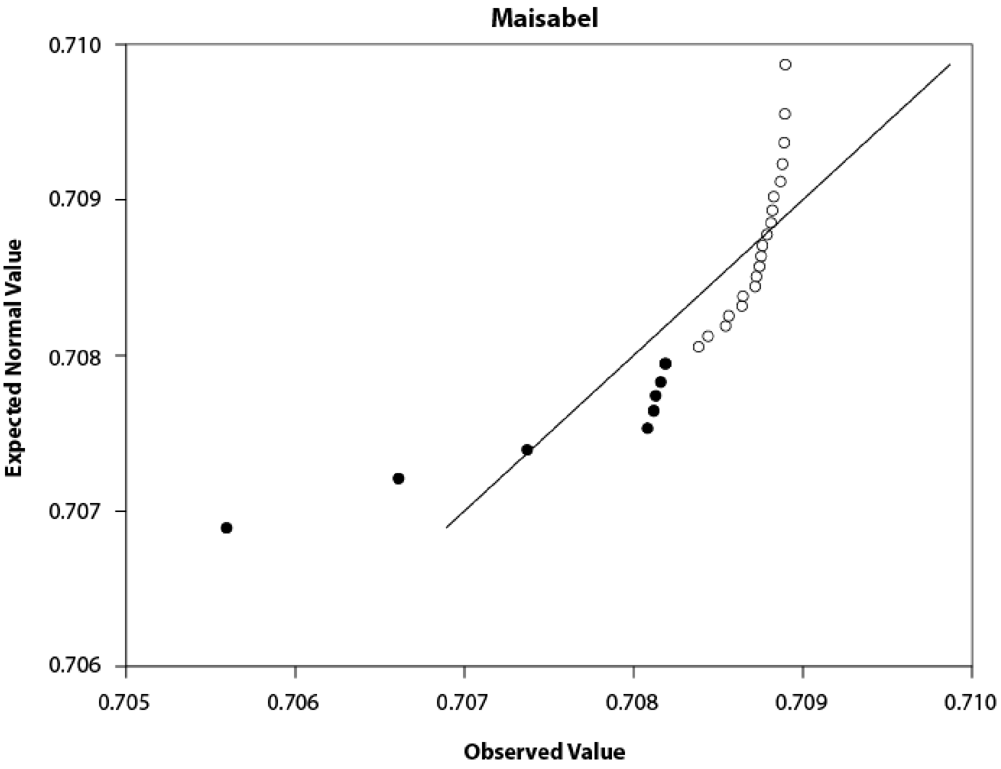


Figure 35 Normal probability Q-Q plot of human ^{87}Sr/^{86}Sr data from Maisabel. Key: symbols are the same as Figure 31.

7.3.4 Tutu- St. Thomas, U.S. Virgin Islands

Two biosphere samples were available from the Tutu site to assess the local ^{87}Sr/^{86}Sr range (one snail and one grass sample). These data were pooled with the human data and the pooled data set was subjected to statistical analysis. The first iteration identified three outliers and the distribution of the data set was non-normal and highly skewed. These three outliers were removed and the trimmed data set was reanalyzed. The second iteration identified another outlier but did not substantially reduce the skewness or produce a normally distributed population so this outlier was removed and the process was repeated. The third iteration revealed two additional outliers and produced a distribution that approached normal but with a skewness that was more than double its standard error so these two outliers were removed and a further iteration was conducted. One additional outlier was identified in this last iteration of the trimmed sample population, which had a convergent mean and median, a skewness that was similar to its standard error, and was normally distributed (W=0.968, df=25, p=0.583).

Using this statistical approach to the assessment of the pooled $^{87}Sr/^{86}Sr$ data set from Tutu provides an estimate of the local $^{87}Sr/^{86}Sr$ range of approximately 0.7074 to 0.7083. In total, seven nonlocals were identified from the Tutu population (~24%). The $^{87}Sr/^{86}Sr$ ratios of nonlocals from Tutu fall into two broad groupings (Figure 36). The first is composed of a single individual with a $^{87}Sr/^{86}Sr$ ratio (0.70871) that is elevated relative to the local population at Tutu but only slightly higher than the absolute range of biosphere (floral) $^{87}Sr/^{86}Sr$ ratios for the island of St. Thomas (0.70746-0.70864. The second group consists of six individuals with somewhat variable $^{87}Sr/^{86}Sr$ ratios (~0.7063 to 0.7073) that are all low relative to the local range at Tutu. Interestingly, these six nonlocals are outside of the absolute range of biosphere $^{87}Sr/^{86}Sr$ ratios for the island of St. Thomas. Based on the available evidence, these six individuals may be nonlocal not only to the Tutu site but to the island of St. Thomas. The $^{87}Sr/^{86}Sr$ ratios of all the nonlocals at Tutu are within the range(s) of biosphere $^{87}Sr/^{86}Sr$ for Puerto Rico and many of the islands of the northern Lesser Antilles and thus it is not possible to narrow down their possible origins more precisely using only Sr isotope data. However, additional lines of evidence including data from other isotope measurements permit us to propose more refined investigations of the natal origins of these nonlocals (see section 7.4.6).

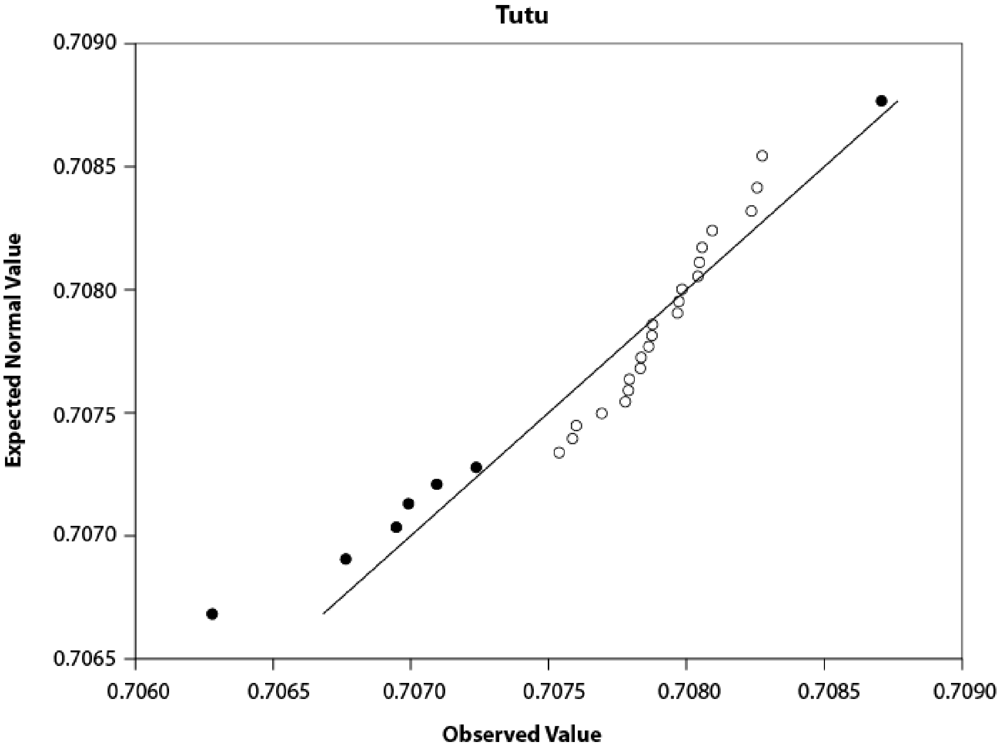


Figure 36 Normal probability Q-Q plot of human $^{87}Sr/^{86}Sr$ data from Tutu.
Key: symbols are the same as Figure 31.

7.3.5 Kelbey's Ridge 2 and Spring Bay- Saba

All human $^{87}Sr/^{86}Sr$ ratios from Kelbey's Ridge are within the absolute range of local biosphere Sr isotope variation, at the scale of both the site and the island. One modern land snail shell sample was an extreme outlier relative to the rest of the sample population from Kelbey's Ridge, including all of the archaeological snails from this site. Owing to the possibility that the Sr isotope ratio from this sample reflects the incorporation of Sr from modern pollutants or fertilizers, this sample was excluded from the pooled sample population. Exploratory data analysis of the pooled human and biosphere sample population from Kelbey's Ridge was conducted to assess structure and pattern within this data. The analysis identified one outlier that fell just outside the lower quartile minus

1.5*IQR. The population displayed a similar mean and median, a skewness that was similar to its standard error, and a normal distribution (W=0.946, df=31, p=0.121).

The statistical approach to the assessment of the pooled $^{87}Sr/^{86}Sr$ data set from Kelbey's Ridge provides an estimate of the local $^{87}Sr/^{86}Sr$ range for this site of approximately 0.7078 to 0.7089. Within this study, Saba, is the most extensively and intensely mapped islands in terms of biosphere $^{87}Sr/^{86}Sr$ (n=50). The range of biosphere $^{87}Sr/^{86}Sr$ for the entire island of Saba (~0.7064 to 0.7092) is large relative to the size of this island. Based on the statistical analysis, there are no individuals from Kelbey's Ridge that are outliers. One individual has a 'borderline' $^{87}Sr/^{86}Sr$ signal (0.7077) that falls at the low end of the local biosphere range for Kelbey's Ridge and may represent a nonlocal at the site level. However, even if this individual was interpreted as a nonlocal at the scale of this site, the $^{87}Sr/^{86}Sr$ value is within the absolute range of biosphere $^{87}Sr/^{86}Sr$ for the island of Saba.

The single human sample from the neighboring site of Spring Bay 1c has an $^{87}Sr/^{86}Sr$ ratio of 0.70785 that is within the range of biosphere samples from Kelbey's Ridge. Although it is not possible to independently assess the $^{87}Sr/^{86}Sr$ range for the site of Spring Bay itself, owing to a lack of comparative samples, I consider it appropriate to use the Kelbey's Ridge Sr isotope range as the two sites are only separated by a few hundred meters. This individual's $^{87}Sr/^{86}Sr$ ratio is within the range of biosphere $^{87}Sr/^{86}Sr$ for the island of Saba indicating a probable local origin at the scale of the island.

7.3.6 Bloody Point- St. Kitts

The four human samples from the site of Bloody Point have heterogeneous Sr isotope ratios ranging from ~0.7074 to 0.7077. Unfortunately, there are no biosphere data from this site with which to compare and assess these results or to independently estimate the local range for this population. Three faunal samples were measured from the Sugar Factory Pier site on St. Kitts located approximately 15 km southeast from Bloody Point on the western coast. Nonetheless, the human $^{87}Sr/^{86}Sr$ ratios from Bloody Point show a high degree of overlap with, and primarily fall within, the range of values from the Sugar

Factory Pier faunal samples (~0.7074 to 0.7081). Five biosphere samples, all from grasses, collected from various locations across St. Kitts display a wide range of $^{87}Sr/^{86}Sr$ ratios (~0.7067 to 0.7086) that entirely encompasses both the faunal samples from Sugar Factory Pier and the human samples from Bloody Point. Thus, although it is not possible at this time to determine if the human samples from Bloody Point are local to this site their $^{87}Sr/^{86}Sr$ ratios are consistent with a local origin on the island of St. Kitts.

7.3.7 Anse à la Gourde- Guadeloupe

Human and faunal $^{87}Sr/^{86}Sr$ ratios from Anse à la Gourde were pooled into a single population and the resulting data set was statistically analyzed. Initial analysis of the pooled data set indicated that the sample population was negatively skewed and not normally distributed. The first iteration identified twelve outliers and the population was reanalyzed after their removal. The second iteration revealed that the removal of these outliers reduced the dispersion of the data and produced mean and median values that were more comparable but that the trimmed data set was still skewed with a skewness that was much greater than its standard error indicating a non-normal distribution. Reanalysis of the trimmed data set identified five additional outliers that were also removed and the iteration was repeated. The resulting trimmed data set produced by this second iteration possesses a reduced skewness that is similar to its standard error. A Shapiro-Wilk test for normality of this trimmed data set does not reject the null hypothesis that the sample is normally distributed (W=0.965, df=55, p=0.107).

Using this statistical approach to the assessment of the pooled $^{87}Sr/^{86}Sr$ data set from Anse à la Gourde provides an estimate of the local $^{87}Sr/^{86}Sr$ range of approximately 0.70898 to 0.70926. This indicates that as many as seventeen individuals from the human population at this site are nonlocal (25%). Based on assessment of the data, the individuals identified as nonlocals at Anse à la Gourde fall into at least three groupings (Figure 37). The first group is represented by three individuals with $^{87}Sr/^{86}Sr$ ratios below 0.7078. These ratios are very low relative to both the local population and expectations based on associated geology. In the Lesser Antilles, biosphere $^{87}Sr/^{86}Sr$ ranges similar to these values are common in most of the islands of the Volcanic Caribbees. The second group is the largest and includes twelve individuals with $^{87}Sr/^{86}Sr$ ratios ranging from roughly 0.70826 to 0.70896. These values are also lower than the local population at this site but less so than the first cluster and fall within the range of biosphere $^{87}Sr/^{86}Sr$ for several islands of the Volcanic Caribbees and many of the composite islands of the Limestone Caribbees. The third group is represented by two individuals with $^{87}Sr/^{86}Sr$ ratios that are elevated relative to the local population. These $^{87}Sr/^{86}Sr$ ratios exceed 0.70928 and thus are higher than seawater, the highest expected Sr isotope end member for this geographic setting. These two ratios are also higher than nearly all human or biosphere $^{87}Sr/^{86}Sr$ measurements for the Antilles (*sensu stricto*). The nearest location with measured $^{87}Sr/^{86}Sr$ ratios similar to these signals is the island of Trinidad.

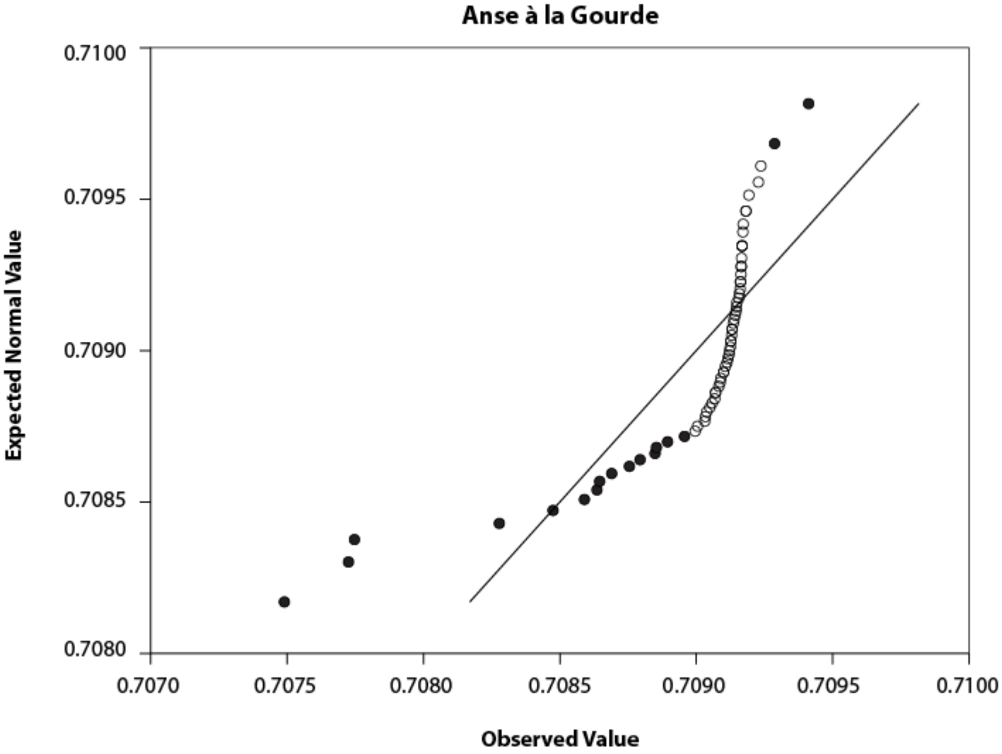


Figure 37 Normal probability Q-Q plot of human $^{87}Sr/^{86}Sr$ data from Anse à la Gourde.
Key: symbols are the same as Figure 31.

7.3.8 Lavoutte and Giraudy- St. Lucia

The Lavoutte population is one of the only samples in this study that is normally distributed before the removal of outliers and thus did not require measures that are used for non-normally distributed data (e.g., stem and leaf methods). Therefore, an estimation of the local range for this population was based on a more traditional method using the mean of all human $^{87}Sr/^{86}Sr$ ratios ± two standard deviations. This method indicates the presence of two nonlocal outliers. Recalculating the local range using a pooled sample that includes both human and biosphere $^{87}Sr/^{86}Sr$ data produces a similar local range estimate and identifies the same two individuals as outliers. Re-analysis of the trimmed sample population, after the removal of these two outliers, indicates that it has a similar mean and median, low skewness and a normal distribution (W=0.970, df=34, p=0.463).

The statistical approach to the assessment of the pooled $^{87}Sr/^{86}Sr$ data set from Lavoutte provides an estimate of the local $^{87}Sr/^{86}Sr$ range of approximately 0.7075 to 0.7083. Two individuals from Lavoutte were identified as nonlocal (~6%) and both of these have $^{87}Sr/^{86}Sr$ ratios that are outside of the absolute range of biosphere values for this site. Of these two nonlocals one possesses a high $^{87}Sr/^{86}Sr$ ratio (0.7086) relative to the local population and the other a lower value (0.7072). In both cases there is a considerable gap between their $^{87}Sr/^{86}Sr$ ratios and the minimum and maximum $^{87}Sr/^{86}Sr$ ratios of the local population, respectively (Figure 38). The nonlocal with an elevated $^{87}Sr/^{86}Sr$ signal relative to the local population is within the absolute range of biosphere $^{87}Sr/^{86}Sr$ for the island of St. Lucia as a whole. Therefore, although this individual appears nonlocal to the site of Lavoutte, he/she could have originated from another site within St. Lucia, for example from areas in the southern part of the island which is characterized by higher $^{87}Sr/^{86}Sr$ ratios. The other nonlocal possesses a lower $^{87}Sr/^{86}Sr$ signal that is outside the absolute range of biosphere $^{87}Sr/^{86}Sr$ for St. Lucia suggesting an extra-insular origin for this individual. The nearest location with similar biosphere $^{87}Sr/^{86}Sr$ ratios is the island of St. Vincent, although other islands in the Lesser Antilles also possess similar biosphere $^{87}Sr/^{86}Sr$ ratios such as Basse-Terre, Grenada, Martinique, Nevis, and Tobago.

One human sample was analyzed from the site of Giraudy in southern St. Lucia. This individual has an $^{87}Sr/^{86}Sr$ ratio of 0.70876 that is within the range of biosphere $^{87}Sr/^{86}Sr$ ratios from St. Lucia and is particularly similar to other ratios obtained from plant samples from the southern part of the island. Although there are insufficient independent data to assess the local biosphere range for this site, the single human $^{87}Sr/^{86}Sr$ value from Giraudy is consistent with an origin in southern St. Lucia.

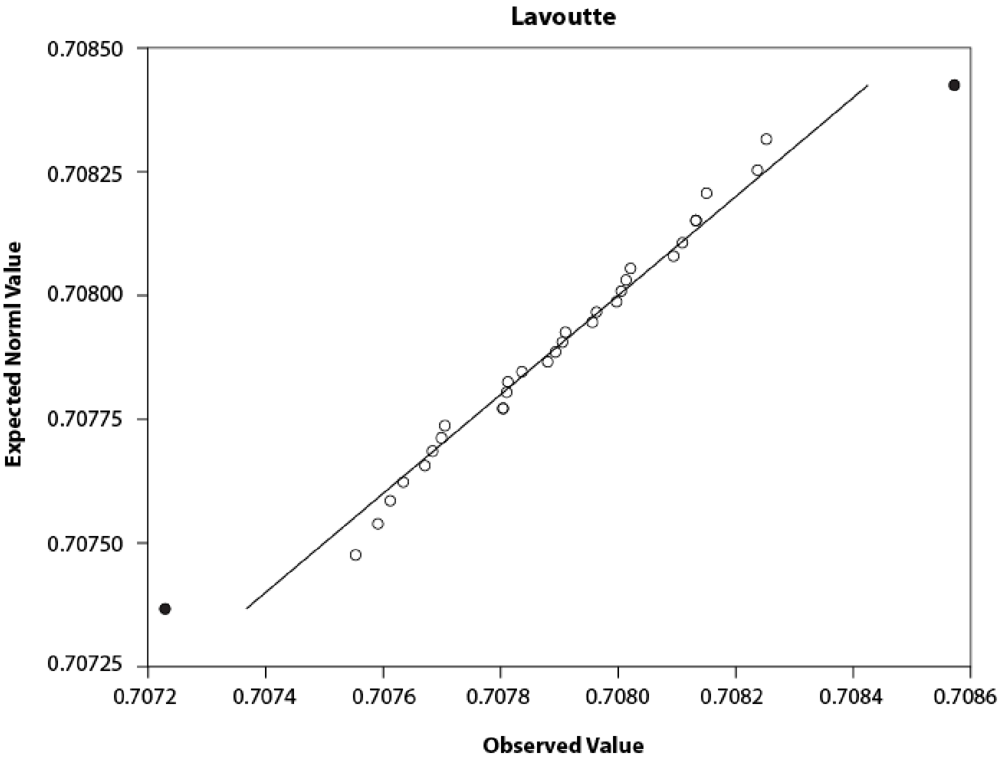


Figure 38 Normal probability Q-Q plot of human $^{87}Sr/^{86}Sr$ data from Lavoutte. Key: symbols are the same as Figure 31.

7.3.9 Escape, Argyle I and II, and Buccament West- St. Vincent

For the sake of statistical analyses, samples from the three adjacent sites of Escape, Argyle I and Argyle II were pooled into a single sample population. This is considered appropriate considering the fact that these three sites are adjacent (within ~200 meters of each other) and thus their inhabitants probably shared similar catchment areas. Furthermore, there is a high degree of overlap between the $^{87}Sr/^{86}Sr$ ratios of the three populations. The three rodent samples from Escape possessed very low $^{87}Sr/^{86}Sr$ ratios relative to all of the human $^{87}Sr/^{86}Sr$ ratios from these three sites with no overlap in $^{87}Sr/^{86}Sr$ ratios. The causes for these discrepancies are unknown but indicate that caution is required in the interpretation of the $^{87}Sr/^{86}Sr$ results from these sites. Owing to this lack of congruence, I have tentatively rejected the hypothesis that all of the humans from this site are nonlocal (i.e., if the biosphere $^{87}Sr/^{86}Sr$ ratios alone were used to estimate the local range) and instead I have not included the biosphere (faunal) samples in the pooled sample population from this site(s). Initial statistical analyses of the human data identified five outliers. These five individuals were removed from the pooled data set and a basic statistical analysis of the trimmed sample was conducted. This process was repeated until no further outliers were identified. The fourth iteration revealed no further outliers and the resulting data set has low skewness relative to its standard error, a coinciding mean and median, and is normally distributed (W=0.977, df=30, p=0.727).

The statistical approach to the assessment of the pooled $^{87}Sr/^{86}Sr$ data set from the Escape/Argyle population(s) provides an estimate of the local $^{87}Sr/^{86}Sr$ range of approximately 0.7074 to 0.7079. In total, twelve nonlocals were identified amongst the pooled Escape/Argyle populations (29%). These nonlocals include six from the Escape site (~23%), one from Argyle I (50%), and five from Argyle II (~36%). These nonlocals fall into three broad groups (Figure 39). The first group is represented by five individuals (four from Escape and one from Argyle II) with relatively low $^{87}Sr/^{86}Sr$ ratios (~0.7067 to 0.70734) that are below the local range for this site. The second group is represented by six individuals (two from Escape, one from Argyle I, and three from Argyle II) with relatively elevated $^{87}Sr/^{86}Sr$ ratios (~0.70794 to 0.70817) that are above the local range for this site. Individuals from these two groups appear to be nonlocal relative to the local population at this site(s) but as their ratios are within the absolute range of biosphere $^{87}Sr/^{86}Sr$ at the scale of the island of St. Vincent (~0.7057 to 0.7081), they are considered local at the scale of this island. A third group is comprised of a single individual with an elevated $^{87}Sr/^{86}Sr$ value (0.7087) that is outside of the absolute range of biosphere $^{87}Sr/^{86}Sr$ for St. Vincent possibly indicating an extra-insular origin for this individual. The nearest location with measured biosphere $^{87}Sr/^{86}Sr$ ratios that are similar to this nonlocal is St. Lucia, while other locations in the Lesser Antilles include Saba, St. Eustatius and much of the Limestone Caribbees.

A single human sample from the Buccament West site was also analyzed. No comparative samples are available with which to assess the local range at this site. This single sample has an $^{87}Sr/^{86}Sr$ value that is substantially lower than all of the human samples from the Escape and Argyle sites. Interestingly, the value from this individual more closely matches the values of faunal remains from the Escape site and the values of floral samples from southern St. Vincent. Thus, although it is not possible to directly assess whether this individual is local to the site of Buccament West, this $^{87}Sr/^{86}Sr$ ratio is consistent with an origin on St. Vincent.

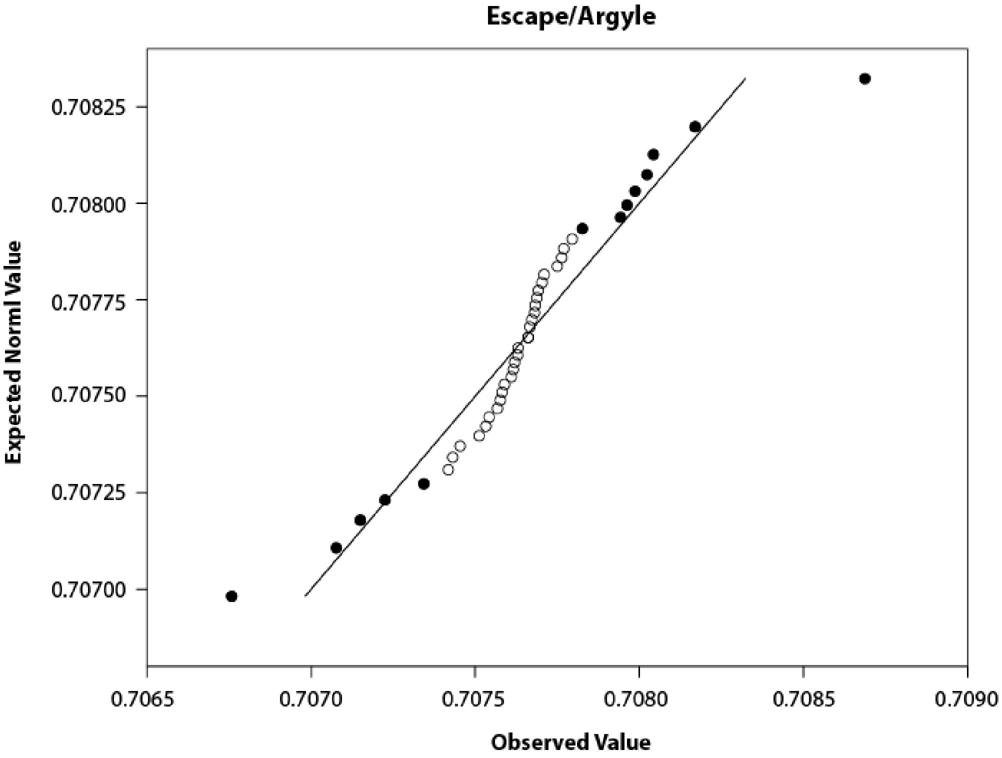


Figure 39 Normal probability Q-Q plot of human $^{87}Sr/^{86}Sr$ data from Escape/Argyle.
Key: symbols are the same as Figure 31.

7.3.10 Heywoods- Barbados

The small number of analyzed human samples (n=3) from the Heywoods site prohibits statistical assessment of this data set but all three samples have nearly identical $^{87}Sr/^{86}Sr$ ratios. No biosphere $^{87}Sr/^{86}Sr$ data are available from this site with which to assess the local range of $^{87}Sr/^{86}Sr$ ratios but one snail sample from the same general area has an $^{87}Sr/^{86}Sr$ ratio that is very similar to the three humans from Heywoods. These values are also consistent with measured $^{87}Sr/^{86}Sr$ ratios of local individuals from the colonial period Newton Plantation site (Schroeder et al. 2009). Furthermore, all of these values are in good agreement with expected $^{87}Sr/^{86}Sr$ ratios (0.7092) based on the underlying geology of most of Barbados, which is primarily composed of late Tertiary and Quaternary marine sedimentary deposits. Therefore, the three individuals from Heywoods appear to be local at least to the island of Barbados.

7.3.11 Manzanilla- Trinidad

The human sample population from Manzanilla was pooled with a single floral sample from this site and the pooled data set was subjected to statistical analysis. The analysis revealed the presence of three outliers, including one extremely elevated $^{87}Sr/^{86}Sr$ ratio. These three outliers were removed and a second iteration was run. The trimmed data set has somewhat similar mean and median values, a skewness that is lower than its standard error, and a normal distribution (W=0.966, df=14, p=0.820). However, it should be noted that although analysis of the trimmed data set did not indicate the presence of any additional outliers, it is possible that other nonlocals exist within this population that remain unidentified. The possibility of unidentified nonlocals in this population is deemed somewhat more likely for this population relative to others, owing to the relative paucity of biosphere samples (n=1); and the relatively high dispersion, variance, and range of the trimmed data set.

The statistical approach to the assessment of the pooled data set from Manzanilla provides an estimate of the local $^{87}Sr/^{86}Sr$ range of approximately 0.7086 to 0.7104. In total, three nonlocals (Figure 40) were identified amongst the Manzanilla population (~19%). Of these three nonlocals, one possesses an $^{87}Sr/^{86}Sr$ ratio that is low relative to the local Manzanilla population but is within the range of biosphere $^{87}Sr/^{86}Sr$ ratios for the island of Trinidad. The second nonlocal has an $^{87}Sr/^{86}Sr$ ratio that is higher than the range of biosphere $^{87}Sr/^{86}Sr$ ratios for the Antilles (excepting a small number of extreme values). This individual's Sr isotope signal is possibly indicative of an origin in mainland South America as the nearest location with measured biosphere $^{87}Sr/^{86}Sr$ ratios is northern coastal Venezuela. The third nonlocal from Manzanilla has by far the highest $^{87}Sr/^{86}Sr$ ratio in our study (n>640). This $^{87}Sr/^{86}Sr$ ratio is higher than unexpected for any Antillean context and furthermore is also higher than any published $^{87}Sr/^{86}Sr$ ratio from Mesoamerica (n>600) with the exception of a single peccary sample from the site of Tipu, Belize (Thornton, 2011). Such an elevated Sr isotope ratio is considered to be relatively rare in the insular Caribbean and would only be expected from regions dominated by very old geological formations. The closest region to Trinidad possessing such older geological formations is the Guiana Shield Region of northeastern South America. A possible origin from this region would not be entirely unexpected given the proposed connection between the Guianas and Trinidad in prehistoric times (Boomert 2000).

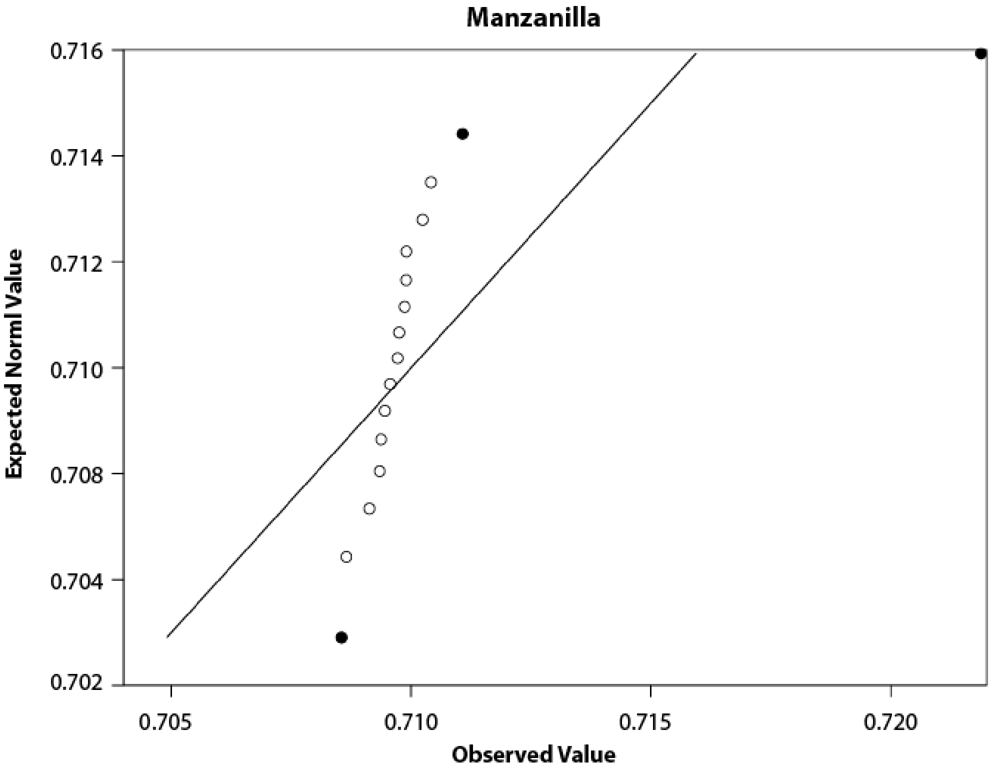


Figure 40 Normal probability Q-Q plot of human $^{87}Sr/^{86}Sr$ data from Manzanilla.
Key: symbols are the same as Figure 31.

7.3.12 Malmok, Canashito, Santa Cruz, Savaneta, and Tanki Flip- Aruba

Human samples from Aruba and derive from several different sites and only five biosphere samples were collected for the entire island of Aruba. As such, it is not possible to conduct statistical analyses separately on each sample population. For a few sites, it is possible to directly compare human and biosphere $^{87}Sr/^{86}Sr$ data. In the case of Malmok, the $^{87}Sr/^{86}Sr$ ratios of the four human samples are very similar (~0.70906 to 0.70918) and to a single grass sample collected at this site (0.70913). In contrast the $^{87}Sr/^{86}Sr$ ratio from a single human sample from Santa Cruz (0.70823) was distinct from the $^{87}Sr/^{86}Sr$ ratio obtained from a grass sample from this site (0.70772). Similarly, ^{87}Sr/^{86}Sr ratios from two humans from Tanki Flip (~0.70859 to 0.70897) were somewhat divergent not only from each other but also relative to a grass sample from this site (0.70764). It is possible that the plant samples are reflecting the incorporation of modern Sr derived from pollution or fertilizers and thus do not accurately reflect the range of biosphere ^{87}Sr/^{86}Sr in the distant past. Alternatively, the limited data set may simply not reflect the degree of ^{87}Sr/^{86}Sr variation that is present at these sites. In the absence of additional relevant data it is difficult to assess the implications of these differences at this time. For Malmok, the preliminary evidence suggests that all four individuals are local to this site. For the other sites, there is simply insufficient data to determine locality at the scale of individual populations or sites.

There is, however, a high degree of overlap between the ranges of ^{87}Sr/^{86}Sr values from human and floral samples from the island of Aruba. Additionally, most of the human ^{87}Sr/^{86}Sr values from Aruba are within the absolute range of floral values from this island. A single human sample from the pre-ceramic site of Canashito has an ^{87}Sr/^{86}Sr value (0.70988) that is notably elevated relative to both the human and floral data sets from Aruba (~0.7076 to 0.7092) and relative to the absolute range of biosphere ^{87}Sr/^{86}Sr for the Antilles in general. Thus, this individual is considered to be a nonlocal at the scale of the island of Aruba and owing to the high ^{87}Sr/^{86}Sr ratio also nonlocal to the Antilles (*sensu stricto*). Although several equally high ^{87}Sr/^{86}Sr values were obtained from Trinidad, the nearest location with similar measured ^{87}Sr/^{86}Sr values is the northern coast of mainland South America. Specifically, this individual's ^{87}Sr/^{86}Sr signature is nearly identical to a number of plant samples from the Falcón Basin region of coastal Venezuela. Such an origin would fit with current hypotheses concerning human migrations from western Venezuela into Aruba (Versteeg 1991a). However, this ^{87}Sr/^{86}Sr value is also within the range of expected ^{87}Sr/^{86}Sr values for many areas of mainland South America, more generally.

7.4 Patterns of Paleomobility

In the following sections I will discuss patterns of paleomobility, including explicit comparisons of locals versus nonlocals in terms of sex, age, chronology, mortuary treatment, and diet. The aim of these comparative analyses is to assess patterns within and between locals and nonlocals for each of the populations in this study. The identification of patterning in these data is important in order to investigate similarities and differences between locals and nonlocals in terms of: 1) biological sex; 2) age at death; 3) chronology; 4) grave goods; and 5) dietary practices. These comparisons are generally limited to the larger populations within this study and to those for which relevant data are available concerning these various parameters. The results of the statistical analyses (using SPSS) are presented separately for each set of comparisons, first by sample population and then for all data pooled together.

7.4.1 Patterns of Paleomobility: biological sex

For the sake of making comparisons between locals and nonlocals in terms of demography (sex and age) these skeletal populations are treated as single populations despite the fact that many of them span several centuries and certain individuals are clearly not contemporaneous with others. This analysis was conducted to determine if there are any distinct correlations between origins and biological sex or age at death independent of chronology [Assessment of locality in relation to chronology is discussed in section 7.4.3]. The populations for which sufficient demographic data are available and that are large enough for statistical analyses are El Chorro de Maíta, Maisabel, Tutu, Anse à la Gourde, and Lavoutte (Table 10 and Figure 41). For these populations individuals that were identified as possible male or possible female based on osteological analyses of skeletal traits were treated as males and females, respectively. Subadults and adults of indeterminate sex were not included in this analysis. Most demographic data described herein are based upon the results of recent osteological analyses (and subsequent skeletal reports) conducted by Darlene Weston, with the exception of the Tutu data which can be found in (Sandford et al. 2002).

Of the 88 individuals from the Chorro de Maíta population that were analyzed for Sr isotope composition, 64 adults were sexed (33 females and 31 males). Of the 33 females, eight are nonlocal (24.2%) and of the 31 males, 13 are nonlocal (41.9%). There are clearly more nonlocal males than nonlocal females both in terms of absolute numbers and proportionally. Although, the difference between these proportions seems large upon initial observation, they are not statistically significant based on a Fisher's exact test (p=0.184). Nonetheless, the proportion of nonlocal males relative to the total male population from El Chorro is the highest of all of the populations in this study. Furthermore, the Chorro de Maíta population is one of only two populations in this study (the other being Manzanilla, Trinidad), where the percentage of nonlocal males exceeds that of nonlocal females.

Of the 29 individuals from Maisabel that were analyzed for Sr isotope composition, 20 adults were sexed (seven females and 13 males). Of the seven females, three are nonlocal (42.9%) and of the 13 males, five are nonlocal (38.5%). In absolute terms, there are more nonlocal males than nonlocal females but proportionally there are slightly more nonlocal females. The observed difference between these two groups is not statistically significant (Fisher's exact test, p=1.000). Interestingly, the Maisabel sample population not only has the largest proportion of nonlocals (~31%) in this study but also by far the highest proportion of nonlocal females and the second highest proportion of nonlocal males.

Of the 29 individuals from Tutu that were analyzed for Sr isotope composition, 19 adults were sexed (13 females and six males). Of the 13 females, five are nonlocal (38.5%) and of the six males, two are nonlocal (33.3%). There are more nonlocal females than nonlocal males both in absolute numbers and proportionally. The observed difference between these two groups is not statistically significant (Fisher's exact test, p=1.000). The Tutu sample population has the second highest proportion of nonlocal females and the third highest proportion of nonlocal males in this study. This is partly a reflection of the fact that most of the nonlocal individuals could be sexed and that nearly all of the juveniles and individuals of indeterminate sex are local.

Of the 68 individuals from Anse à la Gourde analyzed for Sr isotope composition, the biological sex of 57 adults was determined (34 females and 23 males). Of the 34 females, nine are nonlocal (26.5%) and of the 23 males, five are nonlocal (21.7%). In both absolute terms and proportionally, there are more nonlocal females than nonlocal males. The observed difference between these two groups is not statistically significant (Fisher's exact test, p=0.762). The Anse à la Gourde sample population has the third highest proportion of nonlocal females but the fifth highest proportion of nonlocal males in this study.

Of the 32 individuals from Lavoutte that were analyzed for Sr isotope composition, 23 adults were sexed (12 females and 11 males). Of the 12 females, one is nonlocal (8.3%) and of the 11 males, none is nonlocal (0%). The observed difference between these two groups is not statistically significant (Fisher's exact test, p=1.000). The Lavoutte sample population has one of the lowest proportions of nonlocals (~6%) relative to the overall size of the sample population, which is one of the largest in this study. Since only one of the two nonlocals from Lavoutte could be sexed it is not possible to assess any potential differences in mobility between males and females for this population.

For all of the other sample populations in this study, there were an insufficient number of samples, too few nonlocals, and/or a lack of reliable osteological data to assess patterns of mobility relative to biological sex. Therefore, I have pooled all sexed individuals in this study into a single sample population to assess broader patterns of mobility within the entire region. The pooled sample population includes results from the five populations discussed above in addition to the results from Punta Macao and Manzanilla. In total, the pooled sample population includes 207 individuals, almost equally represented by females (n=106) and males (n=101). Interestingly, there is an equal number of nonlocal females and nonlocal males (n=27) and the proportions of each are nearly identical (~25.5% and 26.7%, respectively).

In summary, there is substantial variation between populations in the proportion of nonlocals of each sex, ranging from 0% as some sites to over 40% at others. However, most of this variation can be accounted for by differences in the proportions of nonlocals generally (of both sexes) between different populations. In terms of intra-population variation, the observed differences between nonlocal females and nonlocal males are not statistically significant for any of the populations in this study. Observed differences in the proportions of nonlocals relative to sex are the largest for the Chorro de Maíta population, with a 17% higher proportion of nonlocals amongst males than amongst females.

Table 10: Comparisons between locality and biological sex

Site	**Female**	**Female**	**Female**	**Male**	**Male**	**Male**
	total	nonlocal	%	total	nonlocal	%
Chorro de Maíta	33	8	24.2	31	13	41.9
Punta Macao	5	1	20.0	8	0	0.0
Maisabel	7	3	42.9	13	5	38.5
Tutu	13	5	38.5	6	2	33.3
Anse à la Gourde	34	9	26.5	23	5	21.7
Lavoutte	12	1	8.3	11	0	0.0
Manzanilla	2	0	0.0	9	2	22.2
Total	106	27	25.5	101	27	26.7

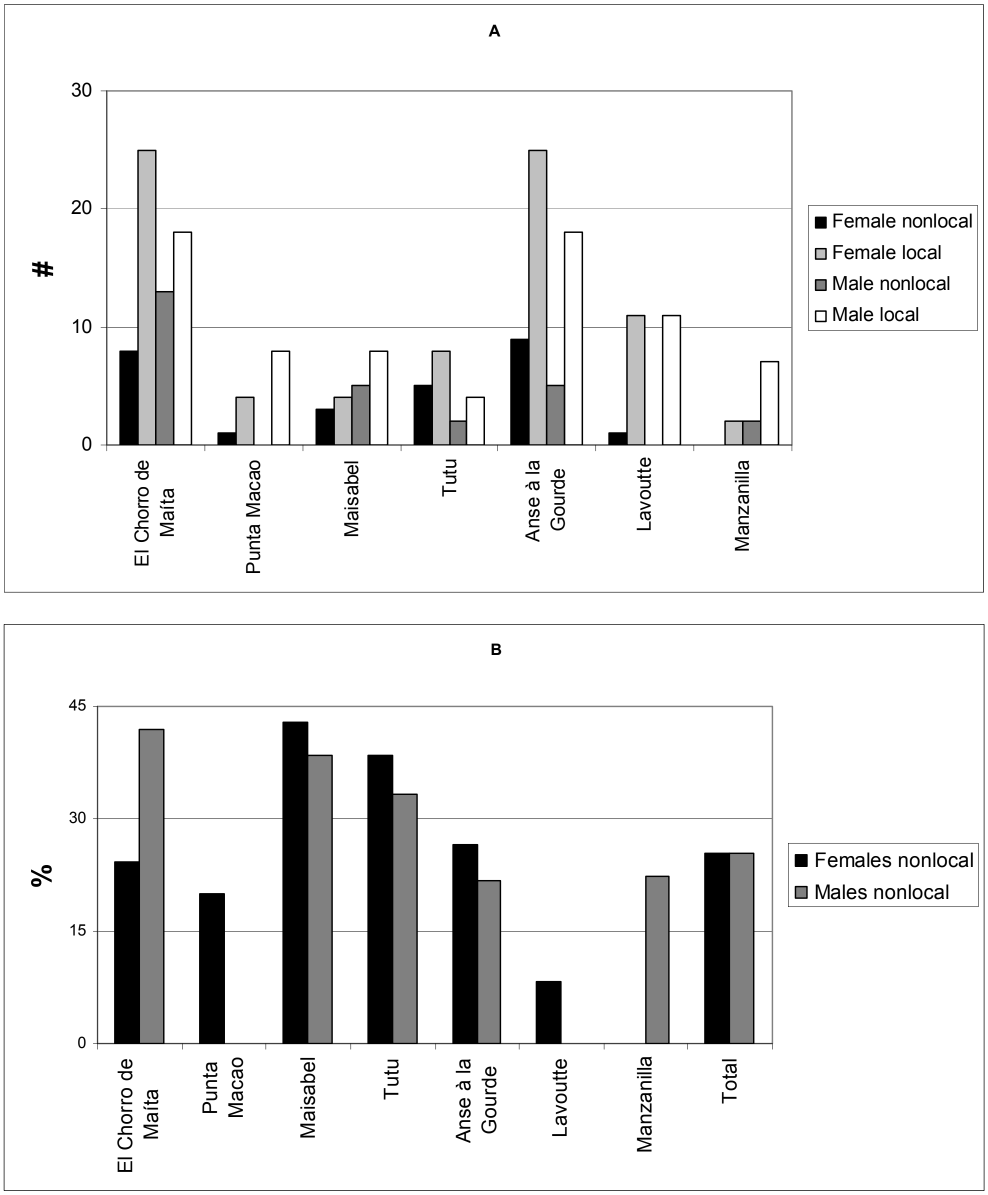


Figure 41 Charts of patterns between locality and biological sex: A) absolute numbers of female locals/nonlocals and male locals/nonlocals per population; and B) percentage of females and males that are nonlocal per population.

7.4.2 Patterns of Paleomobility: age at death

Analyses of locality relative to skeletal age were conducted on the same populations as the analyses for biological sex using the same statistical methods (Table 11 and Figure 42). The available data does not permit the use of more refined age categories and so comparisons are only made between the broad age categories of adults and subadults (defined here as individuals older and younger than 18 years of age at death, respectively). Aging of skeletal remains are based on available physical anthropological reports and publications of the studied populations (Sandford et al. 2002; Weston and Schats 2010; Weston 2011a; Weston 2010b). Individuals that could not be properly aged, for example owing to very poor condition of the skeletal remains, were not included in this analysis.

For the Chorro de Maíta population, there are 63 adults and 25 subadults. Amongst the adults, 20 (31.7%) are nonlocal and amongst the subadults two (8%) are nonlocal. The difference between these groups is statistically significant (Fisher's exact test, p=0.028). The observed pattern matches the expected pattern in that subadults are expected to be relatively less mobile than adults. This does not imply that subadults did not migrate, only that there should be some correlation between age and the likelihood of migration based on a life history model.

For the Maisabel population, there are 23 adults and six subadults. Amongst the adults, eight (34.8%) are nonlocal and amongst the subadults, one (16.7%) is nonlocal. Although the percentage of nonlocals amongst the adults is more than double the percentage of nonlocals amongst the subadults, the difference between these groups is not statistically significant (Fisher's exact test, p=0.633). Small populations such as this are extremely sensitive to small fluctuations as the presence of a single datum (the sole nonlocal subadult) makes a substantial difference in terms of the significance of the difference between these two groups.

For the Tutu population, there are 20 adults and nine subadults. Amongst the adults, seven (35.0%) are nonlocal and amongst the subadults none (0%) are nonlocal. Despite the apparently large difference between these groups, this difference is not quite statistically significant (Fisher's exact test, p=0.066). Nonetheless, the p value is just outside of the range of significance and is probably an artifact of very small sample sizes. Once again, the high proportion of nonlocals amongst the adults and the absence of nonlocals amongst the subadults match expectations.

For the Anse à al Gourde population, there are 59 adults and nine subadults. Amongst the adults, 14 (23.7%) are nonlocal and amongst the subadults three (33.3%) are nonlocal. The difference between these groups is not statistically significant (Fisher's exact test, p=0.762). However, contrary both to expectations and the results from the other populations in this study, there are proportionally more nonlocals amongst the subadults than adults, even though the absolute number of nonlocal adults is larger. Although the absolute number of nonlocal juveniles at this site is small, these results are somewhat peculiar considering that the $^{87}Sr/^{86}Sr$ ratios of two of these nonlocal juveniles are the two highest values amongst this population and are also elevated relative to the absolute range for the Antilles (*sensu stricto*). The nearest location with similar, measured $^{87}Sr/^{86}Sr$ ratios is Trinidad, indicating that these two juveniles possibly migrated from a distant origin (> 500 km) at relatively young ages (~2 and ~5-7 years of age at death, respectively). It is also somewhat peculiar that none of the other nonlocal adults from this population possess similarly elevated $^{87}Sr/^{86}Sr$ values, although this may simply be the result of differential burial treatment or sampling bias.

For the Lavoutte population, there are 27 adults and five subadults. Amongst the adults, two (7.4%) are nonlocal and amongst the subadults none (0%) are nonlocal. The difference between these groups is not statistically significant (Fisher's exact test, p=1.000). The small difference between these groups reflects the fact that a very small percentage of individuals (~6%) from Lavoutte have been identified as nonlocal. This percentage is also relatively small relative to the overall size of this sample population compared to other populations in this study of similar size. However, as with Tutu, none of the subadults from Lavoutte are nonlocal.

Similar to the situation for biological sex, there are insufficient numbers of samples or relevant data to conduct statistical analyses individually for the other populations in this study. Therefore, I have pooled all individuals for which we have an osteological identification of skeletal age into a single sample population for the sake of comparative analysis. The pooled sample population includes results from the five populations discussed above in addition to the results from Punta Macao, Manzanilla, Heywoods, and the composite Escape/Argyle assemblage. In total, the pooled sample population includes 310 individuals, 248 adults and 62 subadults. Statistical analysis of this pooled data set indicates that there is a statistically significant difference between nonlocal adults and nonlocal subadults (Fisher's exact test, p=0.031). Thus despite the high degree of variation between the contexts of the sample populations, the general trend is that adults are far more likely to be nonlocal than subadults.

Table 11: Comparisons between locality and age at death

Site	**Adult**	**Adult**	**Adult**	**Subadult**	**Subadult**	**Subadult**
	total	nonlocal	%	total	nonlocal	%
El Chorro de Maíta	63	20	31.7	25	2	8.0
Punta Macao	16	1	6.3	2	0	0.0
Maisabel	23	8	34.8	6	1	16.7
Tutu	20	7	35.0	9	0	0.0
Anse à la Gourde	59	14	23.7	9	3	33.3
Lavoutte	27	2	7.4	5	0	0.0
Escape/Argyle	26	7	26.9	1	1	100
Heywoods	3	0	0.0	0	0	0.0
Manzanilla	11	2	18.2	5	1	20.0
Total	248	61	24.6	62	8	12.9

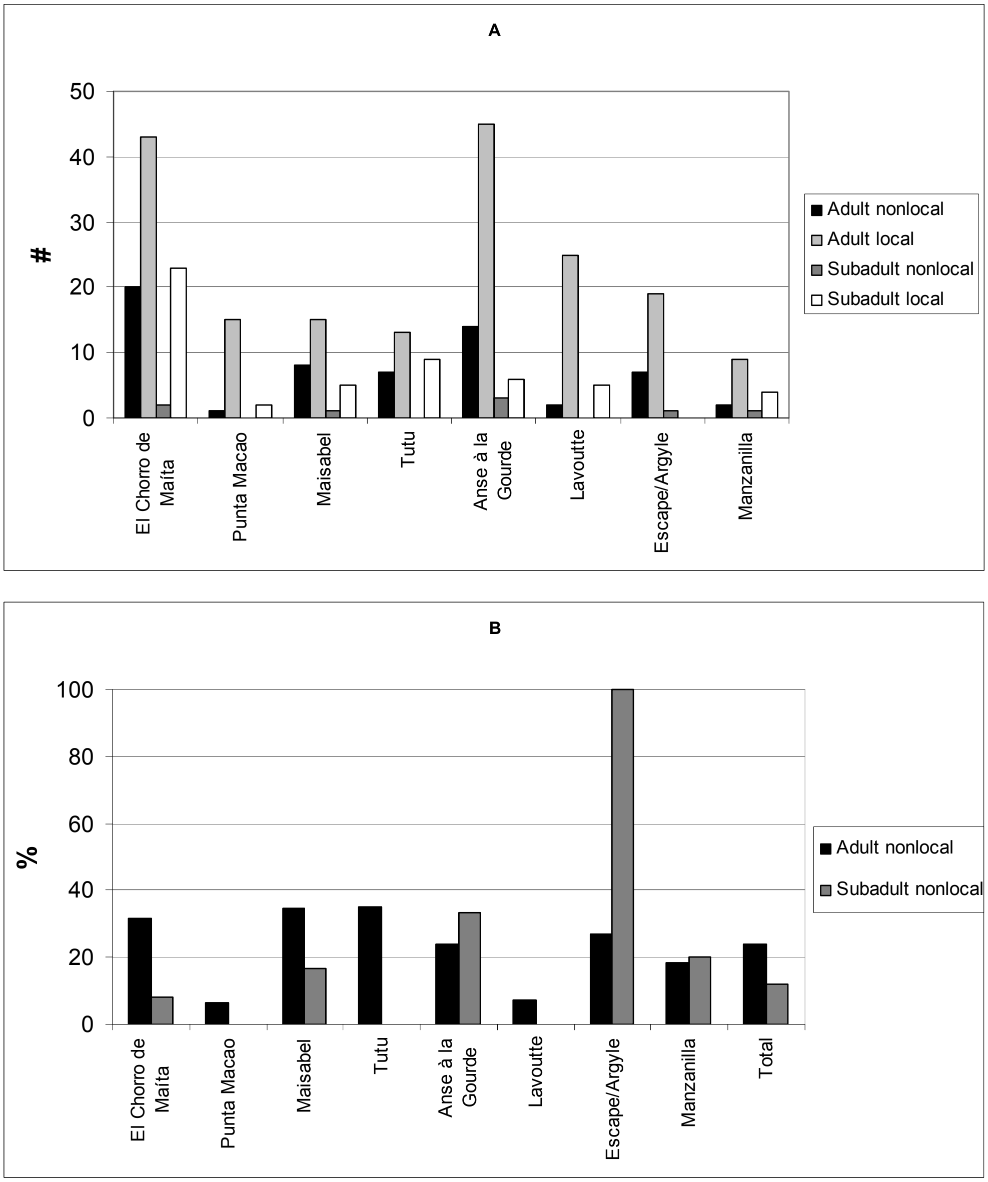


Figure 42 **Chart of patterns between locality and age at death.**
A) Numbers of adult locals/nonlocals and subadult locals/nonlocals per population; and B) Percentages of adults and subadults that are nonlocal per population.

7.4.3 Patterns of Paleomobility: chronology

Sufficient data on the chronology and dating of individual burials are only available for a few of the populations studied herein, namely Maisabel, Tutu, and Anse à la Gourde. Unfortunately, radiocarbon dates are only available for a limited number of individuals from each of these populations. In most cases there is a strong degree of overlap between the 2-sigma radiocarbon dates for different individuals from the same population and in some cases the dispersion of the median probability dates indicates that some burial population represent the long term accumulation of individual over several centuries. Owing to these limitations, the individual skeletal remains have been simply clustered into two or more categories (e.g., early/late) based on direct radiocarbon dating of skeletal remains. These categories have been supplemented, for example in cases where associated material remains or burial practices could be clearly attributed to one or the other of these temporal categories. Statistical analyses was then conducted to determine if there were significant differences in the presence of nonlocals between earlier and later time periods for each of these populations.

For Maisabel, of the 29 individuals analyzed for Sr isotopes, radiocarbon dates (obtained directly from the skeletal material) are available for the vast majority (n=24, ~83%). The five individuals for whom no radiocarbon dates are available could be assigned to an early or later component based on associated material remains, namely ceramic materials. Thus compared to most of the other populations in this study we have good chronological control of the individual burials at least in reference to their derivation from an earlier or later Ceramic Age context. In total, 13 individuals could be assigned to an earlier context dating from roughly A.D 500-1000, and 16 individuals could be assigned to a later group dating from roughly AD 950-1450. The early group is comprised of seven locals and six nonlocals (~46%) and the later group is comprised of 13 locals and three nonlocals (~19%). Despite the fact that there are twice as many nonlocals in the early group compared to the later group and that proportionally the difference is quite large, it is not statistically significant (Fisher's exact test, p=0.226).

For Tutu, of the 29 individuals analyzed for Sr isotopes, radiocarbon dates are available for 24 of them. In total, nine individuals fall into an earlier group dating from roughly A.D. 450-950 and 15 fall into a later group dating from roughly A.D. 1150-1450. The early group is comprised of six locals and three nonlocals (~33%) and the later group is comprised of 11 locals and four nonlocals (~27%). The observed difference between these groups is not statistically significant (Fisher's exact test, p=1.000).

For Anse à la Gourde, of the 68 individuals analyzed for Sr isotopes, radiocarbon dates are available for 24 of them. The dispersion of these radiocarbon dates is somewhat continuous over approximately 500 years of occupation with little clear clustering of the median probability dates. The dated individuals from this site can be divided into three roughly defined groups; 1) an early group dating from roughly A.D. 980-1150; 2) an intermediate group dating from roughly A.D. 1150-1270; and 3) a later group dating from roughly A.D. 1270-1430. The earlier group consists of five individuals, two locals and three nonlocals (60%). The intermediate group consists of 13 individuals, five locals and eight nonlocals (~62%). The later group consists of six individuals, five locals and one nonlocal (~17%). The proportions of nonlocals amongst the dated individuals is somewhat inflated owing to the fact that Sr isotope results guided the sampling strategy for radiocarbon dating analysis. Proportionally, there are clearly many more nonlocals in the early and intermediate groups relative to the later group. These observed differences are, however, not statistically significant (Pearson Chi-Square, 2-sided, p=0.169).

I also conducted a comparison of the number and proportion of nonlocals dating to the Early versus those dating to the Late Ceramic Ages from the sites where secure chronological data was available (for the sake of this analysis, a cutoff of ~A.D. 700 was used). For this comparison I included individuals from the larger sample populations who could be clearly assigned to one of these two groups based on direct radiocarbon dates and/or associated material remains. This pooled dataset includes individuals from the populations of Punta Macao, Maisabel, Tutu, Anse à la Gourde, Lavoutte, Escape/Argyle 1. Other populations were not included if they dated to the Archaic Age (Malmok) or contact period (El Chorro de Maíta and Argyle 2), if there was ambiguity in terms of assigning a particular burial to one of these two time periods (e.g., undated individuals from Tutu), or if local Sr isotope range estimates could not be done at the site level (e.g., Ceramic Age sites on Aruba). In total, 224 individuals were included in this analysis. Amongst 62 individuals dating to the Early Ceramic Age there are 20 nonlocals (32.3%)

and amongst the 162 individuals dating to the Late Ceramic Age there are 27 nonlocals (16.7%). Thus proportionally, the percentage of nonlocals from the earlier period is twice that of the later period and this difference is statistically significant (Fisher's exact test, p=0.016). Therefore, in general there are proportionally many more nonlocals in the Early Ceramic Age compared to the Late Ceramic Age. This pattern is consistent with current models of human migration patterns for the Early Ceramic Age, during which population densities were much lower and social relationships (including possible marriage exchange) were frequently maintained over long distances.

7.4.4 Patterns of Paleomobility: grave goods

To assess possible patterns or associations between mobility and mortuary treatment, I compiled available mortuary data for several of the populations included in this study. Unfortunately, for several burial populations details of mortuary treatment are poorly documented or simply not available. For other populations, the quality of the available data is highly variable thereby limiting comparative analyses. Therefore, comparative analysis between mobility and mortuary treatment are restricted to direct assessments of locals and nonlocals relative to the presence or absence of grave goods and in a limited number of cases to the types of grave goods. These analyses have been conducted for the El Chorro de Maíta, Tutu, and Anse à la Gourde burial populations. Substantial mortuary data are also available for the Maisabel population but nearly all of the individuals that were analyzed for Sr isotopes have cultural materials associated with the burials pits. Thus no comparison could be made based on the presence/absence of grave inclusions and no pattern was found between natal residence and the type of grave goods for this site.

At El Chorro de Maíta, of the 88 individuals analyzed for Sr isotope composition, 71 individuals were not interred with grave goods and 17 individuals were interred with grave goods (Valcárcel Rojas 2012). Of the 71 individuals that were not interred with grave goods, 53 are local and 18 are nonlocal (~25%). Of the17 that were interred with grave goods, 13 are local and four are nonlocal (~24%). These observed differences are not statistically significant (Fisher's exact test, p=1.000). All four of the nonlocals with grave goods were found with aglets, or brass tubes, presumably of European origin, 3 adult males and a juvenile age 10-11 years at death. However, most of the individuals that were interred with aglets are local.

At Tutu, of the 29 individuals analyzed for Sr isotope composition, 19 individuals were not interred with grave goods and 10 individuals were interred with grave goods, primarily pottery (Righter 2002; Sandford et al. 2002). Individuals buried in or with ceramic vessels are mostly represented by subadults and adults dating to the earlier component of the site. Of the 19 individuals that were not interred with grave goods, 15 are local and four are nonlocal (~21%). Of the 10 that were interred with grave goods, seven are local and three are nonlocal (30%). These observed differences are not statistically significant (Fisher's exact test, p=0.665).

At Anse à la Gourde, of the 68 individuals analyzed for Sr isotope composition, 37 individuals were not interred with grave goods and 31 individuals were interred with grave goods. Grave goods consist of a wide variety of materials and objects of both local and exotic origins including for example lithic tools, whole or fragmentary ceramic vessels, and various beads and ornaments of bone, teeth, shell and stone. Of the 37 individuals that were not interred with grave goods, 28 are local and nine are nonlocal (~24%). Of the 31 that were interred with grave goods, 23 are local and eight are nonlocal (~26%). These observed differences are not statistically significant (Fisher's exact test, p=1.000). One interesting pattern that was observed for this site is that grave inclusions of exotic origin, including a flake of Long Island flint, an adze of St. Martin greenstone, and an apron consisting of over 1000 shell beads, primarily composed of *Strombus gigas* (Lammers-Keijsers 2007) are exclusively associated with nonlocal females (Hoogland et al. 2010).

Some assessment of associations between mortuary treatment and locality is possible for the site of Manzanilla, Trinidad. One burial contains the remains of a nonlocal adult male as a secondary deposit of a bone bundle (Dorst 2008). Another burial contains a nonlocal adult male in a composite burial of four individuals in total, including both primary and secondary burials. This individual's extremely radiogenic $^{87}Sr/^{86}Sr$ signature (0.7219) is by far the highest in this study and suggests a possible origin in

Guiana Shield region of South America based on comparison with the high $^{87}Sr/^{86}Sr$ of this geologically old region. Interestingly, two other individuals in this composite burial possess apparently local $^{87}Sr/^{86}Sr$ values, indicating the inclusion of both locals and a nonlocal in the same burial deposit. Lastly, another nonlocal is an adolescent aged 14-16 years interred in a single, primary flexed burial, possibly dating to the Araquinoid period occupation (Dorst 2008). This individual exhibits the second highest $^{87}Sr/^{86}Sr$ ratio (0.7111) recorded to date amongst prehistoric Antillean skeletal collections. A frog-shaped ornament, possibly made of chlorite, found in association with burial F291 may have an exotic (Amazonian) origin (Boomert 1987) although the provenance of this specimen has yet to be determined with certainty.

7.4.5 Patterns of Paleomobility: dietary patterns

For a large number of individuals in this study carbon and nitrogen isotope data are available with which to compare the strontium isotope data. Bone isotope data are available for populations from the sites of Maisabel, Tutu, and Anse à la Gourde (Table 12 and Figure 43). In this section I will make direct comparisons between local and nonlocal groups from these sites based on the available bone isotope data and also assess these in terms of the overall variation in dietary isotope patterns throughout the Caribbean region (Figure 44). The purpose is not so much to attempt to reconstruct patterns of paleo-diet but to assess similarities and differences between locals and nonlocals in terms of general dietary patterns and the potential of dietary isotope data for exploring the potential natal origins of nonlocal individuals.

One possible complication of comparing dietary patterns to patterns of migration as inferred from strontium isotope data are the direct consumption of marine resources. In principle, this could substantially contribute to the overall dietary Sr budget and thus alter the $^{87}Sr/^{86}Sr$ ratios of biogenic tissues shifting them towards a seawater signal. Abundant evidence indicates that most, if not all, indigenous populations of the Antilles consumed marine resources but that there was considerable inter- and intra-societal variation in this regard (deFrance et al. 1996; Keegan and DeNiro 1988; Newsom and Wing 2004; Pestle

2010; Stokes 1998). There is also evidence that salt was an economically, socially, and symbolically important commodity in the ancient Antilles and may have been widely used as a food preservative (Morsink 2012). Sea salt consumption has been identified as a possible source of altered (elevated) $^{87}Sr/^{86}Sr$ ratios amongst prehistoric Maya populations (Wright 2005).

Nonetheless, the Sr isotope results from this study do not support a scenario in which marine strontium (obtained directly from the consumption of marine resources) is a primary or dominant source of dietary strontium. For almost all of the populations studied herein (with the exception of the St. Vincent sites), the $^{87}Sr/^{86}Sr$ ratios of the locally defined population closely match not only those of small terrestrial animals but in many cases also those of plants collected from the site or in the surrounding vicinity. Furthermore, for several populations the $^{87}Sr/^{86}Sr$ ratios of nonlocal individuals fall significantly below both the main cluster of (local) human values but also local biosphere samples. Thus the direct consumption of marine Sr can be ruled out as a cause for these lower $^{87}Sr/^{86}Sr$ ratios as the consumption of marine Sr would elevate $^{87}Sr/^{86}Sr$ ratios in most Antillean contexts. Lastly, as discussed in section 7.2, inputs of marine Sr into local terrestrial ecosystems in the Antilles via rainfall, sea spray, or dry fall are substantial and produce a noticeable effect on the $^{87}Sr/^{86}Sr$ ratios of the Caribbean biosphere at all levels of the local food chains. As previously mentioned, another caveat of this approach is that isotopes in bone generally reflect the last years or decades of life, while dental enamel (the material that was analyzed for Sr isotopes) reflects the early years of life, i.e., childhood. As such a degree of caution is required in the direct comparisons of these different data sets. Dietary information derived from carbon isotope analyses of dental enamel, reflecting dietary intake during childhood is discussed in section 7.6.

For the site of Maisabel, Stokes (1998) has reported carbon and nitrogen isotope results from the analysis of bone collagen and carbon isotope results from the analysis of bone apatite (n=18). Sixteen of these have also been analyzed for Sr isotopes, nine of whom are local and seven are nonlocal. Comparison of the bone collagen data between the locals and nonlocals indicates broadly similar trends for $\delta^{13}C_{co}$ but clear differences in $\delta^{15}N$. The mean $\delta^{13}C_{co}$ for locals and nonlocals is identical (-18.1‰). The mean $\delta^{15}N$ for locals (10.1‰) is enriched by about 1‰ relative to nonlocals (9.2‰) [errors for $\delta^{13}C$ and

$\delta^{15}N$ are typically in the range of ± 0.1‰]. Although this difference seems modest, the difference is significant using Student's t-test ($p=0.014$). This pattern is interesting in regard to the possible origins of the nonlocals at this site and requires further examination at the scale of specific individuals.

The five most depleted $\delta^{15}N$ values from Maisabel all derive from nonlocals. Of these, B23 (an adult female) possesses the most depleted $\delta^{13}C_{co}$ of this population, and B2 (an adult male) possesses the most enriched $\delta^{13}C_{co}$ of this population. Interestingly, these values are also at the far extremes of measured $\delta^{13}C_{co}$ values from Puerto Rico (Pestle 2010). B23's combined $\delta^{13}C_{co}$ and $\delta^{15}N$ values are generally more comparable to those obtained from the site of Paso del Indio. Of the more than two hundred measurements from prehistoric Puerto Rican sites, B2's $\delta^{13}C_{co}$ value is exceeded only by one sample from the site of Punta Candelero (Pestle 2010) and is actually more comparable to values obtained from sites in the northern Lesser Antilles (Norr 2002; Stokes 1998). Two other nonlocal individuals have depleted $\delta^{15}N$ values, B7 and B21, but possess $\delta^{13}C_{co}$ and $\delta^{13}C_{ca}$ bone values that are within the range of local variation.

Interestingly, the dental enamel carbon isotope values of both of these individuals are also extremely depleted in $\delta^{13}C_{ca}$. The degree of offset between their enamel and bone $\delta^{13}C_{ca}$ values (~2.8‰ and 3.7‰, respectively) far exceeds what would be expected based on trophic level effects related to weaning and suggests possible mobility-related changes in diet between childhood and adulthood. In fact, the enamel $\delta^{13}C_{ca}$ value from B21 (-13.1‰) is one of the most depleted measurements ever obtained for the ancient Antilles and suggests relatively minimal contributions of C_4 resources to this individual's childhood dietary energy. This is particularly interesting considering B21's extremely low $^{87}Sr/^{86}Sr$ value (0.7056) which is the lowest value amongst the entire human data set in this study (n>360). Another nonlocal, B14 possesses a very low $\delta^{13}C_{ca}$ bone values (-11.7‰), not only relative to Maisabel but to ancient Puerto Rico populations more generally. Compared to the total Puerto Rican data set (n>200), B14's $\delta^{13}C_{ca}$ value (and $\delta^{13}C_{ap\text{-}co}$ value) is exceeded only by a few measurements from Paso del Indio, and compared to the overall Antillean data set is more similar to measured values from the Dominican Republic (Stokes 1998).

If we assume that the nearest possible origins are the most likely, then inland or central Puerto Rico may be the natal origin(s) of several of the nonlocals at Maisabel, especially those with relatively depleted $^{87}Sr/^{86}Sr$ values which match biosphere $^{87}Sr/^{86}Sr$ values from the central and southern regions of the island. Nonlocals with inland origins might be expected to consume less marine protein relative to coastal populations such as the local population at Maisabel. If so, this might explain the observed pattern of somewhat depleted $\delta^{15}N$ values amongst certain nonlocals (the possible inland migrants) at Maisabel relative to the local group at this site. However, it should be noted that other factors might be affecting this particular pattern, for example this may also reflect temporal variation in dietary patterns as the majority of the nonlocals at Maisabel date to the earlier period. The mean $\delta^{13}C_{ap}$ for locals (-10.0‰) and nonlocals (-9.7‰) are within analytical error, indicating relatively little difference between these groups in terms of the average carbon isotope compositions of whole diets. Additionally, comparisons with the range and variance of measured $\delta^{13}C_{co}$, $\delta^{13}C_{ap}$, and $\delta^{15}N$ in the Caribbean indicate that some of the nonlocals at Maisabel may have non-Puerto Rican origins.

For the site of Tutu, Norr (2002) reported carbon and nitrogen isotope results from the analysis of bone collagen and carbon isotope results from the analysis of bone apatite (n=25). Twenty of these individuals have also been analyzed for Sr isotopes, including 14 locals and six nonlocals. Comparisons of these stable isotope values indicate very similar patterns for locals and nonlocals at this site. The mean $\delta^{13}C_{co}$ for locals is -15.4‰ and for nonlocals -15.7‰. The mean $\delta^{15}N$ for locals is 12.4‰ and for nonlocals is 11.5‰. The mean $\delta^{13}C_{ap}$ for locals is (-10.4‰) and nonlocals (-10.7‰). Student t-tests of these results indicate no significant differences between locals and nonlocals for any of these three data sets: $\delta^{13}C_{co}$ (p=0.684); $\delta^{15}N$ (p=0.121); $\delta^{13}C_{ap}$ (p=0.359).

Exploring the relationships between nonlocals and dietary practices at the scale of individuals highlights some interesting patterns. Two nonlocal individuals, T4 and T31 (both adult females) have the most depleted $\delta^{15}N$ values and also two of the most depleted $\delta^{13}C_{co}$ values amongst this population. Of these, T4's combined $\delta^{15}N$ and $\delta^{13}C_{co}$ values fall in between the main clusters of values from the Lesser and Greater Antilles. T31's $\delta^{15}N$ and $\delta^{13}C_{co}$ values clearly are outside the absolute range of values for the Lesser Antilles and are most similar to those obtained from Puerto Rican populations. Another individual from Tutu, T26 (also an adult female) has a similarly depleted $\delta^{13}C_{co}$ value but a $\delta^{15}N$ that is similar to the local population at this site. All three of these individuals also have relatively low $^{87}Sr/^{86}Sr$ ratios that are very similar to biosphere $^{87}Sr/^{86}Sr$ ranges from Puerto Rico, indicating that this island could be the origin of one or all of them. A fourth nonlocal from Tutu, T38 (an adult male) has the most enriched $\delta^{13}C_{co}$ value from Tutu (-12.9‰) and one of the most enriched $\delta^{13}C_{co}$ values in the entire Caribbean and also an extremely low $\delta^{13}C_{ap-co}$ value. T38's combined $\delta^{13}C_{co}$, $\delta^{13}C_{ap}$, and $\delta^{15}N$ values are distinct from the rest of the Tutu population (both locals and other nonlocals) and are most similar to those obtained reported for the Bahamas, Anguilla, and Grande-Terre (Guadeloupe). However, T38's $^{87}Sr/^{86}Sr$ value (0.7087) is probably too low for an origin in any of these places which generally possess higher biosphere $^{87}Sr/^{86}Sr$ ranges (~0.7090-0.7092). It is possible that T38's natal origin is in an area with similar dietary (but unreported) dietary isotope patterns as these islands but somewhat lower biosphere $^{87}Sr/^{86}Sr$ ranges, for example possibly some of the composite islands of the northern Lesser Antilles.

For the site of Anse à la Gourde, Stokes (1998) and de Vos (2010) [see also (Laffoon and de Vos 2011)] reported carbon and nitrogen isotope results from the analysis of bone collagen (n=58) and carbon isotope results from the analysis of bone apatite (n=21). Of the bone collagen samples, 49 have also been analyzed for Sr isotopes, including 36 locals and 13 nonlocals. Analyses of the stable isotope data indicate very similar dietary patterns between locals and nonlocals for this population. The mean $\delta^{13}C_{co}$ for locals is -14.7‰ and for nonlocals -14.9‰. The mean $\delta^{15}N$ for locals is 11.0‰ and for nonlocals is 10.9‰. Of the bone apatite samples, 17 have also been analyzed for Sr isotopes, including 11 locals and six nonlocals. The mean $\delta^{13}C_{ap}$ for locals is (-8.5‰) and nonlocals (-8.2‰). Student t-tests of these results indicate no significant differences between locals and nonlocals for any of these three data sets: $\delta^{13}C_{co}$ ($p=0.561$); $\delta^{15}N$ ($p=0.732$); $\delta^{13}C_{ap}$ ($p=0.687$).

There are, however, some correlations between diet and locality as certain nonlocals at Anse à la Gourde also possess distinct carbon and nitrogen isotope values. For example, individual F2215 (an adult female), has the most depleted $\delta^{13}C_{co}$ value and the second most depleted $\delta^{15}N$ value amongst this population. F2215's $\delta^{13}C_{co}$ value is at the extreme of the range of variation for the Lesser Antilles and is in fact more comparable to values obtained from the Greater Antilles, especially Puerto Rico. A Puerto Rican origin is also possible for this individual based on her $^{87}Sr/^{86}Sr$. No $\delta^{13}C_{ap}$ bone measurement is available for this individual, although her $\delta^{13}C_{ap}$ enamel value is similar to the local population.

Another nonlocal individual, F311 (also an adult female), has the most enriched $\delta^{13}C_{ap}$ value and highest $\delta^{13}C_{ap\text{-}co}$ value amongst this population. In fact, F311's $\delta^{13}C_{ap}$ value is one of the highest values recorded to date in the Antilles. Although a few similarly enriched values have been obtained from Puerto Rican individuals, F311's $\delta^{13}C_{co}$ value is outside of the range of variation for Puerto Rico. Significantly, F311's enamel $\delta^{13}C_{ap}$ value (-11.1‰) is substantially more depleted than her bone value (-6.0‰) and is quite similar to the local population at Anse à la Gourde. This pattern suggests not only a profound change in dietary practices between childhood and adulthood but also that during childhood her diet was more similar to the local population than during adulthood. Another interesting fact to note about individual F311 is that she was interred with a bead apron consisting of over 1000 drilled shell beads and is the only individual from this burial assemblage (or from anywhere in the Antilles) that has been discovered with such a grave inclusion. Since there is no evidence for local production of these types of beads at this site, this apron has been interpreted as a foreign import (Lammers-Keijsers 2007).

Table 12: Comparisons between locality and diet for three prehistoric Caribbean populations

Note: data sources are- 1) Stokes 1998; 2) Norr 2002; 3) Laffoon and de Vos 2011; 4) Pestle 2010; 5) Antón 2008; 6) Krigbaum et al. in press; 7) St. Christopher's National Trust- unpublished archival data

Island	Site	Group	$\delta^{15}N_{co}$	$\delta^{13}C_{co}$	$\delta^{13}C_{ap}$	$\Delta^{13}C_{ap\text{-}co}$	source
			mean	mean	mean	mean	
Puerto Rico	Maisabel	All	9.7	-18.1	-9.9	8.2	1
		locals	*10.1*	*-18.1*	*-10.0*	*8.0*	1
		nonlocals	*9.2*	*-18.1*	*-9.7*	*8.4*	1
St. Thomas (USVI)	Tutu	All	12.2	-15.5	-10.5	5.0	2
		locals	*12.4*	*-15.4*	*-10.4*	*5.0*	2
		nonlocals	*11.5*	*-15.7*	*-10.7*	*5.0*	2
Grande-Terre (Guad.)	Anse à la Gourde	All	10.9	-14.8	-8.4	6.4	1,3
		locals	*11.0*	*-14.7*	*-8.5*	*6.3*	1,3
		nonlocals	*10.9*	*-14.9*	*-8.2*	*6.7*	1,3
Bahamas	multiple	All	9.8	-13.4	-10.8	2.6	1
La Tortue (Haiti)	Manigat Cave	All	8.7	-16.5	-9.9	6.6	1
Dominican Republic	Juan Dolio	All	11.9	-17.1	-12.5	4.6	1
	Boca del Socco	All	11.9	-18.0	-11.9	6.2	1
Puerto Rico	Punta Candelero	All	9.9	-17.5	-8.3	9.2	4
	Paso del Indio	All	9.8	-19.1	-9.4	9.7	4
	Tibes	All	9.5	-17.6	-8.6	9.0	4
	Rio Tanamá	All	9.1	-19.6	-10.5	9.1	5
Anguilla	multiple	All	10.1	-14.4	-10.7	3.7	1
Saba	multiple	All	10.8	-15.7	-11.0	4.7	1
St. Martin	Hope Estate	All	10.4	-15.7	-10.8	4.9	1
La Desirade (Guad.)	Petite Riviere	All	10.3	-14.1	-8.2	5.9	1
St. Lucia	Grande Anse	All	12.4	-16.3	-8.1	8.3	1
Carriacou	Grand Bay	All	11.1	-12.8	-8.6	4.1	6
Grenada	Pearls	All	12.6	-17.0	-13.0	4.0	1
St. Kitts	Bloody Point	All	11.0	-15.3	-9.9	5.4	7

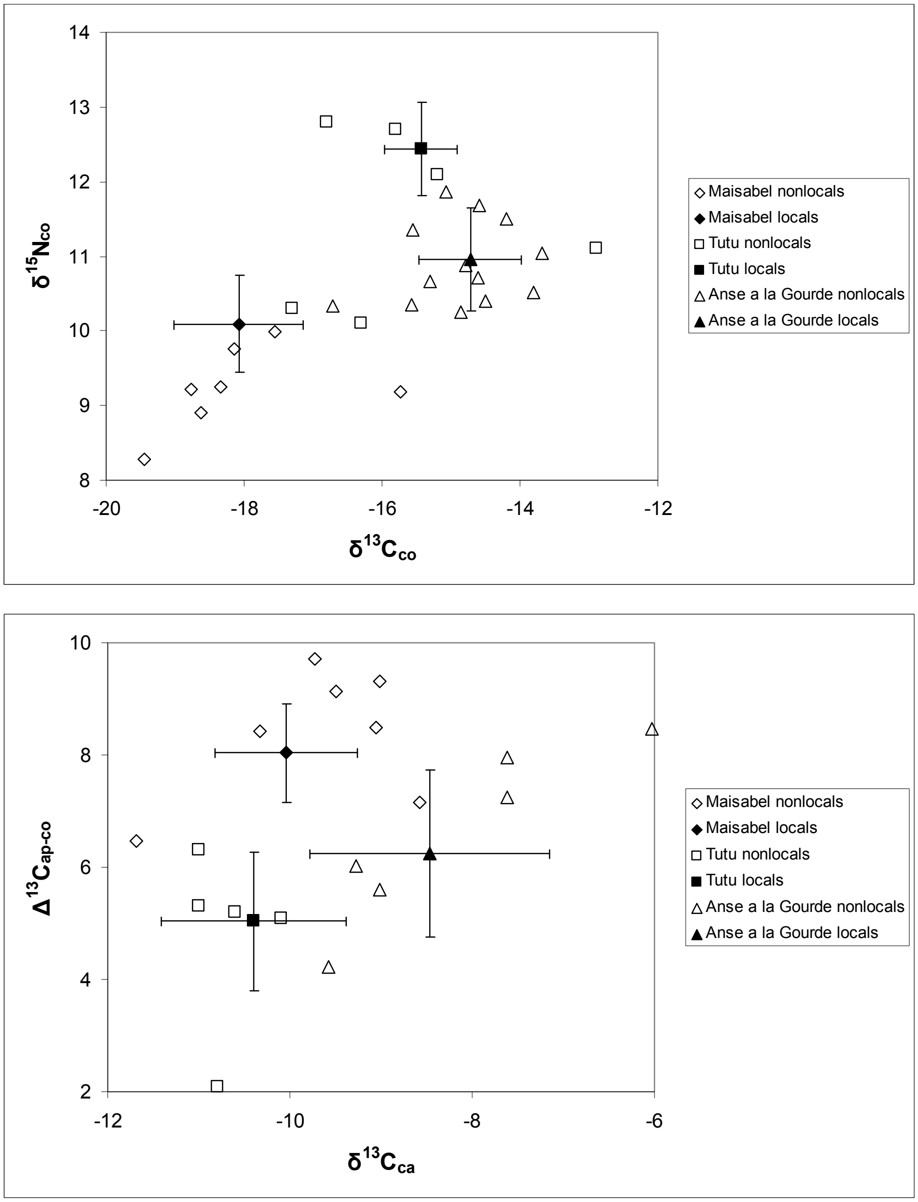


Figure 43 Diagrams of bone $\delta^{13}C$ and $\delta^{15}N$ data from 3 populations included in this study.

A) $\delta^{13}C_{co}$ and $\delta^{15}N_{co}$; B) $\delta^{13}C_{ap}$ and $\Delta^{13}C_{ap\text{-}co}$. Note: The symbols for nonlocals represent isotope values of individual samples and the symbols for locals represent the mean ± standard deviation (1σ) of the local samples. Carbon and nitrogen isotope data are from Laffoon and de Vos 2011; Norr 2002; Stokes 1998.

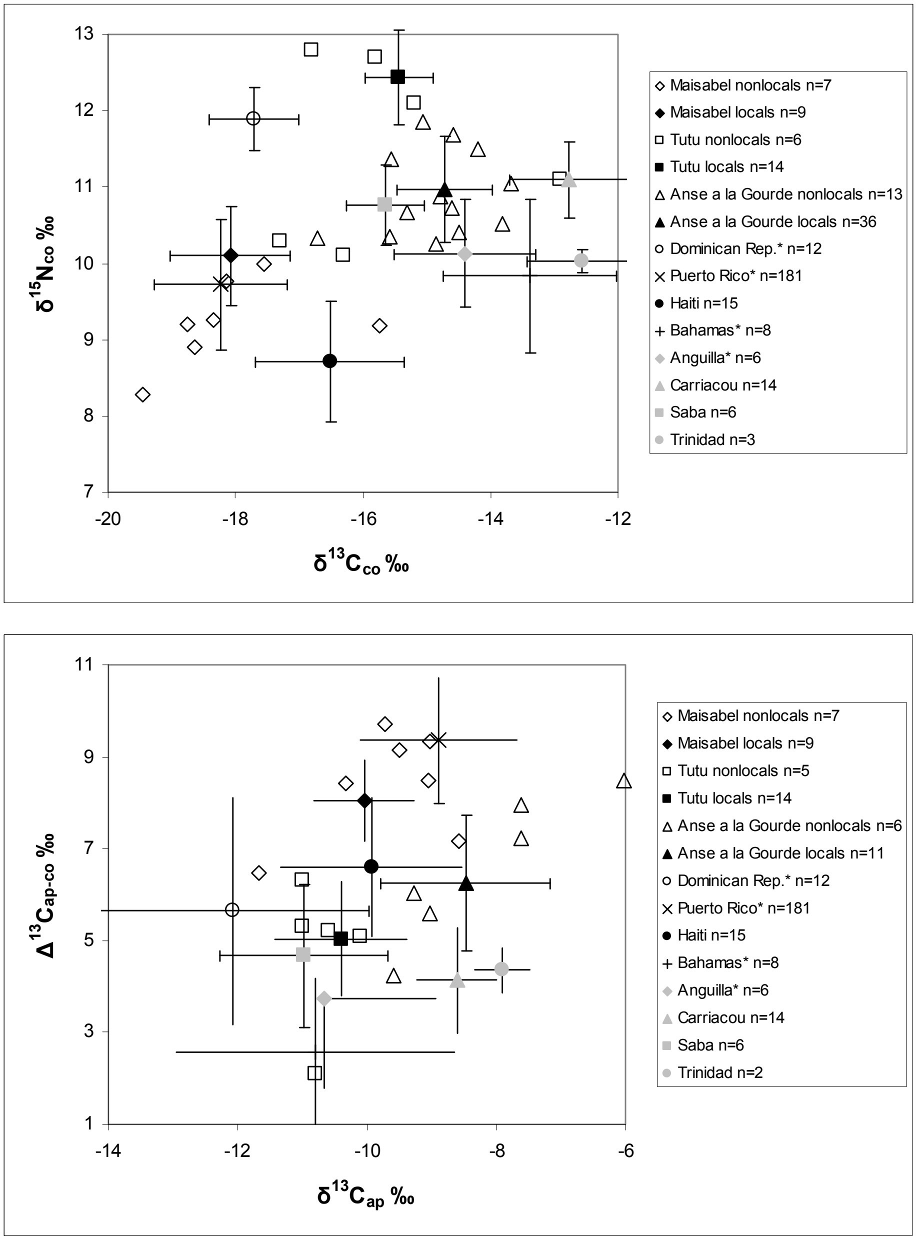


Figure 44 Diagrams of bone $\delta^{13}C$ and $\delta^{15}N$ data from prehistoric Caribbean populations.

A) $\delta^{13}C_{co}$ and $\delta^{15}N_{co}$; and B) $\delta^{13}C_{ap}$ and $\Delta^{13}C_{ap\text{-}co}$. The symbols for nonlocals = isotope values of individual samples and the symbols for locals = the mean ± standard deviation (1σ) of the local samples; * = samples pooled from multiple sites. isotope data are from-Krigbaum et al. in press; Laffoon and de Vos 2011; Norr 2002; Pestle 2010; Stokes 1998.

7.5 Assessing Human Dental Enamel Carbon and Oxygen Isotope Results

As previously mentioned, the promising provenance results obtained from strontium isotope analyses of human dental enamel from the Caribbean led to the exploration of the utility of other isotopes for the study of paleomobility in the Caribbean (Laffoon et al. 2012b). A subset of our total human sample population was analyzed for carbon and oxygen isotopes with the aim of assessing whether sufficient spatial variation of ^{18}O exists within this region to infer ancient migrations and to explore the usefulness of both ^{18}O and ^{13}C for investigating the nonlocal origins of several specific individuals that were determined to be nonlocal based on Sr their isotope values and other evidence for foreign origins.

The oxygen isotope results from archaeological human dental enamel in the Caribbean display relatively little variation as a whole. In general, despite minor differences in δ^{18}O between different islands, the intra-population variance is nearly as large as the inter-population variance and is not substantial relative to other potential sources of error (e.g., temporal variation in climatic and hydrological conditions, weaning effects, and various other cultural practices) influencing the δ^{18}O of consumed water (Knudson 2009). Overall, these patterns suggest that the analysis of δ^{18}O in archaeological teeth from the Antilles may be potentially more useful for the identification of individuals immigrating from outside of the Antilles (and assessments of their possible origins) than as a tool for tracking intra-Caribbean mobility.

Published δ^{18}O data from the Caribbean (both local and African born) and Mesoamerica were compiled to compare with our Antillean data set and to assess intra- and inter-regional variation (Table 13, Figures 45 and 46). Published δ^{18}O results from archaeological human dental remains from Caribbean contexts are limited to one study of the slave cemetery of Newton Plantation, Barbados (Schroeder et al. 2009). These results are of particular interest to our research in that they provide a baseline of δ^{18}O ranges in the Antilles although comparisons between the data sets must be done with caution owing to several caveats concerning temporal, spatial and cultural sources of δ^{18}O variation. The Newton Plantation population dates to a later time period (ca. 17th to 19th centuries) than our sample set (ca. 6th to 16th centuries). Barbados is also a geographic outlier relative to the rest of the Antilles as it is not actually in the Caribbean Sea but in the Atlantic Ocean approximately 100 kilometers east of the southern Lesser Antilles. Additionally, large cultural differences may be expected between a British-controlled sugar plantation population and pre- and proto-historic Amerindian communities in terms of weaning ages and/or the storage, processing, and consumption of imbibed water sources.

Table 13: Summary of human enamel $\delta^{18}O$ and $\delta^{13}C$ data from Caribbean archaeological populations

Note: * does not include outliers; † indicates data from Schroeder et al. (2009).

Site	Region	Population	n	$\delta^{18}O_{ca}$ ‰	$\delta^{13}C_{ca}$ ‰
				Mean (range)	*Mean (range)*
Chorro de Maíta*	Cuba	Antillean	9	-2.7 (-3.3 to -2.0)	-12.2 (-12.9 to -11.4)
Punta Macao	Dom. Rep.	Antillean	5	-2.3 (-2.8 to -1.8)	-13.1 (-14.2 to -12.4)
Maisabel	Puerto Rico	Antillean	5	-2.0 (-2.9 to -1.1)	-12.1 (-13.1 to -11.10
Tutu	St. Thomas	Antillean	5	-2.4 (-3.1 to -1.8)	-11.3 (-12.1 to -9.3)
Kelbey's Ridge 2	Saba	Antillean	5	-2.3 (-2.7 to -2.0)	-11.7 (-12.8 to -9.9)
Anse à la Gourde	Guadeloupe	Antillean	7	-2.1 (-2.8 to -1.3)	-11.2 (-12.1 to -10.8)
Lavoutte	St. Lucia	Antillean	5	-2.8 (-3.4 to -2.0)	-11.0 (-12.0 to -9.1)
Manzanilla	Trinidad	Antillean	5	-2.8 (-3.3 to -2.1)	-9.1 (-12.5 to -7.2)
All sites (pooled)	Antilles	Antillean	46	-2.5 (-3.4 to -1.1)	-11.5 (-14.2 to -7.2)
Newton Plantation	Barbados †	Barbadian	18	-4.3 (-5.5 to -3.5)	-10.5 (-12.4 to -8.8)
Newton Plantation	Barbados †	African	7	-5.8 (-6.2 to -5.4)	-16.0 (-19.9 to -10.6)
El Chorro de Maíta	Cuba	CM45	1	-5.4	-5.1
El Chorro de Maíta	Cuba	CM72B	1	-3.7	-3.7

Based on the results of multiple isotope analyses and skeletal indicators of foreign cultural practices (African-style dental modification) the Newton Plantation population has been divided into first and later generation groups (Schroeder et al. 2009). The mean $\delta^{18}O_{ca}$ from the Barbadian born group is -4.3‰ and ranges from -5.5‰ to -3.5‰ (n=18). The mean $\delta^{18}O_{ca}$ of the proposed African-born group is -5.8‰ and ranges from -5.4‰ to -6.2‰ (n=7). Clearly, the Barbadian born individuals are less depleted in $\delta^{18}O$ relative to the African born individuals with almost no overlap in $\delta^{18}O$ values.

Despite their broadly similar $\delta^{18}O$ values, Schroeder and colleagues (2009) have proposed that the first-generation, forced migrants interred at Newton Plantation originated from several different regions within Africa, based primarily on their highly variable $^{87}Sr/^{86}Sr$ signatures.

In comparison with our $\delta^{18}O_{ca}$ data set, the Barbadian-born population at Newton Plantation is relatively depleted in $\delta^{18}O_{ca}$ (Schroeder et al. 2009). The cause of these differences is unknown but may be related to differences in precipitation patterns between Barbados and the rest of the Antilles. The mean $\delta^{18}O_{ca}$ of the trimmed data set from this study (minus three outliers) is -2.4‰, which is a difference of -1.9‰ compared to the locally born population at Newton Plantation, with no overlap in the ranges of values. Nonetheless, the $\delta^{18}O_{ca}$ values of the African born immigrants at Newton Plantation are potentially useful for assessments of the natal origins of the African individual from El Chorro de Maíta, Cuba (CM45). The $\delta^{18}O_{ca}$ value of CM45 is -5.4‰, falling within the range of values amongst the African-born individuals from Newton Plantation.

Large data sets of $\delta^{18}O$ results from the analyses of archaeological human teeth and bone from Mesoamerica have been published in recent years (Price et al. 2007b; Price et al. 2010; Schwarcz et al. 2010; White et al. 1998; White et al. 2002; White et al. 2007; Wright and Schwarcz 1998, 1999; Wright 2004; Wright et al. 2010). Available $\delta^{18}O$ data from Mesoamerica have been derived from the analyses of bone and enamel phosphate. Here we report enamel carbonate values and approximate carbonate equivalents of phosphate oxygen values as reported by Price and colleagues (Price et al. 2010) and Wright and colleagues (Wright et al. 2010). In Mesoamerican skeletal remains, $\delta^{18}O_{ca}$ values vary from roughly -10‰ to >0‰ (relative to PDB) with lower values found amongst populations from the Pacific coast and Central Highlands of Mexico and higher values from lowland Mesoamerica, such as northern Guatemala and Belize. This range of $\delta^{18}O_{ca}$ values (>10‰) is substantially larger than, and entirely encompasses, the relatively small range of (local) Antillean $\delta^{18}O$ data (~2.3‰) from this study (excluding three outliers). At finer spatial scales, the Antillean $\delta^{18}O$ data more closely match the values obtained from lowland Mesoamerica. The nearest match with the Antillean $\delta^{18}O$ data set in terms of mean and ranges is lowland Belize, although considerable overlap also exists with many populations from lowland areas and the Gulf Coast.

The available $\delta^{18}O$ data sets from Mesoamerica can be used to explore the possible Mesoamerican origin of individual CM72B from El Chorro de Maíta, Cuba. Comparison of CM72B's $\delta^{18}O$ value of -3.7‰ with reported $\delta^{18}O$ ranges from various regions of Mesoamerica further constrains the possible natal origins for this individual. Published $\delta^{18}O_{ca}$ (and $^{87}Sr/^{86}Sr$ isotope) data from several major sites in ancient Mesoamerica illustrate some of the broad spatial patterns of isotopic variation in this region (Price et al. 2007b; Price et al. 2010; Wright 2004; Wright et al. 2010). Central Highland sites in the relatively higher and drier areas of Mexico such as Teotihuacán possess more negative $\delta^{18}O_{ca}$ (<-6‰) while Southern Highland sites such as Kaminaljuyú and Copán possess more intermediate $\delta^{18}O_{ca}$ (roughly -3.5‰ to -6‰). Lowland sites like Tikal possess less negative $\delta^{18}O_{ca}$ (>-4‰) relative to sites in the highlands. On the one extreme, there is no overlap between CM72B's $\delta^{18}O$ value and the $\delta^{18}O$ ranges of any populations from the Central Highlands or Pacific Coast regions, which are all relatively depleted in ^{18}O. On the other extreme, $\delta^{18}O$ ranges in the lowland areas such as Belize and the Petén are relatively more enriched in ^{18}O and similar to the Antillean range, which is not surprising given their overall similarities in latitude, altitude, and temperature and rainfall regimes. However, on the basis of $\delta^{18}O$ values alone many other sites and regions within Mesoamerica cannot be eliminated as a potential origin(s) for individual CM72B.

The consideration of $^{87}Sr/^{86}Sr$ data can further constrain the potential origins of individual CM72B, as Mesoamerica is one of the more extensively mapped regions of the world in terms of both human and biosphere $^{87}Sr/^{86}Sr$ variation (Buikstra et al. 2004; Hodell et al. 2004; Price et al. 2000; Price et al. 2006; Price et al. 2008; Thornton 2011; White et al. 2007; White et al. 2009; Wright 2005; Wright et al. 2010). While the $\delta^{18}O$ data permits the elimination of most of western and southern Mesoamerica as potential areas of origin, the $^{87}Sr/^{86}Sr$ value from CM72B (~0.7075) is also too elevated for an origin in the Central or Southern Highlands, which generally possess much lower $^{87}Sr/^{86}Sr$ (<0.706). On the other hand, the $^{87}Sr/^{86}Sr$ value from CM72B is too low for an origin in the Northern Lowlands, which generally possesses more elevated $^{87}Sr/^{86}Sr$ (>0.708) (Hodell et al. 2004; Price et al. 2010). The combination of these two independent sets of isotope data (^{18}O and $^{87}Sr/^{86}Sr$) narrow down the possible origins of

CM72B to a smaller portion of Mesoamerica, roughly representing the Southern Maya Lowlands, a conclusion that is also consistent with comparisons of her style of dental modification to documented patterns amongst the ancient Maya (Romero Molina 1986) [see also discussion in (Valcárcel Rojas et al. 2011)].

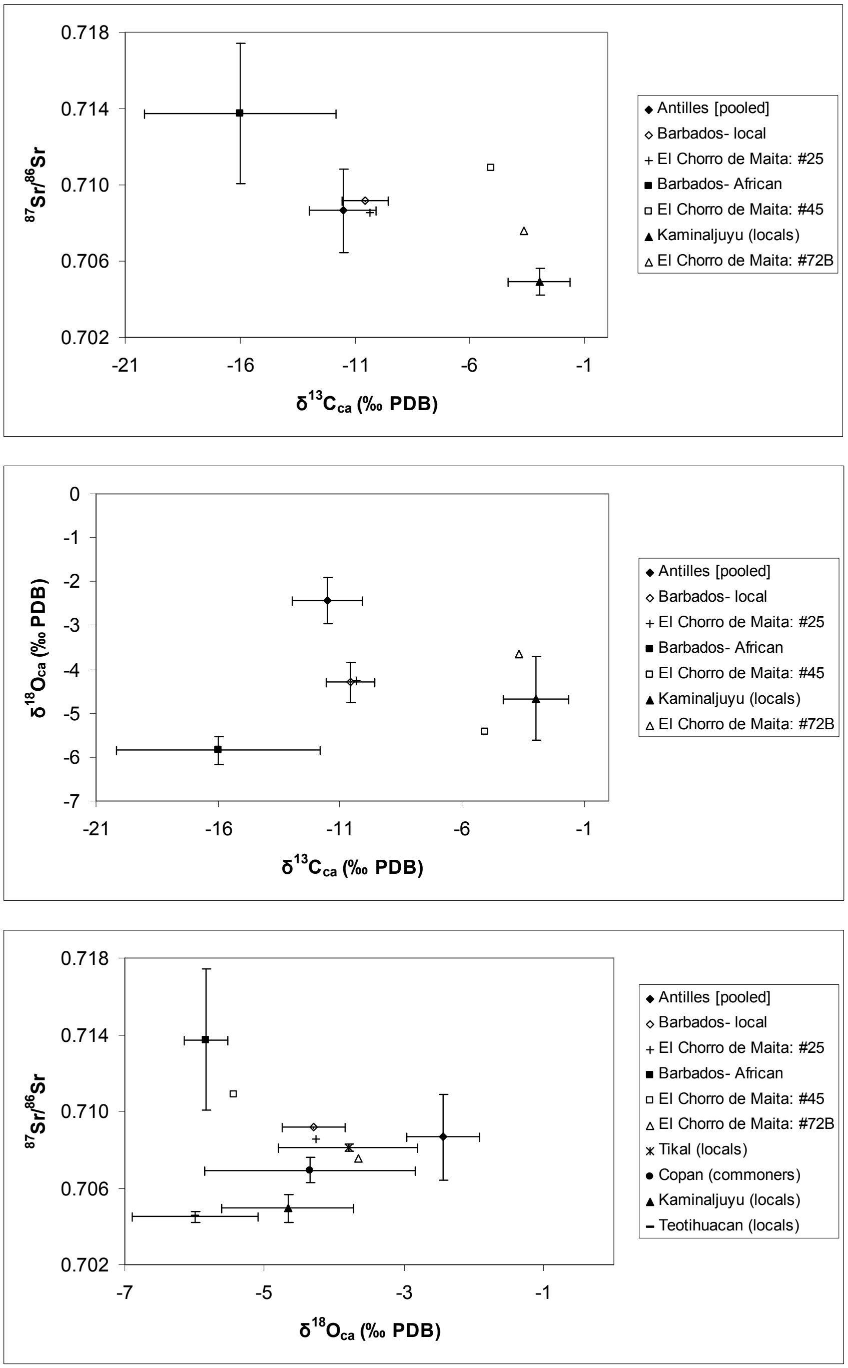


Figure 45 **Diagrams of enamel $^{87}Sr/^{86}Sr$, $\delta^{13}C_{ca}$ and $\delta^{18}O_{ca}$ data from this study compared with other archaeological populations from Barbados and Mesoamerica.**

A) $\delta^{13}C_{ca}$ and $^{87}Sr/^{86}Sr$; B) $\delta^{13}C_{ca}$ and $\delta^{18}O_{ca}$; C) $\delta^{18}O_{ca}$ and $^{87}Sr/^{86}Sr$. Note: Barbadian isotope data are from (Schroeder et al. 2009) and Mesoamerican isotope data are from (Buikstra et al. 2004; Hodell et al. 2004; Price et al. 2000; Price et al. 2006; Price et al. 2008; Thornton 2011; White et al. 1998; White et al. 2007; White et al. 2009; Wright and Schwarcz 1998; Wright 2005; Wright et al. 2010).

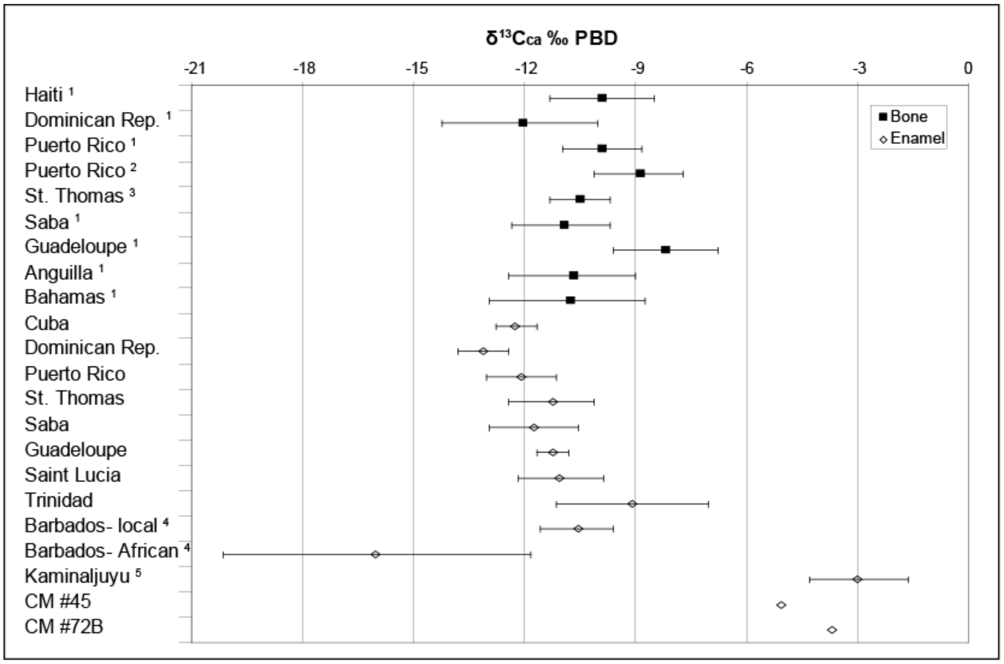


Figure 46 Diagram of enamel $\delta^{13}C_{ca}$ data from this study compared with bone and enamel $\delta^{13}C_{ca}$ data from other archaeological populations in the Caribbean and Mesoamerica.

Note: Isotope data are from [1]Stokes 1998; [2]Pestle 2010; [3]Norr 2002; [4]Schroeder et al. 2009; [5]Wright and Schwarcz 1998; and this study.

To provide a regional comparison, I also compiled published $\delta^{13}C$ from various sites in the Caribbean and Mesoamerica (Figures 45 and 46). Most prehistoric $\delta^{13}C$ data from the Caribbean are derived from the analysis of bone. Owing to the trophic level effect of breastfeeding on $\delta^{13}C$ values from human enamel, caution is required in the comparison of results. The estimated offset in $\delta^{13}C$ (~1‰) from breastfeeding (Richards et al. 2002; Wright and Schwarcz 1998, 1999) is relatively small compared to the overall extent of $\delta^{13}C$ variation both within the Antilles, and between the Antilles and Mesoamerica. Antillean bone $\delta^{13}C_{ap}$ values range from approximately -17‰ to -5‰ indicating a relatively high degree of individual variation in the consumption of C_4 resources. However, mean values per population are much more restricted ranging from -12.1‰ to -8.2‰, possibly indicating that the presence of a few individuals with atypical dietary practices are somewhat inflating the general pattern of variation both at individual sites and within the Antilles more generally.

Enamel $\delta^{13}C_{ca}$ results from this study are broadly similar to published bone $\delta^{13}C_{ap}$ results but display reduced intra-population variance possibly owing to much smaller sample sizes. Comparisons amongst populations indicate that bone $\delta^{13}C_{ap}$ values are generally higher than enamel $\delta^{13}C_{ca}$ values from the same site. Direct bone-enamel comparisons could be made for specific individuals and these indicate distinct differences between tissue types (mean absolute pair-wise difference is 2.4‰, n=12). Ten of these individuals have bone $\delta^{13}C_{ca}$ that are higher than their enamel $\delta^{13}C_{ca}$, in some cases the degree of offset is substantial (>3‰). This trend may result from large differences in dietary consumption patterns between adults and children within a local population. Another possibility is that age-related differences in dietary practices are attributable to migration between areas with different dietary practices (Müldner et al. 2011; Schroeder et al. 2009). Nonetheless, the overall pattern for both enamel and bone carbonate $\delta^{13}C$ indicates limited C_4 consumption amongst most prehistoric Caribbean populations. In other words, there is little isotopic evidence to indicate that C_4 plants in general, or maize in particular, were primary staple crops in the prehistoric Antilles [see also(Mickleburgh and Pagán Jiménez 2012)].

Mesoamerica is the origin of the domestication of maize and it is in this region that maize was first adopted as a staple crop and the area where intensive maize agriculture has its longest history (Johannessen and Hasdorf 1994; White et al. 200). Mean $\delta^{13}C$ values from Mesoamerican populations are consistently higher than Caribbean populations. Various lines of archaeological, iconographic, ethno-historic, and isotopic evidence indicate that maize was clearly a staple crop in this region (Johannessen and Hasdorf 1994). Comparing $\delta^{13}C$ results from the Caribbean with the large body of published $\delta^{13}C$ results from Mesoamerica (Price et al. 2010; Tykot 2002; White et al. 200; Wright and Schwarcz 1998, 1999; Wright et al. 2010) highlights several interesting patterns. Despite considerable variation in $\delta^{13}C$ within and between different Mesoamerican populations, and some degree of overlap on an individual basis, most Mesoamerican populations consumed greater amounts of C_4 resources than their contemporary Caribbean counterparts.

Two of the foreign migrants at El Chorro de Maíta, CM45 and CM72B, possess two of the highest enamel $\delta^{13}C_{ca}$ values ever measured amongst Caribbean populations. Individual 72B's $\delta^{13}C_{ca}$ value is -3.7‰, and more comparable to most Mesoamerican populations than to any Caribbean population. Contextualizing this value in reference to $\delta^{13}C$ values obtained directly from dental carbonate from the Maya region permits direct comparisons between data sets without the potential complications of comparing bone versus enamel values. For example, published enamel $\delta^{13}C_{ca}$ from the local population at the site of Kaminaljuyú, Guatemala range from approximately -0.6‰ to -6.9‰ (Wright and Schwarcz 1998; Wright et al. 2010). This does not indicate that CM72B originated from this site or even from Guatemala, but clearly her $\delta^{13}C_{ca}$ value is in much closer agreement to this population than it is to the local population at the site of El Chorro de Maíta, Cuba, or to any other population in the insular Caribbean. As such this result provides further support for the interpretation of this individual as a migrant from the Maya region.

Individual CM45, the proposed African immigrant at El Chorro de Maíta, is not only an outlier in terms of his $\delta^{18}O$ (-5.4‰) but also in terms of his $\delta^{13}C_{ca}$ (-5.1‰). The carbon isotope ratio is extreme not only relative to the rest of the population from this site but also relative to Caribbean populations generally and indicates substantial consumption of C_4 plant resources during childhood. CM45 also possesses $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values that are comparable to several African immigrants amongst the Newton Plantation slave population (Schroeder et al. 2009). However, his $\delta^{13}C_{ca}$ value is highly enriched relative to the Africans from Newton Plantation (ranging from -19.9‰ to -10.6‰). Despite similarities in $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ ratios between CM45 and many of these African born individuals, their $\delta^{13}C$ values are different and do not support a shared origin. A distinct origin for CM45, relative to the African-born individuals at Newton

Plantation, would not be surprising given the known regional, historical, and cultural differences in their burial contexts. In other words, an African arriving in the early decades of the Spanish colonization of Cuba (ca. 16th century) may be expected to have arrived in the Americas by rather different mechanisms than African slaves brought to an English colonial sugar plantation in Barbados (ca. 17th-19th centuries).

Given the other lines of evidence pointing to an African origin for CM45, I propose millet or sorghum (as opposed to maize) as the most likely C_4 resources accounting for this individual's less negative $\delta^{13}C$ value. Millet and sorghum were staple crops amongst many traditional societies of north-central Africa, including much of the Sahel region (Harris 1976). Interestingly, although millet consumption has been documented in other areas of West Africa, these areas are characterized as rice and vegecultural zones owing to their traditionally greater reliance on rice, root crops and plantains (Carney 2001; Harris 1976). Therefore, an immigrant originating from the millet-sorghum zone of northern West Africa would be expected to possess a higher $\delta^{13}C_{ca}$ value than one originating from other locations in West Africa (Schroeder et al. 2009). Thus the combined isotopic evidence supports an interpretation of West African natal residence and can be used to further constrain this individual's childhood origins. We tentatively propose that individual CM45 may have originated from the millet-sorghum zone of West Africa (based on $\delta^{13}C_{ca}$); did not originate from the area underlain by the West African craton (based on $^{87}Sr/^{86}Sr$); and may have originated from a more inland region (based on $\delta^{18}O$).

7.6 Characterizing Caribbean Paleomobility

Strontium isotope analysis of 360 ancient human remains from multiple sites reported in this chapter demonstrates complex patterns of mobility throughout the Caribbean. Intriguing patterns were revealed in terms of intra- and inter-site variation in the proportions of nonlocals at each site, the demographic composition of local and nonlocal groups, differential mortuary treatment and dietary practices, and the geographic origins of nonlocal individuals. The integration of these results with those provided by carbon and oxygen isotope analysis of 50 ancient human remains has complemented the primary study and confirmed the presence of several foreign migrants originating from distant lands. In the next chapter, I present the major findings and conclusions of the present work in the context of current discussions and debates concerning the prehistory of the Caribbean.