canine area. In regards to assumption 2, only four distributions departed significantly from a normal distribution (Table 6.11). The distributions of left BL, right and left MD, and left canine area did not depart significantly from a normal distribution. The means, standard errors, and 99% confidence intervals were recalculated for all distributions using only the canines from N4, and estimates of sex were produced using both the CO and CI methods (Table 6.12)

Table 6.11 Sample sizes and Shapiro-Wilks tests for lower canines from Necropolis 4

Measurement	Sample	N	Shapiro-Wilks W	*P*
BL	Left	88	0.9845	0.377
	Right	96	0.9551*	0.002
	Total	184	0.9750*	0.002
MD	Left	92	0.9773	0.109
	Right	105	0.9804	0.123
	Total	197	0.98694	0.065
Area	Left	78	0.96877	0.052
	Right	89	0.96149*	0.010
	Total	167	0.9698*	0.001

Table 6.12 Sex ratios calculated using buccolingual diameter, mesiodistal diameter, and area of canines from Necropolis 4

Measurement	Method	Left		Right		Sex ratio	
		♀	♂	♀	♂	Left	Right
MD	CI	40	26	27	42	1: 0.7	1:1.6
	CO	49	36	38	54	1: 0.7	1:1.4
BL	CI	38	31	41	35	1:0.8	1:0.9
	CO	45	36	51	40	1:0.8	1:0.8
Area	CI	39	28	36	38	1:0.7	1:1.1
	CO	46	32	47	42	1:0.7	1:0.9

Shaded sex ratios are from samples which do not depart significantly from a normal distribution. Sex ratios are rounded to the nearest tenth.

A Pearson's chi-square test performed on the counts by sex shown in Table 6.12 showed no significant differences between the rows or columns (x^2 = 13.292, df = 15, *P* = 0.580). Eight of the sex ratios were produced by analyzing distributions which correspond to the third assumption of Gonçalves et al. Of these, six (75%) showed sex ratios that indicated more females were present than males, while two (25%) showed the opposite. All distributions showing a sex ratio of more males than females come from the right canines, and those with the sharpest divergences come from the MD metric.

Breaking distributions down by N4 area (either the disturbed Area 1 or the *in situ* Area 2) reveals that these patterns are largely maintained regardless of sample area (Table 6.13). Unfortunately, this division reduces the P2 sample sizes to the point that assumption 2 (N > 40) is violated, so the sex ratios produced for this area are likely skewed as a result of small sample sizes (Table 6.14). However, when the teeth from Area 1 are examined separately from Area 2, the majority of distributions meeting the Gonçalves et al. assumptions indicate that more females than males were buried in this area (Table 6.13).

Table 6.13 Counts and sex ratios for canines from Necropolis 4

Area	Measurement	Method	Left		Right		Sex ratio	
			♀	♂	♀	♂	Left	Right
Area 1	MD	CI	33	21	23	31	1:0.6	1:1.3
		CO	49	36	33	38	1:0.7	1:1.2
	BL	CI	33	26	33	23	1:0.8	1:0.7
		CO	39	28	42	28	1:0.7	1:0.7
	Area	CI	33	22	35	26	1:0.7	1:0.7
		CO	39	22	40	29	1:0.6	1:0.7
Area 2	MD	CI	7	5	4	11	1:0.7	1:2.75
		CO	9	7	4	16	1:0.8	1:4
	BL	CI	5	5	8	12	1:1	1:1.5
		CO	6	8	9	12	1:1.3	1:1.3
	Area	CI	6	6	5	12	1:1	1:2.4
		CO	7	9	7	20	1:1.3	1:2.9

Table 6.14 Sample sizes for canines from Necropolis 4

Metric	Area 1		Area 2	
	Left	Right	Left	Right
MD	74	81	18	24
BL	72	74	16	22
Area	62	69	16	20

Gonçalves and colleagues do not test for significant statistical differences between left and right canines, though they do compare the median, range, standard deviation and mean (Table 6.15).

Table 6.15 Comparisons of summary statistics for canine metrics from Necropolis 4, left vs. right

Measurement	Side	Median	Min.	Max.	Range	Standard deviation	Mean
MD	**Left**	6.2	5.2	7.6	2.4	0.46	6.23
	Right	6.4	5.6	7.4	1.8	0.38	6.38
BL	**Left**	7.2	5.6	8.8	3.2	0.52	7.25
	Right	7.2	6.1	9.0	2.9	0.58	7.33
Area	**Left**	45.1	31.4	66.8	35.39	5.96	45.63
	Right	45.9	31.3	66.6	31.26	6.12	47.12

Alternate Test: Bimodality and Visual Sorting

An alternate strategy to estimate sex using canine metrics is through a visual examination of the distribution of measurements in order to assess bimodality, which should be best appreciated using canine area (MX x BL diameters). All area distributions showed visually observable bimodality that centered around a break at 46-47 mm^2, close to the mean and median values for all distributions (Figure 6.7-6.9). Dividing the distribution in two at this break and categorizing smaller values as female and larger values as male will necessarily incorrectly categorize males with smaller canines as female and females with larger canines as males. In essence, overlap in the upper tail of the female distribution and lower tail of the male distribution will lead to a high potential for miscategorization in this area. However, this possibility also occurs when using the Gonçalves et al. (2014) method, and is a limitation of any metric strategy used to estimate sex, regardless of the element employed.

Figure 6.7 Distribution of area for canines from Necropolis 4 (left and right)

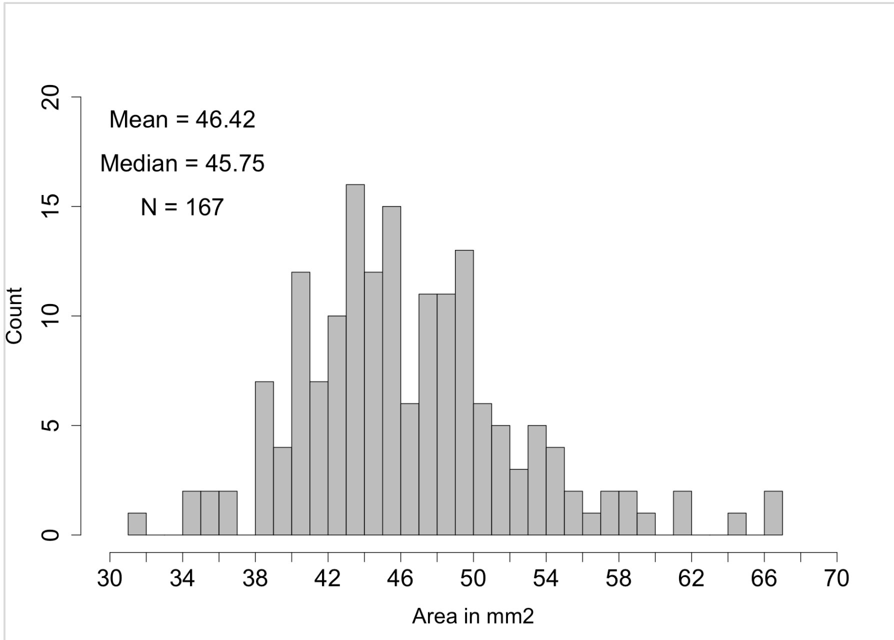


Figure 6.8 Distribution of area for canines from Necropolis 4 (left)

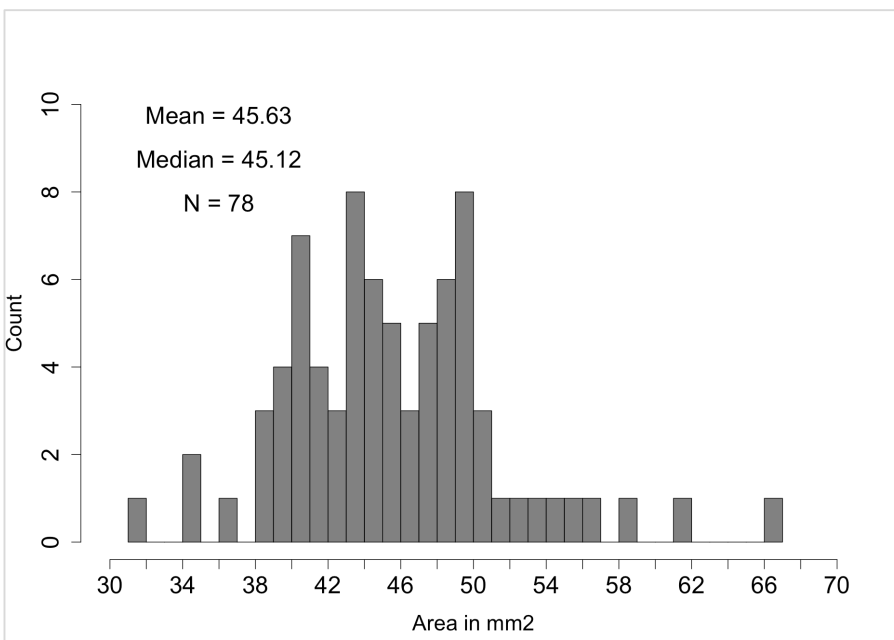
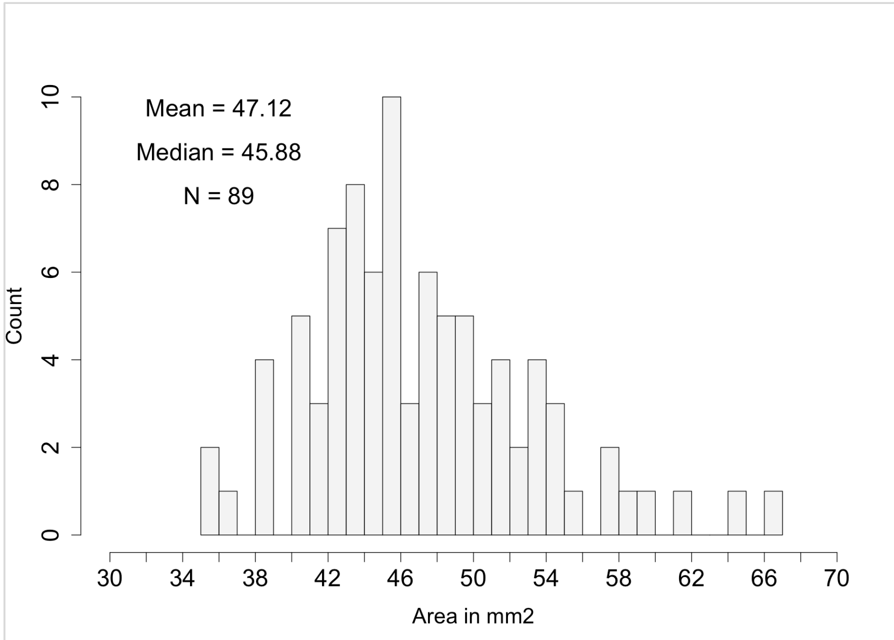


Figure 6.9 Distribution of area for canines from Necropolis 4 (right)



When canines are sorted according to sex based on the breaks in the bimodal distributions, the following sex ratios are produced (Table 6.16).

Table 6.16 Sex ratios for canines from Necropolis 4 calculated using bimodal distributions

Metric	L(F)	L(M)	R(F)	R(M)	Sex Ratio Left	Sex Ratio Right
Canine Area	44	31	46	40	1:0.7	1:0.9

Using the Gonçalves et al. (2014) method, the majority of metrics which meet the assumptions of the method (BL cut-off for left canines, BL confidence interval for left canines, MD cut-off for left canines, MD confidence interval for left canines, area cut-off for left canines, area confidence interval for left canines) agree that the Necropolis 4 sex ratio shows slightly more females than males (in the range of 0.7-0.8 males per female). Of the four distributions that show significant departures from normality (BL right CO, BL right CI, Area right CO), three show sex ratios suggesting more females than males (in the range of 0.8-0.9 males per female), while one (Area Right CI) shows more males than females. Using the more subjective visual assessment of canine area bimodality, the left canine and right canine again produce different sex ratio estimates, but both agree that the ratio contains more females than males (in the range of 0.7-0.9 males per female). The strong agreement shown between the BL and canine area values, for the cut-off method, the confidence interval method, and the bimodality method, is preferred over the sex ratio estimated by the MD of right canines, which is considered an outlier. This assessment additionally agrees with the estimates of sex based on the mental eminence, which suggest more females and probable females than males in this mortuary population.

However, the disparate results produced by the use of the left and right canine suggest that the Gonçalves et al. method should be tested on a sample of archaeological individuals with alternate estimates of sex available, preferably from the pelvis. It is particularly striking that all but one of the estimates of sex ratios based on the right canine show more males than estimates of sex ratios based on the left canine. Clearly, further analyses of both (i) bilateral symmetry of the lower canines, and (2) the differential accuracy of various metric measurements (buccolingual diameter, mesiodistal diameter, and canine area) are needed to improve the rigor of this method. Additionally, given the potential time depth of these mortuary areas, it is difficult to determine whether this sex ratio reflects aspects of living social organization, or whether it is simply an artifact of the palimpsest nature of mortuary deposits. A key takeaway is that according to the canine metrics, both males and females were buried in all mortuary areas.

Assessment of Age for Necropolis 4

As with MNI, adult and subadult estimates of age were calculated separately. Adult age was estimated using the strategy outlined in Gilmore and Grote (2012), while subadult age was estimated using the AlQahtani (2009) and AlQahtani et al. (2010) Atlas of Tooth Development and Eruption.

Estimating Adult Age Using Molar Wear for Necropolis 1, 2, and 4

The Gilmore and Grote (2012) method of molar wear age estimation was employed for adult individuals. This method was preferred over traditional alternatives for two reasons. First, unlike the Miles Method (1962, 2001), Gilmore and Grote do not require a high number of subadults with complete teeth. Of the subadults from N4, only 16 preserved mandibular bone with associated permanent molars, and only 18 preserved maxillary bone with associated permanent molars, yielding a sample size too small to perform the seriation required by the Miles method. Second, the Gilmore and Grote method provides estimates of variance, making it possible to produce age ranges that could be compared to age ranges estimated from skeletal data. Skeletal estimates of age were only possible for individuals from Necropolis 1, so all sets of sequential articulated molars available (from N1, N2, and N4) were used when estimating the population wear rate for Marroquíes Bajos. Because very few individuals from N1 or N2 could be associated with well-preserved pelves or crania, molars from N1 and N2 were also incorporated into the calculation of wear rate, so that molar wear age estimates could also be produced for these areas.

At Necropolis 1, 19 individuals had three or more sequential articulated molars. Of these individuals, one (N1CE27.11) preserved teeth that were too damaged by taphonomy to establish age. Because preservation was far better at N1, upper and lower teeth could be confidently associated with the same individual. All upper and lower molars were used when calculating the Gilmore and Grote wear rate, producing a sample size of 18 observations from Necropolis 1.

At Necropolis 2, only two individuals preserved sequential molars – a right mandibular fragment from Structure 44 contained M1-M3, which could be mirrored and associated with three left loose molars from the same structure. Unit 47 contained a single cranium and associated teeth, including the right upper M1-M3 sequence. Because the lower molars were preferred from the N4 analyses to avoid double-counting individuals, only the lower molars were used, leading to a sample size of 1 observation from N2.

At Necropolis 4, 54 fragments of mandibles or maxillae contained at least three sequential articulated molars. Sequential articulated molars are defined as a set of molars from the same side of the same arcade (e.g. LlM1, LlM2, LlM3). However, in order to ensure that individuals were not double-counted, specifically, to ensure that a fragmentary maxilla and a fragmentary mandible from the same individual were not treated as separate individuals in the calculation of wear rate, only observations with sequential articulated molars from the lower right arcade were included. This produced a sample of 21 observations from N4 that could be used to build the molar wear model.

In total, 40 sets of three or more sequential articulated molars from N1, N2 and N4 were used to calculate the population wear rate for Marroquíes Bajos. The size of the Marroquíes Bajos sample population is thus comparable to Gilmore and Grote's largest sample population of Australian Aboriginal individuals (N = 40).

Molar attrition scores were averaged following the method developed by Li and Ji, who note that "the ASA is the average stage of the attrition on all cusps of a molar when evaluating the attrition degree from stages 0-7 for each cusp" (1995:192). However, because the Smith method was used to score wear on the molars, as recommended by Gilmore and Grote (2012), the stages used ranged from 1-10, with 1 equivalent to "wear facets invisible or very small" and 10 equivalent to "no enamel on any part of quadrant–dentine exposure complete. Wear is extended below the cervicoenamel junction into the root" (Buikstra and Ubelaker 1994:53). Wear scores of all M1s (both upper or lower) were averaged to create a wear score for the first molar (*WearM1*), and the same procedure was followed for the second and third molars (*WearM2*, *WearM3*).

For each individual, *WearM2* was subtracted from *WearM1* to produce a difference (D_i) ($D_i = WearM1_i - WearM2_i$). The differences ($D_i$) for all individuals in the sample were then averaged, and the standard deviation was calculated ($\bar{x}$ =0.99, sd = 0.94). Using the equation $WearM1_i \geq 1 + + SD(D)$, three individuals with lightly worn M1s (*WearM1* ≤ 3.08) were moved from the sample, leaving a sample size of 37 individuals. An average D_i and standard deviation were then calculated for the remaining sample ($\bar{x}$ =1.03, sd = 0.97). The wear rate per year for the sample population was estimated by taking the sample average of *WearM1-WearM2* (D_p), and dividing it by the average age of eruption of second molars in pre-industrial populations, minus the average age of eruption of first molars in pre-industrial populations, as provided by Gilmore and Grote (Table 2: 2012). The wear rate per year for this sample of 40 individuals was 1.03/11.31-6.02, or 0.195 Scott units per year. This falls within the range of wear rates published by Gilmore and Grote for various non-industrial populations, which range from 0.14 – 0.37 (2012:186).

An additional four individuals from N1 and N4 showed high levels of resorption. Miles has recommended a rule of thumb for alveolar resorption, such that “those who have lost more than half their teeth are likely to be over 60 years of age” (2001:977). Because so few individuals from Marroquíes Bajos preserved both maxillary and mandibular dental arcades, here any individuals with more than half of a mandibular arcade preserved (≥8 sockets) were assessed for resorption, and all individuals for which ≥ 40% of the sockets were resorbed were considered to be ≥ 61 years of age at death. The values recommended by Miles were lowered slightly to reflect the lower levels of preservation at N4. These criteria were used to identify four individuals likely ≥ 60 years of age at death (Table 6.17):

Table 6.17 Individuals with ≥ 8 sockets showing ≥ 40% resorption

Mortuary area	Individual	Sockets visible	Sockets resorbed	Resorbed / visible
N1	N1.CE13.25	13	13	1.00
N4	MN.2.196.01	8	6	0.75
N4	MN.2.205.01	13	6	0.46
N4	MN.1.015.01	9	4	0.44

When dental estimates of age based on molar wear were compared to post-cranial estimates of age (which was only possible for a sample of 9 individuals from N1), 5/9 (56%) of the estimated age ranges overlapped, while 3/9 (44%) did not overlap (Table 6.18). Tellingly, in both cases where there was no overlap, the range that was estimated using skeletal data covered an older span of ages, and the skeletal midpoint was older than the dental midpoint in 7/9 (78%) of the cases.

Table 6.18 Agreement between dental and postcranial estimates of age

Individual	Midpoint		Range		Overlap
	Dental	Postcranial	Dental	Postcranial	
N1.CE14.07	18.9	27	16-22	25-29	No
N1.CE13.02	24.0	21.5	20-28	18-25	Yes
N1.CE14.06	27.2	39.5	23-32	35-44	No
N1.CE14.08	29.6	49.5	25-35	40-59	No
N1.CE14.13	30.0	39.5	25-35	35-44	Yes
N1.CE13.11	33.0	49.5	27-39	40-59	No
N1.CE14.05	34.0	34.5	28-40	30-39	Yes
N1.CE13.27	42.0	35	34-50	30-40	Yes
N1.CE14.14	46.3	54.5	38-55	50-59	Yes

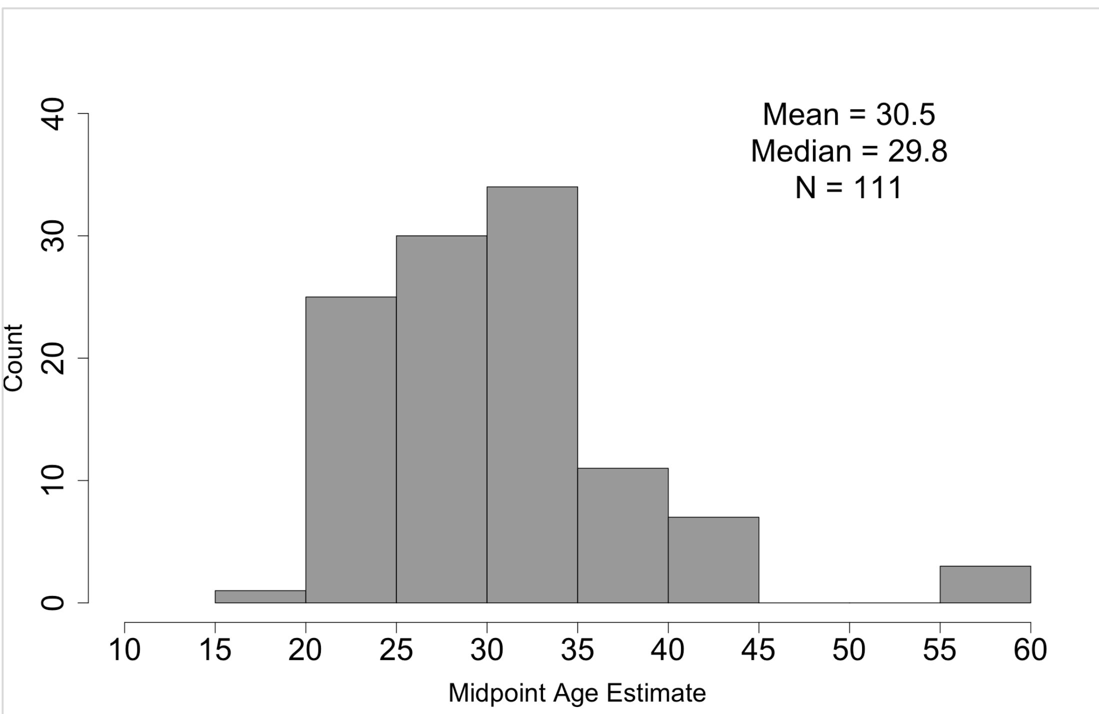
Though left lower first molars were the most commonly represented molar in the entire Marroquíes Bajos sample (Table 6.19), the N4 subadult MNI was calculated used the right mandibular arcade, and isotopic samples were taken from RlM2 and Rldm2. In order to avoid double-counting N4 individuals in the articulated dental sample used to estimate molar wear rate, and to avoid calculating separate age estimates for isotopic samples whenever possible, age was calculated based on RlM1 wear for the remaining 103 loose and articulated lower right first molars from N4 that were not used to build the wear model. Fourteen of these molars from Necropolis 4 (including one originally removed from the molar wear calculation) were so lightly worn that the age estimates were subadult, ranging from 12. 4 -17.6 years of age. These molars were removed from the calculations of adult age[29]. Another molar from Necropolis 4 (T.4.052.02) was so heavily worn that it needed to be removed from the estimation of age, while a remaining molar (MN.1.005.02) was affected by an as yet undetermined pathology that may have affected wear, and hence removed from consideration. Overall, the analyses of right lower first molar wear and alveolar resorption produced a total sample of 111 adult individuals for which age estimation was possible (77% of the N4 adult MNI) (Figure 6.10).

[29] Because it is still possible that some of these molars were very lightly worn adult teeth (e.g. if an adult individual was preferentially chewing with one side of the jaw due to injury or pathology), these lightly worn molars were not included in the sample of subadult teeth.

Table 6.19 All loose and articulated permanent molars from Necropolis 1, 2, and 4

Tooth	N1			N2			N4		
	Loose	Articulated	N	Loose	Articulated	N	Loose	Articulated	N
LM_1	1	16	17	9	1	10	73	48	121
LM_2	1	18	19	10	2	12	58	45	103
LM_3	0	12	12	2	0	2	25	28	53
RM_1	1	16	17	5	2	7	72	52	124
RM_2	2	18	20	7	2	9	60	45	105
RM_3	2	14	16	0	2	2	34	24	58
LM^1	0	12	12	7	1	8	65	26	91
LM^2	1	12	13	4	2	6	41	22	63
LM^3	1	14	15	1	2	3	39	10	49
RM^1	2	12	14	6	2	8	69	37	106
RM^2	1	13	14	3	1	4	48	31	79
RM^3	0	12	12	3	1	4	51	13	64
Total	12	169	181	57	18	75	635	381	1016

Figure 6.10 Distribution of adult ages from Necropolis 4



Estimating Subadult Age for Necropolis 4 Using Dental Eruption and Development

The London Atlas developed by AlQahtani et al. (2010) was used to estimate the age of all subadult teeth from Marroquíes Bajos. Before beginning the N4 dental analysis, teeth were sorted into five categories (Table 6.20).

Table 6.20 Tooth categories

<table>
<tr><th>Age</th><th>Category</th><th>Description</th></tr>
<tr><td rowspan="2">Adult</td><td>Permanent</td><td>Permanent teeth with root apices complete (Ac).</td></tr>
<tr><td>Developing permanent</td><td>Developing permanent teeth estimated to be ≥ 18 years of age using the AlQahtani et al. Atlas.</td></tr>
<tr><td rowspan="3">Subadult</td><td>Developing permanent</td><td>Developing permanent teeth at stages of development preceding Ac or < 18 years of age.</td></tr>
<tr><td>Deciduous</td><td>Subadult teeth with root apices Ac.</td></tr>
<tr><td>Developing deciduous</td><td>Subadult teeth at stages of development preceding Ac.</td></tr>
</table>

Adult teeth were assessed separately from subadult teeth. Subadult teeth were further subdivided into two categories:

1. *Articulated* – more than one tooth was present, associated within the same portion or associated portions of alveolar bone;
2. *Loose* – tooth could not be associated with alveolar bone or other teeth.

Articulated subadult teeth were analyzed with reference to the Atlas of Human Tooth Development and Eruption (AlQahtani 2009). In the following description, *age category* refers to the chronological year (e.g. category 3.5 represents an individual between 3-4 years of age), while *stage* refers to the level of development of the tooth (e.g. Crown initiated, Root complete, etc.). Level of development of tooth crown, root, and eruption were recorded for each tooth using the Moorrees' et al. (1963) stages, also described in Buikstra and Ubelaker (1994:50), and also used by AlQahtani (2009). The level of development of all preserved teeth was used to match the teeth to corresponding age category, or categories, portrayed by the London Atlas. The midpoint of all assigned age categories was used as the midpoint age for the articulated subadult teeth.

Loose subadult teeth were analyzed with reference to Tables 2-9 in AlQahtani et al. (2010). The tooth was matched to the age category that listed the tooth level of development as a *median*. If the level of development recorded was the median of more than one age category, then the age range for the tooth extended to cover both categories, and the tooth was assigned to the middle of those two categories.

Example: A tooth is at level root initiated (Ri)

1. If Ri is the median of only one age category, the tooth is assigned to that age category (a one-year range);
2. If Ri persists as the median through two age categories, the tooth is assigned to the middle of those two age categories (a two year-range);
3. If Ri falls between two different age categories, but is the median for neither, the tooth is assigned to the middle of those two age categories (a two-year range). For example, a M^3 at Ri falls between category 13.5 (minimum Ci, maximum $R^1/_4$) and categories 14.5 and 15.5 (median $R^1/_4$). The median for each age category, rather than the minimum and maximum range, is treated as most important in estimating age. As an additional example, an M^1 at Ri-$R^1/_4$ falls into three categories, 3.5 (minimum $Cr^1/_2$ – maximum $R^1/_4$), 4.5 (median $R^1/_4$) and 5.5 (median $R^1/_4$). For this tooth at Ri-$R^1/_4$, the youngest level of development falls into category 3.5 (Ri), while the oldest level of development falls into category 5.5 ($R^1/_4$).
4. If a tooth is at a developmental level that falls in between categories, the younger bound for the age range is the age category that encompasses the preceding level of development as a median. In the case of a tooth at Ri, the preceding stage is Crc. The older bound for the age range is that containing the subsequent level of development. In the case of a tooth at Ri, the subsequent level of development is $R^1/_4$. If the upper bound falls into two different age categories, the oldest age category is treated as the older bound for the estimated age range. Conversely, for the lower bound, the youngest age category is used. This is the reason that age category 5.5 was treated as the older bound in the example of the M^1 outlined in Step 4. One exception was made to this rule: M^1s at level Ri were classed at category 3.5, because the younger bound for the next category was $R^1/_4$, which already exceeded the Ri stage.

Using the AlQahtani (2009) and AlQahtani et al. (2010) methods, age was estimated for the majority of the 784 subadult teeth (Table 6.21). The subadult sample from N4 contained 220 articulated teeth that were definitely subadult based on patterning of eruption and tooth development, all of which were aged through comparison with the AlQahtani (2009) Atlas. An additional 21 articulated teeth were classed as “probable subadults” based on lack of eruption of M2 or M3. One of these observations, a fragment of mandible containing first and second right molars, showed such heavy wear that it was re-categorized as an adult, with the other 19 teeth added to the subadult articulated sample. In addition to the articulated subadult teeth, N4 contained 274 loose developing permanent teeth. Age ranges could be estimated for each tooth using the AlQahtani et al. Atlas (2010), and the midpoint age for each tooth was used to calculate an age-stratified MNI. Ten teeth (T.3.209.12, T.4.098.28, T.4.065.35, T. 3.122.07, MN.2.154.04, MN.4.146.01, MN.3.153.02, T.3.209.25, T.2.274.58, T.3.120.21) were removed from the sample as their roots or crowns were so damaged that it was not possible to gauge level of development (though the root thickness and preserved level of completion indicated that the teeth were subadult). A further five teeth (T.3.209.28, T.3.142.32, T.4.081.60, T.2.245.15, T.1.004.04) were removed from the sample as they could not be sided, and so could not contribute to the MNI.

In addition to the permanent and developing permanent teeth, the N4 sample contained 73 loose developing deciduous teeth, which could all be aged using their level of development. Finally, N4 contained a sample of 207 deciduous teeth with root apices complete. For these teeth, models of the relationship between dental wear and midpoint age were developed using the articulated teeth, and age could be estimated for 107 of the teeth in this category. The sample of 82 apex complete deciduous first and second molars was reduced by one, as one tooth (T.3.215.50) was so taphonomically damaged that an accurate assessment of wear was not possible. The sample of loose, apex complete, deciduous incisors and canines is significantly reduced, with 100 teeth removed, because no articulated teeth preserved any of these categories of deciduous teeth, and so a simple alternative system of partitioning teeth into age categories based on degree of wear was developed for this analysis. However, this system was only effective for the lower incisors, as these teeth are in the mouth for the shortest period of time. Overall, 667 teeth (85% of the subadult sample) could be used in the construction of an age-stratified subadult MNI for N4.

Table 6.21 Counts of subadult teeth from Necropolis 4 by category

Category	No. teeth	No. teeth age possible	Age estimated using
Articulated	220	220	AlQahtani et al. (2010) median ages.
Permanent articulated (likely subadult)	19	19	AlQahtani et al. (2010) median ages.
Developing permanent	265	250	AlQahtani et al. (2010) median ages.
Developing deciduous	73	73	AlQahtani et al. (2010) median ages.
dm1 and dm2 (Ac or NP)	82	81	Linear model of deciduous molar wear and age constructed in R.
i1, i2, c (Ac)	125	25	Lower incisors sorted into age categories based on degree of wear
Total		**667**	

Developing New Strategies to Age Loose and Articulated Subadult Teeth

Several categories of subadult teeth proved problematic to age, because the data available produced extremely broad age ranges. These categories include:

1. Subadult articulated elements that preserved only erupted deciduous first and second molars, with no information as to level of root development due to preservation of alveolar bone (*N* = 5);
2. Loose deciduous first and second molars with root apices complete (*N* = 82);
3. Loose deciduous incisors and canines with root apices complete (*N* = 125).
4. Permanent teeth categorized as likely subadults based on eruption and development of molars and molar sockets and limited tooth wear (N = 21 teeth, 7 fragments of alveolar bone)

Descriptions of the strategies used to analyze these three categories of teeth are discussed separately in each sub-section below.

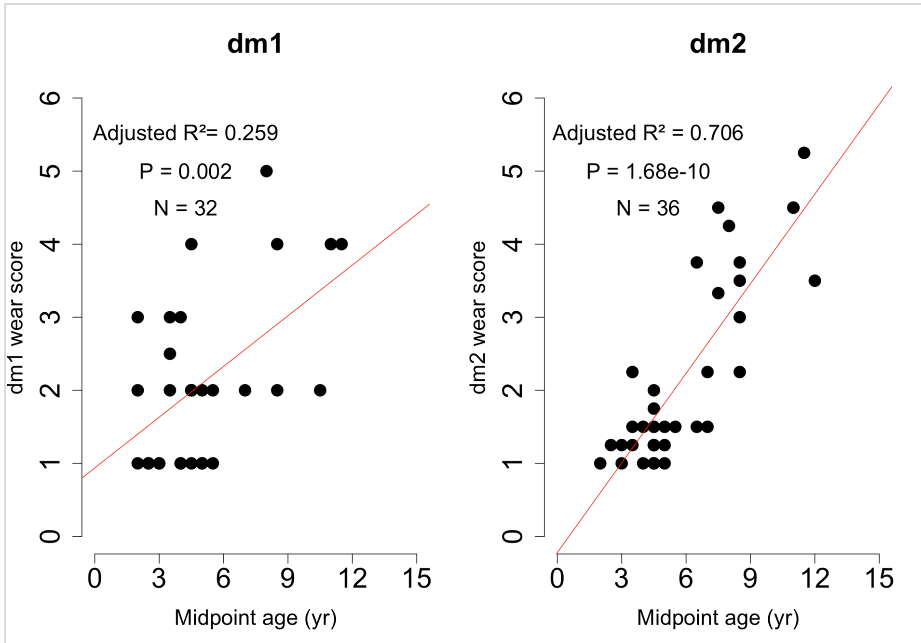
A) Using Wear to Predict Age for Articulated Deciduous Teeth (dm1, dm2)

One strategy for assessing the age of subadult individuals with articulated teeth and relatively complete alveolar bone is radiographic analysis. However, temporal and financial constraints prohibit many bioarchaeologists from using radiographic methods to estimate age. Accordingly, an alternate method was developed to estimate age for deciduous first and second molars using dental wear. The AlQahtani system was used to estimate age for the majority of the articulated teeth, as it was often possible to observe the eruption of teeth, or the level of development of teeth through fragmentary alveolar bone. However, five observations contained only deciduous first and second molars in relatively intact alveolar bone. For these five observations, models of deciduous molar wear and midpoint age were built separately for dm1 and dm2.

For dm1s, dental wear was recorded using the Smith guidelines outlined for premolars in Buikstra and Ubelaker (1994:52), as dm1 is replaced by the P3. Wear for dm2 was recorded with reference to the Scott guidelines for the permanent molars (Buikstra and Ubelaker 1994:53). In keeping with the methods used for estimating age based on adult molar wear (Li and Ji 1995; Gilmore and Grote 2012;), dm2 wear was calculated as the *average* of wear for all observable cusps. In total, there were 223 articulated subadult teeth. However, wear could only be observed for 212 teeth; 11 teeth were still erupting or still in crypts, so it was not possible to observe wear.

Examining the regressions for deciduous first (N = 32) and second molar (N = 36) wear versus chronological age revealed that the dm2 wear had a stronger positive correlation to midpoint age than dm1 wear (Figure 6.11, dm2 adjusted $R^2 = 0.71$, dm1 adjusted $R^2 = 0.26$). This may be related to the fact that the dm2 is erupted and in occlusion for a longer period of time than the dm1. AlQahtani, Hector and Liversidge (2010) indicate that the dm2 is in occlusion from stages 2.5 – 11.5 (a ten-year window), while the dm1 is typically in occlusion from only stages 1.5 –10.5 (a nine-year window). Because the dm1 is replaced sooner, it will also lack a year's worth of wear related to the consumption of solid foods, rather than earlier consumption of milk or weaning foods (which seem less likely to contribute to dental attrition).

Figure 6.11 Midpoint age vs. dm1 or dm2 wear



For the five observations which only contained articulated dm1s and dm2s, root development was not visible, and no other teeth were preserved. Here, the *predict (lm)* function in R is used to predict midpoint age based on dm2 average cusp wear for this sample of five individuals, setting a 95% confidence interval. For these predictions, the lower and upper bounds produced by R were treated as the minimum and maximum of the age range estimate (Table 6.22).

Table 6.22 Age ranges estimated using the dm2 wear model

Element ID	dm2 wear	Predicted midpoint age	Lower bound	Upper bound
MX.2.120.01	1	3.9	3.2	4.5
MX.4.130.01	1.25	4.3	3.7	4.9
MX.3.203.02	1.5	4.7	4.1	5.3
MX.1006.02	3.75	8.6	7.9	9.2
MN.2.120.04	4.5	10.0	9.0	11.0

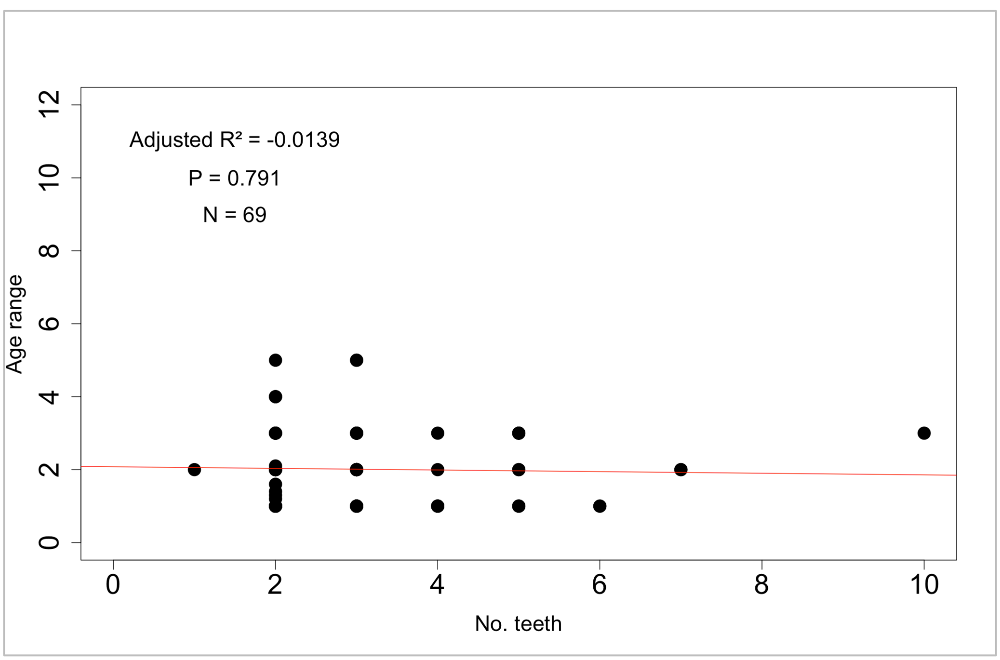
These estimates of age were incorporated into the age-stratified MNI for Area 1 and Area 2.

B) Using Wear to Predict Age for Loose (Ac) Deciduous Teeth (dm1, dm2)

For loose dm1s and dm2s with apices complete, a regression model was built to estimate age using the wear scores and estimated ages of the articulated teeth. The five articulated observations for which wear was used to estimate age (MX.2.120.01, MX.4.130.01, MX.3.203.02, MX.1006.02, and MN.2.120.04) were excluded when building this model. However, before applying the regression equation to the loose dm1 and dm2 data, it was necessary to construct a model with the strongest possible relationship between age and wear.

I compared three different strategies that could be used to strengthen the relationship between age and wear. First, a regression of age range versus number of teeth was constructed for the articulated subadult teeth. In theory, the more teeth present, the more information preserved concerning developmental age, so greater numbers of teeth should correlate with smaller age range estimates. However, there was no significant relationship between the total number of teeth preserved per individual and the size of the estimated age range within the subadult articulated dental sample (Figure 6.12). This strategy was accordingly abandoned.

Figure 6.12 Number of teeth vs. age range in the sample of articulated subadult teeth from Necropolis 4



The second approach that tested was an *age range* strategy. This removed all observations with broad estimated age ranges (e.g. > 4 years). The third approach tested was a *high leverage* strategy. This entailed removing all high leverage observations identified by the *plot (model)* command in R. High leverage observations are those which exert an undue influence on the trajectory of the fitted regression model due to a dearth of neighboring observations. Both the age range strategy and the high leverage strategy were tested separately for the model of dm1 wear and the model of dm2 wear.

The Age Range Strategy and the High Leverage Strategy in the dm1 Model

For the dm1s, three observations showed age ranges of 5, and so were dropped from the age range model. Similarly, four high-leverage observations were identified using the *plot (model)* function in R (Table 6.23).

Table 6.23 High leverage observations identified for the sample of articulated dm1s

Point order	Element ID	Midpoint age	Total teeth	Age range
5	MN.1.006.09	10.5	3	3
12	MN.2.274.01	2	2	2
24	MN.2.197.01	4.5	5	3
28	MN.2.246.04	8	7	2

The removal of high leverage observations provided a stronger predictive equation than the removal of observations with a broad age range (Figure 6.13). Because removing the higher leverage points produced a stronger relationship between dm1 wear and midpoint age, I developed a model for dm1 wear with the highest leverage points removed, and used the *predict* command in R to estimate age based on dm1 wear (Table 6.24).

Figure 6.13 Age range vs. high leverage strategy for the sample of articulated dm1s

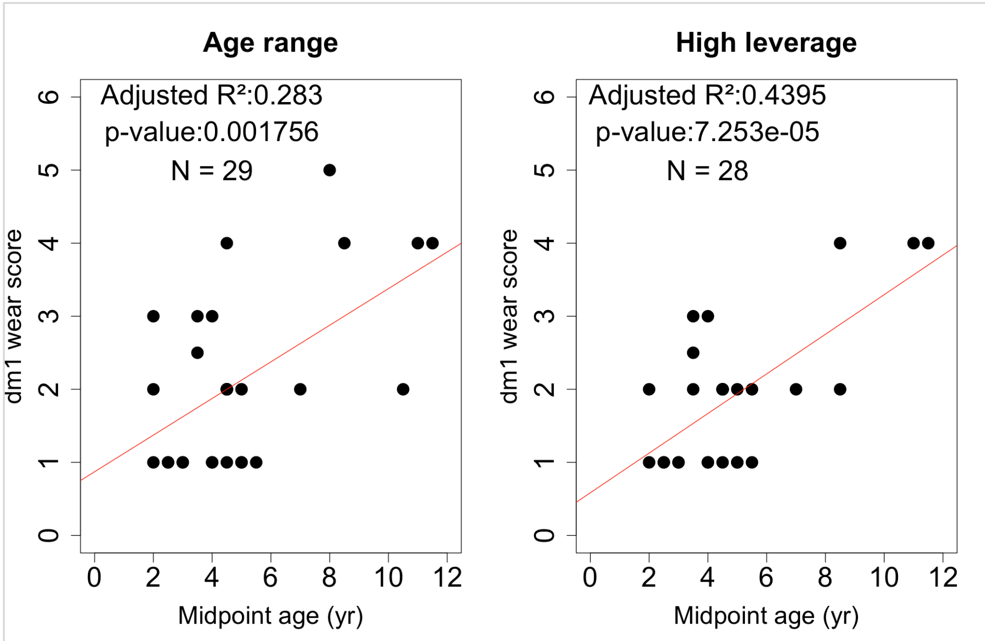


Table 6.24 dm1 age ranges estimated using the high leverage model

Average cusp wear	N	Predicted midpoint age (yr)	Lower bound	Upper bound	Age range (yrs)
1	12	3.3	2.4	4.3	1.9
2	14	5.0	4.3	5.7	1.4
3	6	6.7	5.7	7.8	2.1
4	7	8.4	6.7	10.1	3.4
5	2	10.1	7.7	12.5	4.8

The Age Range Strategy and the High Leverage Strategy in the dm2 Model

The same procedure was used to estimate the age of loose dm2s that were either apex complete (Ac) or dm2s for which the level of root development could not be assessed due to taphonomic damage. One right dm_2 (T.3.215.50) was removed from the analysis because its crown was obliterated and wear could not be scored, leaving a dm2 sample size of 40. Three individuals with dm2s had age ranges of 5 years, and were dropped from the age range model. The *plot (model)* function in R was once more used to identify high leverage observations (Table 6.25):

Table 6.25 High leverage observations identified for the articulated dm2 sample

Point order	Element ID	Midpoint age	Total teeth	Age Range (yrs)
6	MN.1.006.10	7.4	3	3
11	MX.2.274.02	12	5	2
23	MX.2.175.02	11.5	5	3
28	MN.2.246.04	8	7	2
45	MX.4.055.01	6.5	2	1

Removing the high leverage observations produced a stronger relationship between dm2 wear and midpoint age than the removal of the individuals with broad age ranges (Figure 6.14). Accordingly, a model was developed for dm2 wear with the highest leverage points removed using the articulated subadult sample, and then used the *predict* command in R to estimate age based on dm2 wear. Table 6.26 lists the age ranges that were estimated for fifteen different stages of dm2 wear.

Figure 6.14 Age range vs. high leverage strategy for the articulated dm2 sample

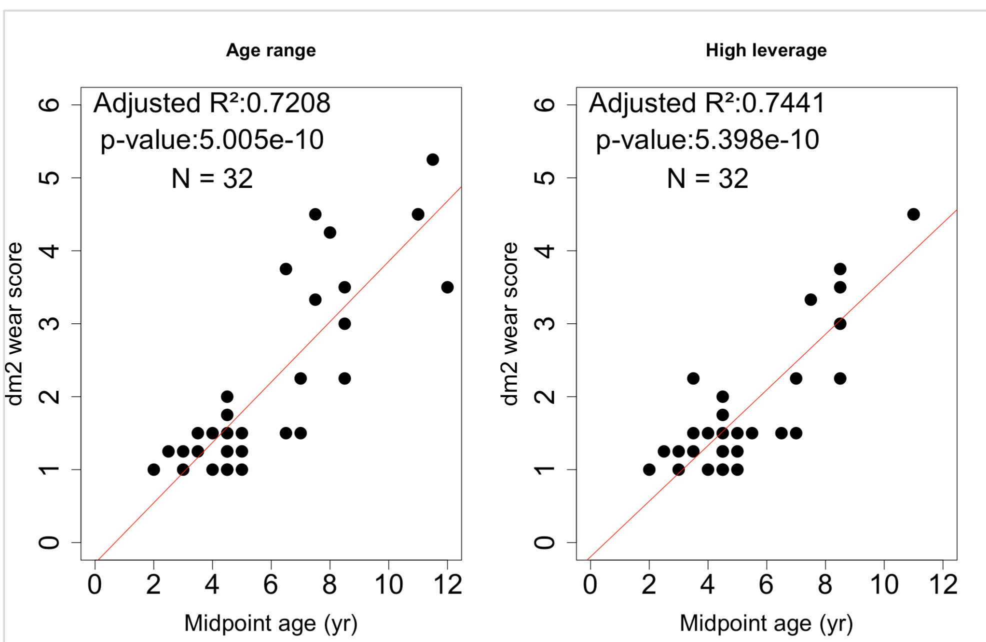


Table 6.26 dm2 age ranges estimated using the high leverage model

Average cusp wear	N	Predicted midpoint age	Lower bound	Upper bound	Age range (yrs)
1	6	3.7	3.1	4.3	1.2
1.25	2	4.2	3.7	4.7	1
1.5	5	4.7	4.2	5.2	1
2	4	5.7	5.2	5.1	0.9
2.25	2	6.2	5.7	6.7	1
2.5	2	5.7	6.2	7.2	1
2.67	1	7	6.5	7.6	1.1
2.75	1	7.2	6.6	7.8	1.2
3	4	7.7	7	8.3	1.3
3.25	2	8.2	7.4	8.9	1.5
3.5	3	8.7	7.8	9.5	1.7
3.75	2	9.1	8.2	10.1	1.9
4	3	9.6	8.6	10.7	2.1
4.25	2	10.1	9	11.3	2.3
5.25	1	12.1	10.6	13.6	3

The difference between the number of wear scores for dm1s (5) and the number of wear scores for dm2s (15) is related to different method of recording wear scores for each category of tooth. Deciduous first molars have only two cusps, and scoring them relative to Smith's guidelines for the premolars (Buikstra and Ubelaker 1994:52) produces only one numeric score per tooth. In contrast, deciduous second molars have four distinct cusps and are scored using Scott's system for the molars, producing four scores per tooth (one per cusp) (Buikstra and Ubelaker 1994:53). The average cusp wear score is used here, paralleling Gilmore and Grote's (2012) recommendations for attrition-based age estimates of adult teeth, producing more of a continuous distribution of scores than those for the deciduous first molars.

Once age was estimated for this subsample of loose deciduous first and deciduous second molars, the midpoint age estimates for these teeth were then sorted by area to build the age-stratified subadult MNI. As with the articulated subadult teeth, Area 1 was separated from Area 2.

C) Using Wear to Predict Age for Loose (Ac) Deciduous Teeth (i1, i2)

Deciduous first and second incisors have relatively short tenure in the mouth after becoming apex complete, while deciduous canines are retained for a much longer time span (Table 6.27).

Table 6.27 Tenure of deciduous canines and incisors based on AlQahtani (2009) and AlQahtani et al. (2010)

Tooth	First age category Ac	Last age category in mouth	Age range
i^1	2.5	6.5	5
i_1	2.5	5.5	4
i^2	2.5	7.5	6
i_2	2.5	6.5	5
c^1	3.5	9.5	7
c_1	3.5	11.5	9

Table 6.28 Sample sizes of deciduous canines and incisors

Tooth	Left	Right	Total
i^1	13	12	25
i_1	6	6	12
i^2	11	12	23
i_2	7	6	13
c^1	19	12	31
c_1	13	8	21

The age ranges for the deciduous lower incisors were tighter than the age ranges for the deciduous upper incisors, producing more accurate assessments of age. Accordingly, age estimates were only made for the lower deciduous incisors. The age ranges for the deciduous canines (N = 52) were so broad that they were abandoned for purposes of this analysis (Table 6.28). This meant that the age-stratified MNI had to be calculated with reference to the lower teeth (N = 296), rather than the upper teeth (N = 323). However, the higher count of the upper sample was sacrificed for the greater accuracy of the deciduous incisor age estimates. Age estimates were calculated for the lower deciduous incisors by matching each age category with a level of wear (Table 6.29). Because the wear scores range from a possible 1-7, but no wear scores higher than four were recorded, the highest age category listed for i_2 is 5.5, even though the tooth stays in the mouth until age 6.5.

Table 6.29 Age categories matched with lower deciduous incisor wear

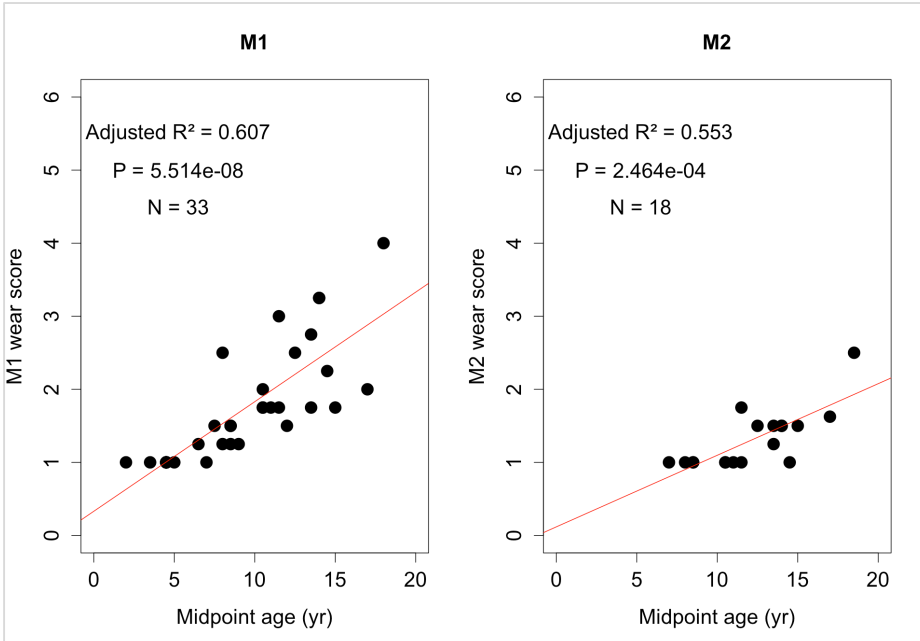
Level of wear	i_1 age category	i_1 count		i_2 age category	i_2 count	
		Left	Right		Left	Right
1	2.5	1	1	2.5	1	2
2	3.5	0	1	3.5	1	1
3	4.5	2	2	4.5	4	3
4	5.5	3	1	5.5	1	0
5	5.5	0	1	6.5	0	0

D) Using Wear to Predict the Age of Articulated Permanent and Developing Permanent Teeth

Finally, a sample of 21 teeth in eight separate alveolar fragments of mandibles or maxillae were categorized as "probable subadult" over the course of analysis. All of these observations contained only erupted permanent teeth, with relatively lightly worn first or first and second molars, and none of them contained erupted third molars. These were therefore either subadult individuals, or adult individuals demonstrating third molars agenesis.

With the exception of MN.2.177.05, with an M1 Wear Score of 6.25, all of these molar wear scores fall beneath the minimum wear score of 3.08 calculated for the adult teeth, bolstering the assessment of these individuals as probable subadults. Given the higher degree of wear on MN.2.177.05, this may be a case of lower third molar agenesis. MN.2.177.05 was therefore categorized as an adult, and age was estimated using the adult age and wear model. Because the sample of first molars is larger, and first molar wear showed a stronger positive relationship with midpoint age (Figure 6.15), a model of M1 molar wear was created to estimate the age of the sample of permanent and developing permanent articulated teeth.

Figure 6.15 Relationship between permanent molar wear and midpoint age



The Age Range Strategy and the High Leverage Strategy in the M1 Model

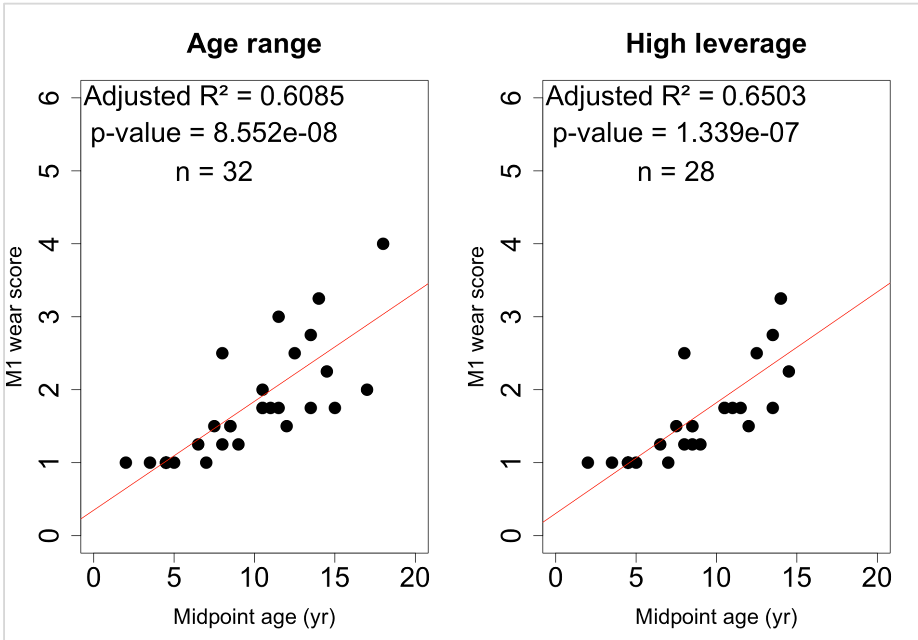
For the M1s, one observation showed an age range of 5, and was dropped from the age range model. Similarly, five high-leverage observations were identified using the *plot (model)* function in R (Table 6.30).

Table 6.30 High leverage observations identified for the sample of M1s

Point Order	Element ID	Midpoint Age	Total Teeth	Age Range
22	MX.2.177.04	15	5	1
32	MN.2.155.06	17	7	2
65	MN.4.065.07	11.5	2	1
66	MN.4.100.07	10.5	2	3
67	MX.4.103.03	18	2	4

The removal of high leverage observations provided a stronger predictive equation than the removal of observations with a broad age range (Figure 6.16).

Figure 6.16 Age range strategy vs. high leverage strategy for the sample of articulated M1s



Because removing the higher leverage points produced a stronger relationship between dm1 wear and midpoint age, I developed a model for M1 wear with the highest leverage points removed, and used the *predict* command in R to estimate age based on M1 wear (Table 6.31).

Table 6.31 Age ranges estimated for M1s using the high leverage model

Average cusp wear	N	Predicted midpoint age	Lower bound	Upper bound	Age range (yrs)
2.00	1	10.3	9.3	11.3	2
2.25	1	11.4	10.3	12.6	2.3
2.50	4	12.5	11.1	13.9	2.8
2.75	1	13.6	11.9	15.3	3.4

Dental Completion for Necropolis 4

Expected adult tooth counts were calculated using the adult dental MNI of 145, adjusting the count of each individual tooth category to reflect the total antemortem tooth loos (AMTL) frequency recorded for N1, N2, and N4. Expected subadult tooth counts were calculated using the age-stratified right mandibular subadult dental MNI of 60, using the AlQahtani et al. atlas to count the number of deciduous teeth ≥ Ri, and the number of developing permanent teeth that were ≥ Cr3/4, and less than Ac or estimated to be < 18 years of age.

Overall, dental completion was higher for adults than for subadults. 70% (3034 observed / 4346 expected) of the expected adult teeth were preserved, while only 42% (779 observed / 1842 expected) subadult teeth were preserved. The best represented adult tooth category was canines (82% of expected), followed by premolars (69% of expected), molars (65% of expected), and incisors (67% of expected). More developing permanent subadult teeth (48% of expected) were preserved than deciduous teeth (35% of expected), and unsurprising outcome given the smaller size, and hence poorer preservation and lower recoverability of deciduous teeth. The best represented subadult developing permanent tooth category was permanent molars (58% of expected), followed by permanent premolars (35% of expected), permanent incisors (31% of expected), and permanent canines (29% of expected). The best represented deciduous tooth category was deciduous molars (55% of expected), followed by deciduous canines (44% of expected), and deciduous incisors (32% of expected).

Dental Pathology for Necropolis 4

The most frequently documented insult at N4 was dental calculus, which affected 1446/2742 total observable teeth (53%) (Table 6.32). Calculus was most common on permanent incisors and canines affecting 50% of teeth, and less common on permanent premolars (38%) and molars (35%). Calculus was observed on only 14/362 (4%) of deciduous teeth, which is unsurprising given their shorter tenure in the mouth. Percentages for calculus were calculated by dividing number of teeth affected by total observable tooth counts (for subadults, observable counts only included erupted teeth). The most common score for calculus was 1 (N = 736), followed by 2 (N = 511), and 3 (N = 199).

For caries, frequencies were calculated by dividing the number of teeth affected by the number of teeth for which caries were observable (for subadults, observable counts only included erupted teeth). 97% of caries were observed on adult teeth, and in total, 221 caries were found on 3241 observable teeth (7%). Hypoplasias were rarer, affecting 34 subadult teeth and 108 adult teeth, or 142/3325 (4%) of enamel observable teeth. The most commonly affected tooth type was the left lower deciduous canine, affecting 8/22 (36%) teeth, and left lower permanent canine, affecting 24/73 (33%) teeth. Less common dental pathologies or abnormalities observed in the N4 adult sample included two maxillary abscesses, two mandibular abscesses, 1 upper supernumerary tooth, one RlP4 with delayed eruption, 3 enamel defects, and 4 enamel pearls. Among the subadults, there were 12 teeth with hypocalcifications, 2 enamel defects, and 1 upper supernumerary tooth.

Table 6.32 Dental pathology at Necropolis 4

Pathology	Observation	Adults		Subadult	
		Count	Frequency	Count	Frequency
Calculus	Teeth Affected	1426	0.46	20	0.05
	Total Teeth	3089		369	
Caries	Teeth Affected	238	0.07*	8	0.02
	Teeth Caries Observable	3085		369	
Hypoplasias	Teeth Affected	108	0.04	34	0.05
	Teeth with Observable Enamel	2637		688	

*Though there were 238 adult caries, only 213/3085 adult teeth were affected, as 191 teeth had 1 caries, 20 teeth had 2 caries, 1 tooth had 3 caries, and 1 tooth had 4 caries.

Rates of antemortem tooth loss (AMTL) were relatively low at N4. Of the 1612 mandibular and maxillary sockets that could be observed, only 88 had resorbed (5%). The highest frequencies of resorption occurred for the RuM1 (5/30 – 17%), LlM1 (13/83 – 16%), RlM1 (15/95 – 16%), and LuP4 (3/20 – 15%). This patterning is unsurprising as the distal teeth, particularly the molars, have higher rates of caries (Demirci et al. 2010), which is one of the factors that can lead to tooth loss and subsequent resorption of sockets.

Conclusions

Analyses of the N4 dental data reveal that much can be done with loose and commingled teeth. With careful consideration, I was able to extract significant amounts of data on demography and health from prehistoric teeth, even from a sample of predominantly loose and commingled teeth. The MNI estimate of 145 adults for Necropolis 4 was based on the presence of the right upper canine, while the age-stratified MNI of 60 subadults was constructed using estimates of subadult age and the presence of teeth from the right mandibular arcade. When combined, these results indicate that at least 205 individuals were buried in Necropolis 4, 165 in Area 1 and 40 in Area 2.

These analyses also reveal the limitations of existing methods, and indicate some necessary directions for future research. In particular, testing the Gonçalves et al. (2014) canine metric strategy for estimation of sex, both by side, and on a larger sample of individuals of known sex, is a necessary step to ensure the rigor of that method. In the future investigations of the tooth wear of older adults (> 40 years) from prehistoric collections, where age has previously been estimated with reference to skeletal data, could likewise provide profitable insight into developing methods to overcome the middle and older age gap produced by estimates of age with reference to dental attrition. Finally, the strategies developed here to estimate the age of "problematic" categories of loose subadult teeth can serve as a blueprint for future approaches developed with reference to larger samples of both articulated and loose subadult teeth.

Chapter 7

From Bones to Bodies: Results of Bioarchaeological Analyses for Necropolis 1 and Necropolis 2

> *For those of us accustomed to clearly defined pit features containing extended skeletons with grave goods, the notion of what constitutes a burial and mortuary feature must be reshaped to accommodate the archaeological record in a place where there is in a sense no such thing as a primary burial.*
>
> – *Ann L.W. Stodder, The Bioarchaeology and Taphonomy of Mortuary Ritual on the Sepik Coast, Papua New Guinea, (2005:249)*

Working with a sample of fragmentary human remains requires a particular set of methodological and analytical considerations. Working with three different samples of fragmentary human remains, each the product of different mortuary treatments, taphonomic conditions, excavation strategies, and museum storage practices, is thus a complex process necessitating explicit attention to issues of context and taphonomy. Because of the slightly different excavation and storage practices undertaken for each mortuary area, results of analyses are presented separately, so as to document the methodological considerations I employed for each distinct case.

This chapter describes the results of my analyses of Necropolis 1 (N1) and Necropolis 2 (N2) from Marroquíes Bajos. The description of the results for each mortuary area follows the same organization, beginning with a discussion of Minimum Number of Individuals (MNI) estimates, then covering assessments of age, sex, pathology, and a discussion of dental completion as this relates to mortuary treatment. The final section of this chapter compares and contrasts the results of bioarchaeological analyses at N1, N2, and N4, focusing on similarities and differences in mortuary treatment, demography, and dental pathology among all three mortuary areas.

Necropolis 1

Necropolis 1 (N1) is a Copper Age necropolis situated between the fourth and fifth ditch, in the northwest quadrant of the Marroquíes Bajos settlement (for a further description of site context and history, see Chapter 4 of this dissertation). Salvage excavations in 1998 and 1999 showed that this mortuary area contained multiple individuals interred in six different mortuary structures. Funerary ritual emphasized communal burial, with a minimum of one individual burial in Structure 22, and a maximum of 16 individuals in Structure 14. Because burials were relatively discrete, individual interments were identified by excavators and were subsequently curated by the museum as separate individuals, a storage practice which allowed individuals to be treated as units of analysis.

Minimum Number of Individuals for Necropolis 1

At N1, detailed site maps document 46 human burials in six different structures. Unfortunately, ten of these inhumations could not be located in the collections at the Museum of Jaén – one mapped individual is missing from Structure 14, four mapped individuals are missing from Structure 26, and five mapped individuals are missing from Structure 27. The missing individuals are likely a result of the decade and a half hiatus between excavation and analysis, and compounded by the immense volume of salvage-excavated material curated in the Museum of Jaén.

In addition to the mapped interments, the human remains for N1 included 21 smaller bags, each with individual proveniences in Structure 13, Structure 14 or Structure 27. These bags were labeled simply *Huesos Sueltos* or "Loose Bones." The bags contained a mixture of fragmentary human and faunal remains. Human remains were separated from faunal remains for this purposes of this analysis. Further analysis of the loose human remains identified an additional three individuals not depicted on the site maps – two were individually bagged adult mandibles (N1.CE13.36 and N1.CE13.191), and one was a collection of subadult postcranial remains that overlapped anatomically with all other subadults for the structure (N1.CE13.206). While three adult burials for Structure 13 lacked mandibles (N1.CE13.01, N1.CE13.02 and N1.CE13.18), all three burials were depicted on the maps as being highly fragmentary, and no mandibles were clearly sketched in for these individuals. Because loose mandibles 13.36 and 13.191 come from proveniences with different floors and stratigraphic units to the individuals lacking mandibles, these were treated as two distinct individuals.

One additional set of dentition was found in the loose remains from Structure 13 – a separately bagged subadult maxilla (N1.CE13.211) and mandible (N1.CE13.157), both with an estimated age of 5.0-8.0 years. Analysis of the Structure 13 maps and associated burials revealed that one more subadult individual (N1.CE13.14) buried in Structure 13 was depicted on the map as having a mandible and maxilla. However, the bag for N1.CE13.14 contained no alveolar bone. Age for N1.CE13.14 could only be estimated with reference to fragmentary post-cranial remains, which produced an estimate of between 1.5-5 years of age. The relationship between the metrics of developing bones and chronological age are population specific, so the age estimate of 1.5-5 years for N1.CE13.14 could be underestimating the age of this individual. Given the limitations of age estimates based on fragmentary post-cranial bones, N1.CE13.14 was associated with the loose mandible and maxilla to avoid inflating the subadult MNI for this mortuary area.

Finally, it became apparent that three burials depicted on the site maps actually contained the jumbled remains of two individuals (13.31, 14.02 and 14.21). After untangling the number of individuals available for study, a full bioarchaeological analysis, assessing skeletal completion, age, sex and pathology, was conducted for the 42 individuals that could be located in museum collections. Accordingly, while bioarchaeological data are available for 42/52 individuals, it is important to acknowledge that this analysis represents an 80% sample of the documented mortuary population for this necropolis (Table 7.1).

Table 7.1 MNI for Necropolis 1 by structure

Age Category	Structure				
	13	14	22	27	52*
Adults	11	11	1	8	1*
Subadults	5	6	0	0	0
Structure total	17	17	1	8	0*
Adult MNI					31
Subadult MNI					11
Grand Total					42

*Structure 52 contained only a partial human fibula. The low levels of skeletal completion for this structure led to it being removed from this analysis for purposes of MNI.

Assessment of Sex for Necropolis 1

For N1, it was possible to estimate the sex of 17/31 (55%) of adult individuals. Even though it was possible to analyze distinct individuals at this mortuary area, human remains were still relatively fragmentary. In particular, anterior ossa coxae (specifically the pubis), crania, and mandibles preserved poorly. Best practice in human osteology involves drawing upon multiple indicators in order to assess the sex of an individual. Unfortunately, most individuals from N1 preserved only one or two of the suite of sexually dimorphic non-metric features required to estimate sex. The assessments of sex noted in Table 7.2 reflect the specific feature(s) listed. For example, the assessment of "male" for individual N1.CE13.11 reflects the mental eminence itself, rather than the composite estimate for multiple features. The estimates of sex for this mortuary area, along with the non-metric traits these assessments are derived from, are listed in Table 7.2. Preserved pelvic features are listed before cranial features as these generally provide more rigorous estimates of sex. The "confidence" column reflects confidence in assessment of features relative to their preservation; low entries reflect more poorly preserved or fragmentary specimens.

Table 7.2 Estimates of sex for Necropolis 1 adults (non-metric features)*

Individual	Estimate of sex	Features observed	Confidence
N1.CE13.11*	Male	Mental eminence	Low
N1.CE13.12	Probable female	GSN, Mastoid Process, Nuchal Crest	Low
N1.CE13.13*	Probable female	GSN	Medium
N1.CE13.18	Female	GSN, pre-auricular sulcus	High
N1.CE13.25	Female	GSN, pre-auricular surface, Phenice features of pubis	High
N1.CE13.26	Probable male	GSN, supraorbital ridge, mastoid processes, nuchal crest	Medium
N1.CE13.27	Probable male	Phenice features of pubis, mental eminence, nuchal crest	Low-Medium
N1.CE14.03*	Probable female	GSN	High
N1.CE14.05	Probable male	GSN, supraorbital ridge, mastoid process, mental eminence	High
N1.CE14.06	Probable male	GSN, mastoid process, mental eminence	High
N1.CE14.07	Probable female	GSN, mastoid process, nuchal crest	Low
N1.CE14.08	Female	GSN, Phenice features of the pubis	High
N1.CE14.09*	Probable female	Mastoid process	Low
N1.CE14.13	Male	GSN, mental eminence	High
N1.CE14.14	Female	GSN, pre-auricular sulcus	High
N1.CE22.01	Probable male	GSN, mastoid processes	Low
N1.CE27.02	Female	GSN	Medium

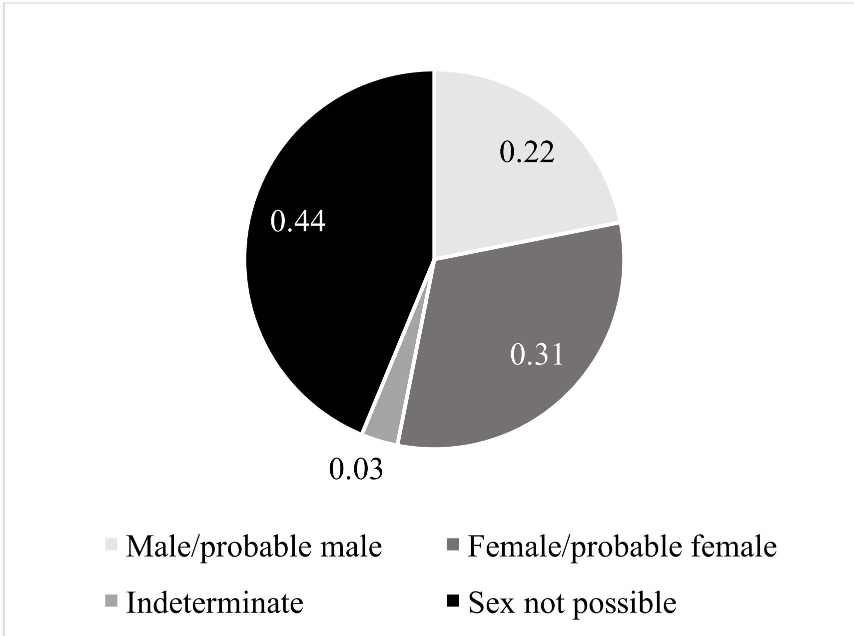
* Individuals with asterisks preserved only one non-metric feature that could be used for estimating sex. These assessments are therefore the least rigorous of this sample.

Table 7.3 Estimation of sex for adults from Necropolis 1 (non-metric traits)

Structure	Male/probable male	Female/probable female	Indeterminate*	Sex not possible	Total adults
13	3	4	1	4	12
14	3	5	0	3	11
22	1	0	0	0	1
27	0	1	0	7	8
N1 Total	**7**	**10**	**1**	**14**	**32**
N1 %	**22**	**31**	**3**	**44**	**100**

* "Indeterminate" refers to individuals with non-metric traits that fall in between "male" and "female" scores. "Sex not possible" refers to individuals who did not preserve the regions of the pelvis and/or cranium necessary for estimating sex.

Figure 7.1 Estimation of sex for adults from Necropolis 1 based on non-metric traits (% adult sample)



Further details on these estimates of sex can be found in Appendix B (Individual Summaries for Necropolis 1).

Unfortunately, the sample size is too small to test for significance when estimates of sex are broken down by structure (Table 7.3), particularly considering that the number of "indeterminate" or "sex not possible" individuals could potentially be used to balance out differences in the representation of each sex for Structures 13, 14, and 27. Additionally, the fact that multiple individuals are missing from each structure must be taken into consideration when thinking about potential patterning in regards to sex.

Two points must be emphasized about the results of this analysis. First, the structures with the greatest numbers of individuals (Structure 13 and Structure 14), contain both males and females. For Structure 27, estimation of sex for most individuals was hampered by the low levels of completion of remains (Figure 7.1); the sole individual for which it was possible to estimate sex preserved only one relevant non-metric trait. The lack of males and probable males in this feature is therefore likely a reflection of analytical constraints related to fragmentary remains, rather than a true absence of male individuals. Second, there is one structure that definitively contains only one sex, as it only one individual is interred within it. Structure 22 occupies the center of Necropolis 1, and contains only one individual, an adult male. Accordingly, while both males and females were interred in the peripheral mortuary structures that were communal, the only burial at the site containing one individual was reserved for a centrally placed adult male individual.

Age Estimates for Subadults from Necropolis 1

Subadults were analyzed separately from adults at N1. When skeletal completion allowed, age was assessed using dental eruption, dental development, epiphyseal fusion and element size. For adults, age was assessed using molar eruption, dental attrition, the pubic symphyseal face, and auricular surface aging techniques. Of the sample of 42 individuals available for study, 6 individuals (N1.CE13.01, N1.CE14.11, N1.CE27.02, N1.CE27.03, N1.CE27.04, N1.CE27.12) were so poorly preserved that it was not possible to estimate age; however, element size placed these individuals in the adult category.

The developmental indicators used to estimate the age of subadults, and the age estimates themselves, are listed in Table 7.4. Categorical age ranges were explicitly defined in order to be comparable to Cámara Serrano et al.'s (2012) analysis of Necropolis 3. Individuals were assigned to age categories using the midpoint of their estimated age range. Age ranges were defined as follows: preterm infant (prenatal), child (birth–6.9 years), juvenile (7–12.9 years), adolescent (13–20.0 years), and adult (20 +years; Cámara Serrano et al. 2012:54).

Table 7.4 Age estimates for subadults from Necropolis 1*

Individual	Age estimate (yrs)	Age category	Age estimate basis
N1.CE13.14	3.5-7.5	Child	Dental development, element size
N1.CE13.21	5.0-7.5	Child	Dental development, element size
N1.CE13.31.1	14.5-16.5	Adolescent	Epiphyseal fusion
N1.CE13.31.2	5-6	Child	Element size
N1.CE13.206	3-6	Child	Element size
N1.CE14.02.1	1.5-3.5	Child	Dental development
N1.CE14.02.2	6.5-7.5	Juvenile	Dental development
N1.CE14.04	1.5-3.5	Child	Dental development
N1.CE14.12	5.5-7.5	Child	Dental development and eruption, element size
N1.CE14.15	16-19	Adolescent	Epiphyseal fusion
N1.CE14.21.2	3.5-5.5	Child	Dental development, element size

*The initial age estimates listed for N1 subadults (Beck 2015) were derived from the McCall and Schour chart (Thoma and Goldman 1961), Smith (1991), and Ubelaker (1989). However, subsequent use of the more precise AlQahtani (2009), and AlQahtani et al. (2010) aging systems altered the age initial estimates, with the new estimates generally 1-2 years older. Individual N1.CE13.14 was initially aged at 3-6 years of age; combining the element size estimates with the dental estimates, this was increased from 3.5-7.5 years of age using the AlQahtani system. The age estimate for N1.CE13.21 also increased, moving from 4.3-7.0, to 5.0-7.5 years. The age range estimated for N1.CE14.02.1 has likewise been expanded from 2.3-3.25 to 1.5-3.5 years. The estimate for individual N1.CE14.02.2 has increased from 5-7 to 6.5-7.5 years, and has accordingly been moved from the child category to the juvenile category. Finally, the age estimate for N1. CE14.12 has increased from 4.5-6.5 to 5.5-7.5. Individual N1.CE14.21.2 has been re-aged from 3-5 years to 3.5-5.5 years.

Age Estimates for Adults from Necropolis 1

Dental evidence, specifically molar wear, was a high priority when estimating adult age, because this allowed the construction and comparison of age distributions from N1, N2, and N4 using the same methodology.

Of the two necropolises for which both dental and skeletal analyses were conducted, only N1 allowed for association between teeth and skeletal elements. Unfortunately, due to the high levels of fragmentation of the pelvis, comparisons of skeletal estimates of age to patterns of dental attrition were only possible for ten adult individuals from this mortuary area. Average cusp wear was scored using the modified Smith system from Buikstra and Ubelaker (1994). Average cusp wear was calculated for each of the permanent molars by averaging cusps of a given category from all sides and arcades. For example, if an individual had all first molars preserved, the average wear was calculated by summing the individual wear scores for each cusp, and then dividing by 16. Average cusp wear for each category of molar was then compared to the midpoint estimate of skeletal age to assess the relationship between dental attrition and individual age (Figures 7.2-7.4).

Figure 7.2 Midpoint age by M1 average wear score for Necropolis 1 adults

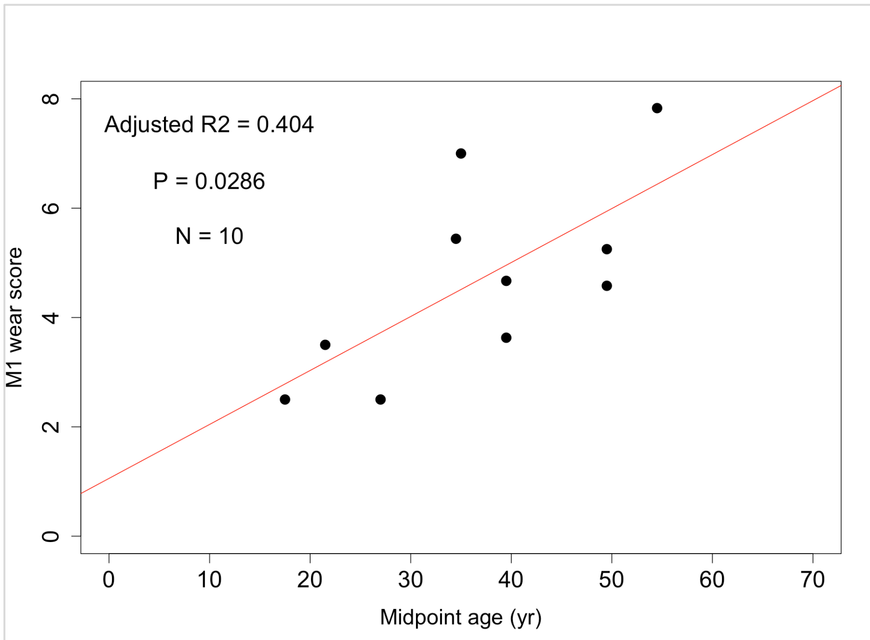


Figure 7.3 Midpoint age by M2 average wear score for Necropolis 1 adults

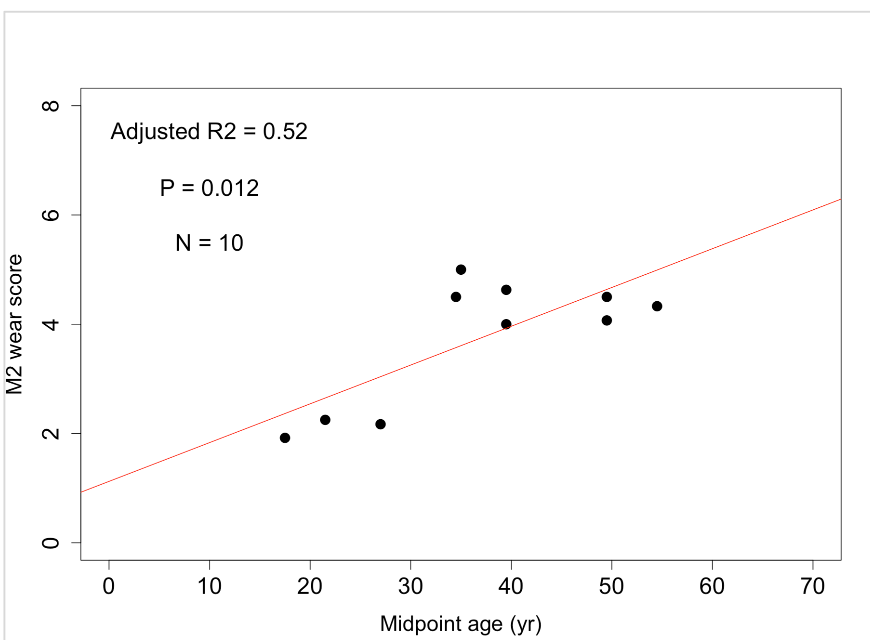


Figure 7.4 Midpoint age by M2 average wear score for Necropolis 1 adults

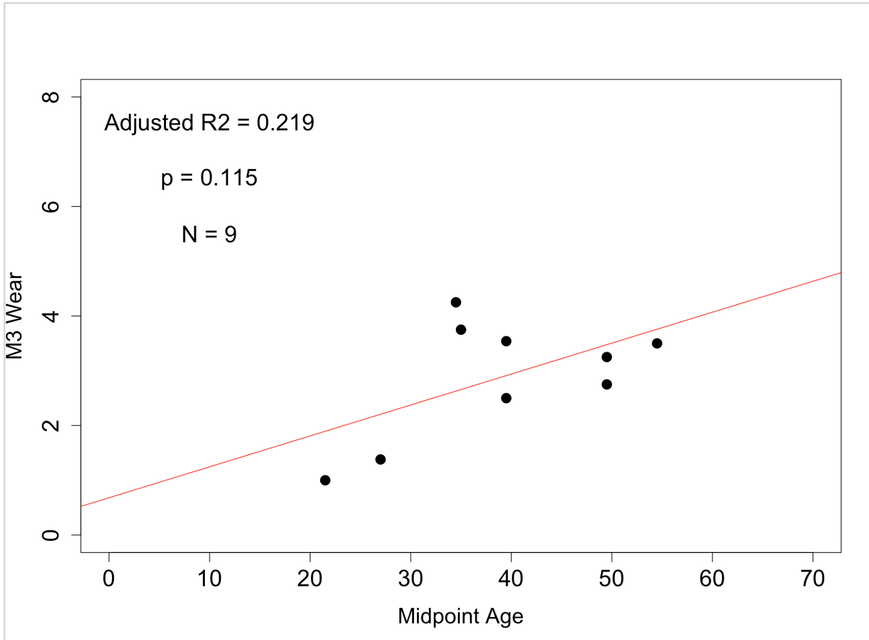


Table 7.5 Skeletal estimates of age for adults and older subadults from Necropolis 1

ID	Skeletal age estimate	Skeletal age	Age range (yrs)	Mid-point	M1 mean wear	M2 mean wear	M3 mean wear
N1.CE13.02	Development of LuM3	18-25	7	21.5	3.50	2.25	1.00
N1.CE13.11	Auricular surface	40-59	19	49.5	5.25	4.50	2.75
N1.CE13.27	Auricular surface	30-40	10	35	7.00	5.00	3.75
N1.CE14.05	Auricular surface,	30-39	9	34.5	5.44	4.50	4.25
N1.CE14.06	Auricular surface	35-44	9	39.5	3.63	4.00	2.50
N1.CE14.07	Auricular surface	25-29	4	27	2.50	2.17	1.38
N1.CE14.08	Auricular surface*	40-59	19	49.5	4.58	4.07	3.25
N1.CE14.13	Auricular surface	35-44	9	39.5	4.67	4.63	3.54
N1.CE14.14	Auricular surface	50-59	9	54.5	7.83	4.33	3.50
N1.CE14.15	Epiphyseal fusion	16-19	3	17.5	2.50	1.92	NA

The comparisons in Figures 7.2 to 7.4 must be taken with a grain of salt. First, sample sizes are small – only ten individuals could be used for the M1 and M2 comparisons, and only nine could be used for the M3 comparisons. Second, using a midpoint estimate of age conceals the true width of age range estimates, especially those for older individuals. The average size of estimated age ranges for this sample was 9.8 years, with a minimum of 3 years and a maximum of 19 years (Table 7.5). In Table 7.5, individual N1.CE14.08 also had an age estimate made using Suchey Brooks, but because (i) the auricular surface was used for the majority of individuals in this sample, and (ii) the auricular surface produced a tighter estimated age range, it was given priority here).

However, despite the small sample sizes and variability introduced by age range estimates, the relationship between the midpoint skeletal estimates of age and dental wear is positive for all categories of molars. There is a significant positive correlation between midpoint skeletal age and average cusp wear for first and second molars, and a positive, though not significant correlation for third molars. The results for third molars are not surprising, given that third molars experience more variable wear patterning than first or second molars (Gilmore and Grote 2012).

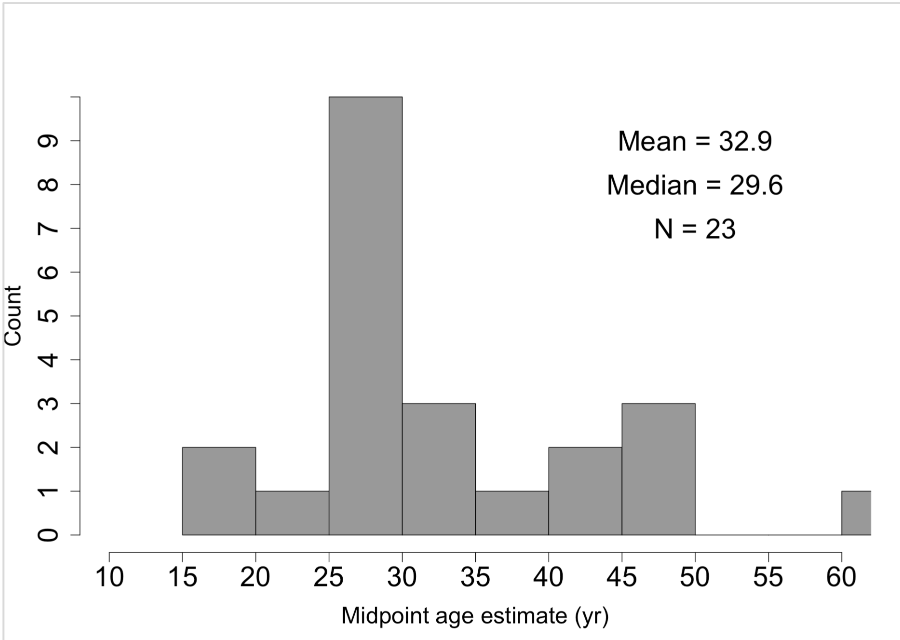
Though comparisons of molar wear and estimated post-cranial age showed a positive relationship, comparisons between the Gilmore and Grote estimated age ranges and post-cranial estimated age ranges showed less congruence, as discussed in Chapter 6. Overall, age estimates based on molar wear were possible for 23 adult individuals from N1 (74% of the adult sample). In order to ensure that age distributions from N1, N2, and N4 were comparable, adult age estimates drawn from the teeth were prioritized for all mortuary areas, but skeletal estimates of age were used if no teeth were preserved for an N1 individual. Age was estimated for 19 individuals using the Gilmore and Grote molar wear method on any available first molar wear scores, for 1 individual using degree of alveolar resorption, for 1 individual using the auricular surface, for 1 individual using development of the upper third molars, and for 1 individual using the wear of an associated RlM2 because the wear score for one quadrant of the RlM1 was 10, as specified in Gilmore and Grote (2012) (Table 7.6, Figure 7.5).

Table 7.6 Age estimates for adults from Necropolis 1

Individual	Midpoint Age Estimate	Age Category	Source
N1.CE14.07	18.9	Very Young Adult	Molar Wear Model
N1.CE14.10	19.5	Very Young Adult	Third Molar Development
N1.CE13.02	24.0	Young Adult	Molar Wear Model
N1.CE22.01	25.3	Young Adult	Molar Wear Model
N1.CE13.36	26.6	Young Adult	Molar Wear Model
N1.CE14.09.1	26.6	Young Adult	Molar Wear Model
N1.CE27.01	26.6	Young Adult	Molar Wear Model
N1.CE27.11	26.6	Young Adult	Molar Wear Model
N1.CE14.06	27.2	Young Adult	Molar Wear Model
N1.CE27.06	28.5	Young Adult	Molar Wear Model
N1.CE27.b20.20	29.3	Young Adult	RlM2 Wear (Associated with RlM1)
N1.CE14.08	29.6	Young Adult	Molar Wear Model
N1.CE14.13	29.9	Young Adult	Molar Wear Model
N1.CE13.191	30.4	Young Adult	Molar Wear Model
N1.CE13.11	33.0	Young Adult	Molar Wear Model
N1.CE14.05	34.0	Young Adult	Molar Wear Model
N1.CE13.18	39.5	Young Adult	Molar Wear Model
N1.CE13.26	40.1	Middle Adult	Molar Wear Model
N1.CE13.27	42.0	Middle Adult	Auricular Surface
N1.CE13.12	45.8	Middle Adult	Molar Wear Model
N1.CE14.14	46.3	Middle Adult	Molar Wear Model
N1.CE13.13	47.1	Middle Adult	Molar Wear Model
N1.CE13.25	61	Old Adult	Alveolar Resorption

* N1.CE27.b20.20 is a right lower second molar that could not be associated with any of the individuals in Structure 27. This tooth was articulated with a RlM1 that could not be scored because one of its quadrants was too heavily worn.

Figure 7.5 Distribution of ages for adults from Necropolis 1



Analysis of Skeletal Completion for Necropolis 1

In addition to identifying the placement of discrete individuals, the Necropolis 1 site maps also made it possible to make informed decisions as to whether individual burials were *primary* or *secondary*. Burials depicted with a high degree of anatomical articulation and a large number of bones present were considered *primary*. Burials of jumbled elements without any discernible patterns of articulation, or isolated burials of crania and clusters of long bones, were considered *secondary*. To determine an individual's level of completion, counts of bones were assembled with reference to the fragmentation-zonation methods used to record element completion (Chapter 5, Table 5.3). These expected counts were compared to the Minimum Number of Elements (MNE) predicted by the MNI (Table 7.7). For example, an MNI of seven adult individuals in a given structure would produce a predicted MNE of seven right humeri. Completion was assessed by comparing the expected MNE to the observed MNE (% expected MNE).

Table 7.7 Expected MNE values for one individual by anatomical region

Anatomical region	Expected MNE	MNE components
Arm	6	Humeri, radii, ulnae
Foot	52	Tarsals, metatarsals, phalanges
Hand	54	Carpals, metacarpals, phalanges
Leg	8	Femora, tibiae, fibulae, patellae
Pelvic Girdle	3	Os coxae, sacrum
Ribs and Thorax	25	Ribs, sternum
Shoulder Girdle	4	Scapulae, clavicles
Spine	24	Cervical vertebrae, thoracic vertebrae, lumbar vertebrae
Cranial Bones	15	Occipital, parietal bones, temporal bones, zygomatic bones, nasal bones, frontal, maxilla, sphenoid (last three divided into left and right halves)
Mandible	1	
Total	**192**	

[1]The hyoid, coccyx, and non-patellar sesamoid bones were excluded as these were rarely recovered at either mortuary area. The fragmentation-zonation method used to record all bones was a modified version of Knüsel and Outram (2004). For the cranium, this system excludes delicate intracranial bones like the vomer, ethmoid and miniscule bones like the auditory ossicles.

Subadults generally have a greater number of individual pieces of elements due to the developmental patterning of ossification (long bones, for example, generally comprise a single primary center of ossification and multiple secondary centers of ossification). However, for the purposes of this analysis the same expected MNE and % MNE was used for adults and subadults, because (i) at N2, so few subadult bones were recovered that all epiphyses were identifiable and counted towards the MNE for specific anatomical regions, and (ii) at N1, elements were associated with individuals for adults and subadults, so epiphyses could often be refit to or associated with long bone diaphyses, and thus were prevented from artificially inflating the observed MNE.

Adults and subadults were separated during the analysis because subadult completion values consistently fell below adult completion values (Figure 7.5). Of the remains available for study in the museum, subadults were only documented for Structure 13 and Structure 14. However, the samples of subadults for both structures demonstrated comparable skeletal completion values (Figure 7.6). In contrast, adult skeletal completion values were more variable. Structure 27 is the only mortuary area for which adult skeletal completion values fall below the necropolis adult average of 31% expected MNE, making it likely that most of the interments available for study from this structure were secondary (Figure 7.7).

Figure 7.6 Average skeletal completion by structure for subadults from Necropolis 1

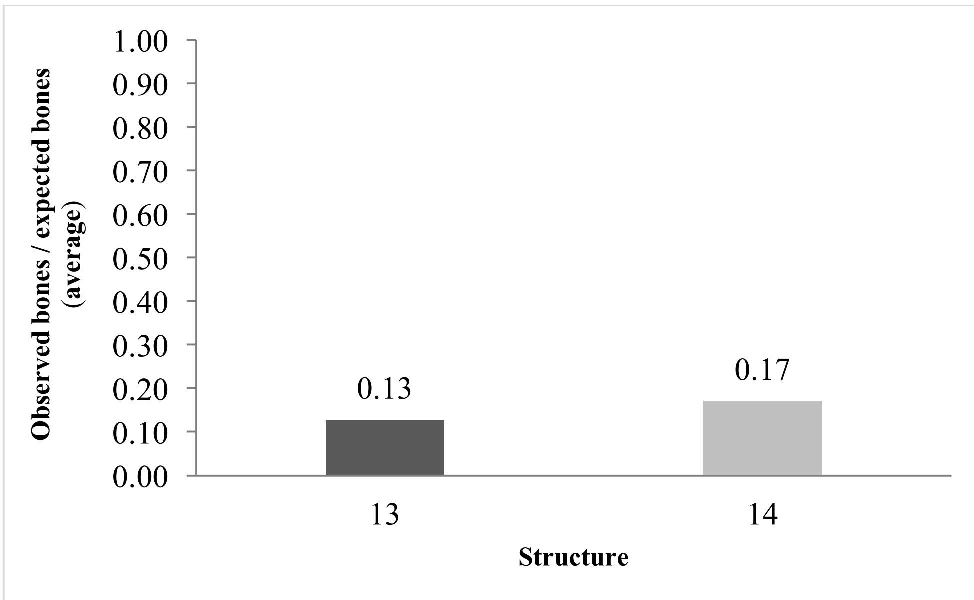
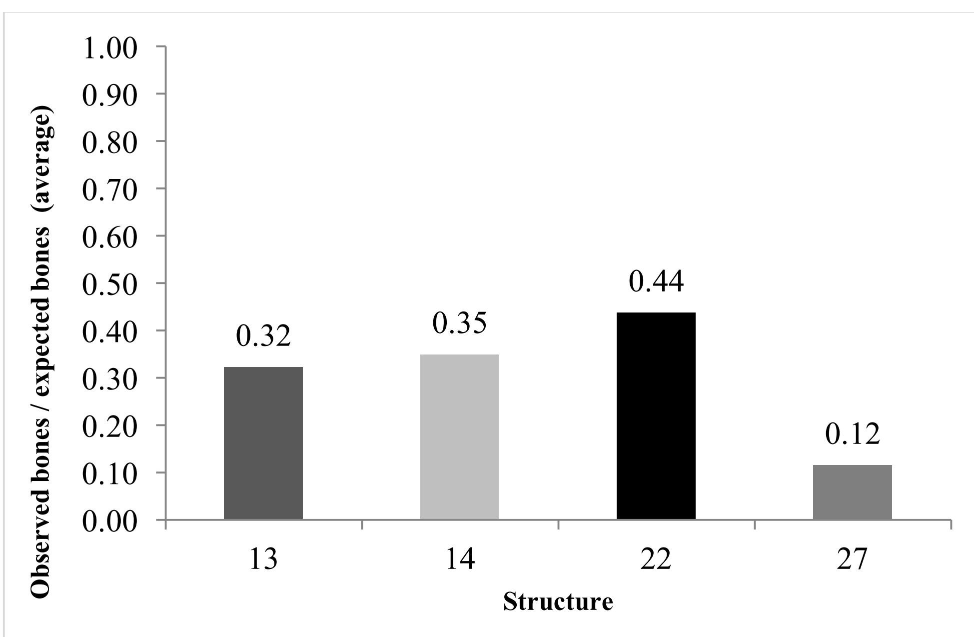


Figure 7.7 Average skeletal completion by structure for adults from Necropolis 1



Calculating Expected Tooth Counts for Necropolis 1 and 2

Differences between primary and secondary burials are also apparent when examining the patterning in dental completion. An approach similar to the skeletal % expected MNE was developed in order to compare the dental signature of primary and secondary burials. Because of age-related trajectories of dental development, different methods were developed to assess observed and expected counts for adults and subadults. Within this chapter, the following dental definitions are used:

1. **Adult Permanent Teeth:** Permanent teeth with (i) root apices complete, or (ii) an estimated age ≥ 18 years. If the tooth root was damaged, but enough of the root was present to suggest that the apex had been complete at time of death, the tooth was identified as permanent.
2. **Subadult Developing Permanent Teeth:** Permanent teeth that had not (i) achieved completion of the root apex or (i) produced an age estimate of < 18 years.
22. **Deciduous Teeth:** Both developing and fully developed deciduous teeth were included in this category.

For N1 adults, individual counts of observed teeth were compared to expected counts for individuals buried with all of their teeth. Adult expected tooth counts incorporated known frequencies of antemortem tooth loss (AMTL) in order to compensate for teeth lost before burial. To estimate the frequency of AMTL, all mandibles and maxillae containing alveolar sockets were examined for resorption. Alveolar sockets were counted as "observable" if the bone containing the socket itself was observable, even if the socket was resorbed. For example, a complete adult mandible with all teeth erupted but two sockets resorbed would be scored as having sixteen observable sockets and two resorbed sockets. For the N1 adult sample, 312 alveolar sockets were observable, and 27 (9%) were resorbed. Expected counts for adult teeth were produced by multiplying the adult MNI by 32 –the number of permanent teeth for an individual with all three molars erupted[30]. The expected tooth count for N1 was then reduced by 9% to account for AMTL.

[30] Human third molars are occasionally agenetic (Lavelle, Ashton and and Flinn 1970), which means that adult individuals can have between 28 and 32 teeth. Future research will calculate the frequency of third molar agenesis within the Marroquíes Bajos tooth populations by comparing dental eruption to age-estimates based on dental attrition, in order to further refine expected counts for adult teeth.

Subadult individuals have a mixed dentition that includes deciduous teeth, developing permanent teeth, and permanent teeth with apex complete. The proportions of this mixed teeth change as an individuals ages. For example, a 2-year old child will have only deciduous teeth and the tiny calcified cusps of the first molars, a seven-year old child will have a mixture of deciduous and developing permanent teeth, and a 12-year-old juvenile will have a mixture of developing permanent teeth and apex complete permanent teeth. As a result, estimating the number of teeth expected for subadults is a complex endeavor, because estimates of the number and level of development of teeth must be tailored to the estimated age of each individual. Calculating expected counts of subadult teeth was a five-step process (Table 7.8).

Table 7.8 Calculating expected counts for subadult teeth from Necropolis 1 and 2

Description
1. **Subadult age estimates were derived from all available skeletal indicators**. These included epiphyseal fusion, element size, and dental development and eruption.
2. **The midpoint of the age range estimate was identified for each subadult individual**.
3. **The midpoint age was matched to the corresponding age in the London Atlas documenting the sequence of formation and eruption of teeth** (AlQahtani 2009, AlQahtani et al. 2010). If the midpoint age estimate for a subadult individual was an exact year (e.g. 9 years), it was rounded up to the AlQahtani age category that included it (e.g. 9.5 years).
4. **Using the median tooth formation stage from the London Atlas, the number of teeth that had reached at least the level of initial root formation (R_i), but were younger than the level of apex complete (Ac) was calculated for each age category**. The developmental level of initial root formation was used as a benchmark to determine expected tooth counts because this was the youngest level of development for which a loose tooth was recovered at N2 and N4. Younger, developing teeth that were still in crypts could be concealed by alveolar bone in relatively complete mandibles and maxillae, and could be more easily lost from fragmentary mandibles and maxillae, leading to lower recovery rates. So as to avoid artificially inflating requirements for subadult dental completion, only teeth that had reached at least the level of initial root formation were used when calculating expected subadult tooth counts. Similarly, because all permanent loose teeth at N2 and N4 that had achieved the stage apex complete were considered adult, expected counts excluded permanent teeth once they reached this stage.
5. **After expected and observed counts were calculated for each individual, the number of expected teeth for each necropolis was compared to the number of observed teeth for each necropolis**.

The resulting expected counts are estimates that are subject to error due to inter-individual variation in dental development and eruption schedules. However, these counts still provide a useful way of measuring completion that takes into account the impact of dental development on estimates of skeletal preservation. For example, N1.CE14.12 from was estimated to be between 5.5-6.5 years old using maximum diaphyseal lengths for the long bones and level of dental development. The London Atlas indicates that an individual in age category 6.5 is expected to have all of their deciduous teeth except the lower i1erupted with root apices complete (eighteen deciduous teeth total), and sixteen developing permanent teeth above the level of Ri (I^1, I^2, C^1, M^1, I_1, I_2, C_1, and M_1), producing an expected count of 34 teeth. 14.12 preserved 5 deciduous teeth and 8 developing permanent teeth. Accordingly, this individual preserved 28% of expected deciduous teeth, and 50% of the developing permanent teeth, or 38% of the total expected teeth.

Because of inter-individual variability in rates of dental attrition, it is difficult to confidently associate permanent loose teeth with subadult individuals. Accordingly, only deciduous and developing permanent expected counts were used when examining dental preservation for subadults. Two subadult individuals at N1, Individual 15 from Structure 14 (16 to 19 years of age) and Individual 31.1 from Structure 13 (14-16.5 years of age) were old enough to expect that all deciduous teeth had been replaced. Because of the difficulties in assigning permanent teeth to the subadult category at N2, the observed and expected tooth counts for these two individuals were removed from this analysis. All deciduous and developing permanent teeth, regardless of their level of development, were then included in the analysis of N1 and N2 subadults.

For clarification, the expected counts listed here do not match the expected counts described in the section "Comparisons: Mortuary Treatment at Necropolis 1, 2, and 4," that were developed to compare differences in dental completion between the three mortuary areas. The expected counts described in the latter section were developed using a structure dental MNI for adults and subadults, and the adult expected counts factored in overall rates of alveolar resorption by tooth from N1, N2 and N4, rather than the total rate of resorption from a single mortuary area.

Dental Completion for Necropolis 1

Teeth from Necropolis 1 was well preserved, with 435 teeth associated with adult individuals, and 132 teeth associated with subadult individuals. For this context, an additional 51 permanent teeth were recovered from remains bagged as "loose material," all of which were associated with Structures 13, 14, and 27. However, because the loose teeth from Structures 14 and 27 could potentially be associated with the individuals missing from the analysis of each necropolis (see previous section), 39 of these loose teeth were discounted in this analysis[31]. This brings the total tooth count for N1 to 435 teeth associated with adult individuals, 12 loose permanent teeth, and 133 teeth associated with subadult individuals.

The results of the N1 dental analysis showed that the necropolis preserved almost half of its expected adult and subadult teeth (Table 7.9). Lower preservation of subadult teeth, even in cases of primary burial is to be expected given the smaller size and greater delicacy of deciduous and developing permanent teeth. Overall, the primary burials showed higher levels of completion than the secondary burials. Factoring the N1 9% frequency of AMTL, primary adult burials preserved 70% (348/495) of their expected teeth, while secondary adult burials preserved only 18% (61/349). Primary adult burials showed higher levels of teeth articulated in mandibles and maxilla – 44% (154/348) of the teeth from primary burials was articulated, and only 16% (10/61) of the teeth from secondary burials were articulated. Similarly, primary subadult burials from N1 preserved 58% (76/130) of their expected deciduous, developing permanent and permanent teeth, while secondary subadult burials preserved only 29% (56/192). The degree of dental articulation was relatively low for all subadults, regardless of burial type – 28% (21/76) of teeth from primary subadult burials were found in articulation, and 27% (15/56) of teeth from secondary subadult burials were found in articulation.

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[31] The dental MNI produced by each sample of teeth is equal to or lower than the number of missing individuals in the structure. Because no individuals were missing from the analysis of Structure 13, the twelve additional loose teeth were added to the inventory of permanent teeth for this area. However, because the loose teeth present overlap with tooth categories that are missing in the individuals buried in Structure 13, these additional loose teeth do not increase the MNI for the structure. For example, although two left lower first premolars were recovered from the loose human remains associated with N1, six of the adult individuals from this structure were missing their left lower first premolars, so these "additional" premolars could be associated with any of those individuals. In this fashion, all of the additional loose teeth have the potential to be associated with existing individuals buried in Structure 13, so they do not increase the structure MNI.

Table 7.9 Dental completion values for adults and subadults from Necropolis 1

Sample	MNI	Expected no. teeth	Observed no. teeth	Observed / expected
Adults	31	902	447	0.50
Subadults	9*	280	120	0.43

*Subadult count for N1 does not include 14.15 and 14.31.1

At N1, when examining the preserved deciduous teeth for subadults accorded secondary burial versus subadults accorded primary burial, at first blush it appears that a greater number of deciduous teeth are actually preserved in the secondary burials. Twenty-seven deciduous teeth are preserved for the primary subadult burials (comprising 36% of the subadult dental MNE), while 26 deciduous teeth are preserved for the secondary subadult burials (comprising 46% of the secondary subadult dental MNE). However, each set of subadult burials has an individual who is too old to preserve any deciduous teeth – for the primary burials, this is 14.15 (a subadult with an estimated age of 16-19 years and 13 teeth preserved) and for the secondary burials this is 13.31 (an individual with an estimated age of 14-16.5 years and no teeth preserved). If these older individuals and their more developed permanent teeth are removed from consideration, then 42% (27/63) of the primary subadult dental MNE is deciduous, with an average of 9 deciduous teeth per individual; 46% of the secondary subadult dental MNE is deciduous, but there is only an average of 5 deciduous teeth per individual for this mortuary area. When individuals 14.15 and 13.31 are removed from the analysis of subadult teeth, the average midpoint age for the primary burials is 5.2 years, while the average midpoint age estimate for the secondary burials is 4.1 years. Accordingly, while we would thus expect *more* deciduous teeth for the slightly younger sample of secondary individuals, there are actually fewer deciduous teeth per individual in the subadult secondary mortuary sample.

The pattern of dental preservation produced by secondary burials is particularly distinguished by the absence of the anterior teeth, as the incisors are most susceptible to loss after the decay of the periodontal ligament (Haglund 1997). The preservation of incisors at N1 replicates the overall preservational patterns for teeth more generally. Focusing solely on the sample of N1 incisors that could be associated with interments identified as either primary or secondary burials (N = 106) reveals that three quarters of the incisors (80/106) can be associated with primary burials, while only one quarter of the incisors (26/106) came from secondary burial contexts. Of the subadult incisors from N1, 11 (55%) are from primary burials, and 9 (45%) are from secondary inhumations.

Mortuary Treatment at Necropolis 1

The results of the skeletal and dental completion analysis suggest that the initial qualitative assignations based on examining the maps are supported by the osteological analysis for N1. The 21 burials designated *primary* with reference to site maps were, on average, 41% complete, with an average of 21 teeth per individual. Seventeen adults and 4 subadults from N1 showed a primary burial signature. The 18 burials designated *secondary* were, on average, 16% complete, with an average of 7 teeth per individual. Twelve adult burials and 6 subadults from N1 showed a secondary burial signature. The process of secondary burial also seemed to lead to dental disarticulation; 41% of the teeth recovered from primary burials were still articulated in alveolar bone, while only 21% of the teeth recovered from secondary burials were articulated (Table 7.10). Subadult dental signatures tend to track the adult dental signatures from the same mortuary context – where completion is low for adults, it is also low for subadults, and vice versa.

Table 7.10 Quantitative differences between primary and secondary burials from Necropolis 1

Category	Primary		Secondary	
	Count			
No. individuals	21		18	
Average no. bones	78		16	
Total no. teeth for adults	348		61	
Total no. teeth for subadults	76		56	
Average no. teeth per subadult individual	19		9.3	
	%			
Average level of skeletal completion	41%		16%	
Minimum level of skeletal completion	10%		1%	
Maximum level of skeletal completion	74%		30%	
	Count	%	Count	%
Average no. teeth per adult individual	20.5	64%	5.1	16%
No. teeth in articulation for adults	154	44%	10	16%
No. teeth in articulation for subadults*	21	28%	15	27%

*Teeth that were still in their crypts (e.g. not yet erupted) were not included in this count.

Pathology and Dental Pathology at Necropolis 1

Levels of skeletal pathology were very low at Necropolis 1, particularly when treated as a percentage of the total number of adult and subadult bones from this mortuary area (N = 1998), or as a percentage of adult MNI affected (N = 31) (Table 7.11). Osteoarthritis, the most frequently observable skeletal pathology, is related to wear and tear on bones that increases with age, so it was unsurprising that all individuals affected with this pathology were adults. Far higher levels of osteoarthritis and fractures are common in prehistoric agricultural populations, and the counts here may underestimate the actual occurrence of the pathologies due to the fragmentary nature of the human remains. Sacralization of L5 is a congenital anomaly, rather than true pathology, and abnormal bone formation, abnormal bone loss and vertebral pathology all occur at such low frequencies that it is impossible to make statistical comparisons between structures.

Table 7.11 Number of bones affected by pathology at Necropolis1

Structure	OA	ABF	ABL	VP	Fractures	Sacralization of L5
13	12	4	6	3	1	0
14	7	2	0	2	2	2
22	0	0	0	0	0	0
27	0	0	0	0	0	0
No˚ bones	19	6	6	5	3	2
% bones affected	10	3	3	3	2	1
% adult individuals affected	15	13	10	6	6	3

OA = osteoarthritis, ABF = abnormal bone formation, ABL = Abnormal Bone Loss, VP = vertebral pathology

Frequencies of dental pathologies were scored out of all observable teeth for adult teeth, and out of erupted and observable teeth for subadult teeth. Unsurprisingly, dental pathologies were more frequent in adult teeth than in subadult teeth (Table 7.12). The most frequently documented insult was dental calculus, which affected 165/560 total observable teeth (29%). The most common score for calculus was 1 (N = 125), followed by 2 (N = 34), and 3 (N = 6). Percentages for calculus were calculated by dividing number of teeth affected by total tooth counts, as calculus could be scored regardless of the visibility of tooth enamel. Observable tooth counts for subadults included all erupted teeth, minus two teeth that were not possible to score for caries or calculus.

For caries, frequencies were calculated by dividing the number of teeth affected by the number of teeth for which caries were observable for adult teeth, and by the number of erupted teeth for which caries were observable for subadult teeth. For hypoplasias, frequency was calculated by dividing the number of teeth affected by the number of teeth with observable enamel (see Chapter 5). Overall, 49 caries affected a total of 47 teeth from N1, as one tooth had three caries. This produced an overall frequency of 47/559 observable teeth (8%). Caries at N1 affected a higher frequency of adult teeth than subadult teeth, and a higher frequency of teeth from secondary burials than teeth from primary burials. Hypoplasias were relatively rare, affecting only 17/425 observable teeth (4%). The most commonly affected tooth type was the left lower permanent canine –4/10 (40%) were affected by hypoplasias. Less common dental pathologies observed in the N1 sample included two abscesses on an adult maxilla (primary burial N1.CE13.26), and two hypocalcifications on two secondary subadult upper premolars (N1.CE14.21.2).

Table 7.12 Dental pathology from Necropolis 1 (C = count, F = frequency)

Pathology	Observation	Adults		Subadults		Primary		Secondary	
		C	F	C	F	C	F	C	F
Calculus	Teeth Affected	155	0.32	10	0.14	127	0.32	17	0.20
	Total Teeth	486		74		392		85	
Caries	Teeth Affected	45	0.08*	4	0.05	28	0.07*	13	0.15
	Teeth Caries Observable	485		74		393		89	
Hypoplasias	Teeth Affected	13	0.04	4	0.04	9	0.03	3	0.05
	Teeth with Observable Enamel	326		99		277		64	

*Though there were 45 adult caries, only 43/485 adult teeth were affected, and though there were 28 primary caries, only 26/393 teeth were affected.

Rates of antemortem tooth loss at N1 were highest for LlM3 (4/14 –29%), LuM2 (2/7 –29%) LlP4 (2/12 –17 %), and RlP4 (2/14 –14%). In total, 27/312 observable sockets were resorbed (9%).

Necropolis 2

Necropolis 2 (N2) is a Copper Age necropolis located inside the fifth concentric ditch of the settlement (see Chapter 4 for further details). Salvage excavations in 2006 revealed five discrete mortuary structures, and one cranium that was excavated out of a wall-cut transecting the settlement's fifth ditch. Descriptions in site reports, photographs of the excavation contexts, and the condition of the remains themselves indicate that these inhumations were extremely fragmentary and commingled *in situ*. Because it was impossible for excavators to identify discrete individuals in the field (given the fragile condition of the remains), all osteological materials within a given structure were stored together in museum collections. Each mortuary structure was treated as a baseline unit of analysis.

Minimum Number of Individuals for Necropolis 2

For N2, MNI estimates were made for each individual structure as this increased the resolution with which it was possible to examine Minimum Number of Elements (MNE) estimates. As is customary practice in bioarchaeological analysis, the element with the greatest MNE in a given structure was used to produce the MNI estimate for that structure.

For three excavation contexts (Structure 41, Structure 45 and Unit 47), osteological preservation was so poor that the highest MNE estimates could only be derived from permanent upper or lower molars (Table 7.13). For the remaining excavation contexts, adult MNI was calculated with reference to the number of humeri present.

The subadult MNI for N2 was calculated by first carefully examining any bones that were clearly subadult based on size or appearance. Age ranges for these individuals were then estimated based on epiphyseal fusion and/or overall element size. Subadult data were then compared to the elements that produced the structure MNE to ensure there was no overlap between the adult MNI and the subadult MNI (specifically to ensure that none of the permanent molars or humeri used to estimate age could belong to subadults of those age ranges).

Table 7.13 Calculation of MNI for Necropolis 2 by structure

Age Category	Structure					
	39	41	43	44	45	47
Subadult	0	1	2	3	2	0
Adult	3	5	4	7	5	1
Adult MNI components	Humeral shafts	I^1	Distal humeri	Humeri and femora	M_2s and dental analysis	Right M^3 ($A_{1/2}$)
Total Adults	25					
Total Subadults	8					
Total Population	32					

Assessment of Sex for Necropolis 2

Human skeletal remains from N2 were more fragmentary than those from N1. As a result, sex could only be estimated for 3/25 (12%) adult individuals (Table 7.14, Figure 7.8). Because the sample size of individuals for which sex could be estimated was so small, no patterning was apparent relative to structure (Table 7.15).

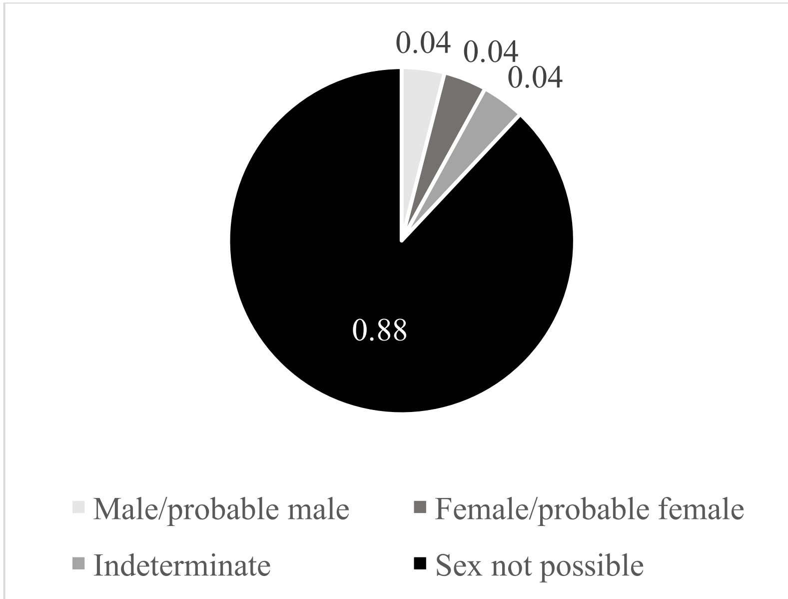
Table 7.14 Estimates of sex for adults from Necropolis 2 (non-metric features)*

Element ID	Estimate of sex	Basis	Confidence
N2.CE47.01 - .02	Probable Female	Nuchal crest (left and right)	Medium - Low
N2.CE43.0048*	Probable Male	Mastoid process	Low
N2.CE43.0056*	Indeterminate	Mental eminence	Low
N2.CE43.0070*	Probable Female	GSN	Low

Table 7.15 Estimation of sex by structure for adults from Necropolis 2

Structure	Male/ probable male	Female/ probable female	Indeterminate	Sex not possible	Total
39	0	0	0	3	3
41	0	0	0	5	5
43	1	1	1	1	4
44	0	0	0	7	7
45	0	0	0	5	5
Unit47	0	**1**	0	0	1
N2 Total	1	2	1	21	25
N2 %	4	8	4	84	100

Figure 7.8 Estimates of sex for Necropolis 2 based on non-metric traits (% adult sample)



Age Estimates for Subadults from Necropolis 2

As at N1, age estimates for adults and subadults were assessed separately for N2. Subadult age estimates were calculated relative to structure provenience, using data drawn from dental development, element size, and patterns of epiphyseal fusion. Detailed descriptions of the age estimates for subadult individuals can be found in Appendix C (Estimates of Age for Necropolis 2 Subadults), as well as the chart below. Categorical age ranges explicitly defined to be comparable to the Cámara Serrano et al. 2012 analysis of N3, and subadult individuals were sorted into age categories based on midpoint age range (Table 7.16).

Table 7.16 Estimates of age for subadults from Necropolis 2 *

Structure	ID	Age range (yrs)	Midpoint (yr)	Bone weight (gr)	Elements represented
41	N2.A	6.0-12	9.0	10.4	Radius 41.14 , tooth 41.43
43	N2.B	8-16.5	12.3	16.3	Proximal manual phalanx 43.043, MT2 43.044, proximal fibular surface 44.0125, scapula 43.0063, lumbar vertebra 43.0142
	N2.C	5.5-8	6.8	50.6	Ischium 43.0074, pubis 43.0075, ilium 43.0076, humerus 43.0082, humerus 43.0083
44	N2.D1	8-14	10	11.9	Distal ulna 44.0222, radius 44.0227, radius 44.0227, distal femoral condyle 44.0191, RuI1 44.01,LuP3 44.02, LlP3 44.35, LlM3 44.44
	N2.D2	15-18	16.5	16.5	LuM2 44.2, LlM3 44.44
	N2.E	1.5-3.5	2.5	17.6	Humerus 44.0157, humerus 44.0159
45	N2. G	11-15	13	NP	LlP3 45.28, LlP4 45.31, RlC1 45.33, LlM3 45.45
	N2. H	9-10	9.5	NP	LlM145.37, RlM1 45.43

*In Beck 2015, an eighth subadult (N2.F) is reported as being 12-21 years of age, with a midpoint of 16.5 years. When the teeth from N2 were re-aged using the London Atlas (AlQahtani 2009), this individual (represented by left and right lower third molars 45.16 and 45.44 at stage Root Complete) was found to be 19-20 years of age (min 17, max 22.5). This more precise age estimate based on the London Atlas gave this individual a midpoint age of 19.5, moving it out of the subadult age category. However, because there were five adults from Structure 45 represented by LlM2s, and these paired third molars could be associated with any of them, the subadult MNI dropped by 1 individual, but the adult MNI did not increase at all. Other subadult estimates of age have shifted slightly from those described in Beck 2015 as a result of the subsequent adoption of the more precise AlQahtani et al. (2010) method.

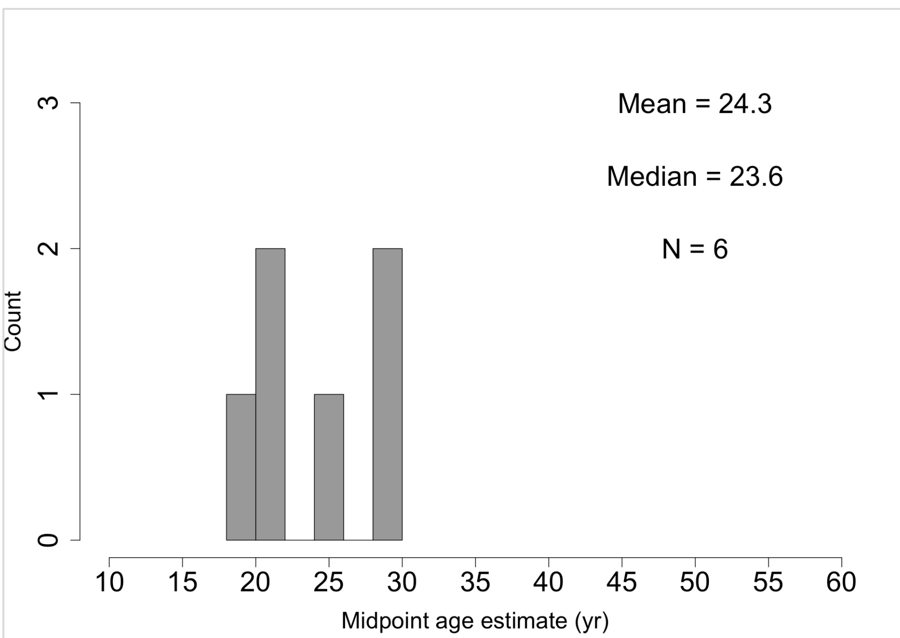
Age Estimates for Adults from Necropolis 2

Adult age estimates were calculated using the Gilmore and Grote (2012) method for estimating age based on lower left and right molar wear (as detailed in Chapter 6), or the development of the third molars (Table 7.17). Right lower first molars were sampled for analyses of wear in order to ensure that no individuals were double-counted. The first molar was selected because the age of first molar eruption is more tightly constrained than the age of second or third molar eruption. Using these strategies, age could be estimated for 6 individuals (25% of the adult sample) (Figure 7.9). The individual from Unit 47 was most easily aged with reference to the development of the upper third molar, and the developmental stage of another set of lower third molars was used to estimate the age of one individual from Structure 45.

Table 7.17 Age Estimates for Necropolis 2 Adults

Structure	ID	Midpoint age (yr)	Age category	Source
44	T.44017.11	18.9	Very young adult	Molar wear model
45	T.45.16 + T.45.44	21.5	Young adult	LlM3 development (Rc)
Unit47	T.47.02 +T47.03	22	Young adult	RuM3 development (A1/2)
41	T.41.12	25.3	Young adult	Molar wear model
41	T.41.10	29.1	Young adult	Molar wear model
41	T.41.11	29.1	Young adult	Molar wear model

Figure 7.9 Distribution of ages for adults from Necropolis 2



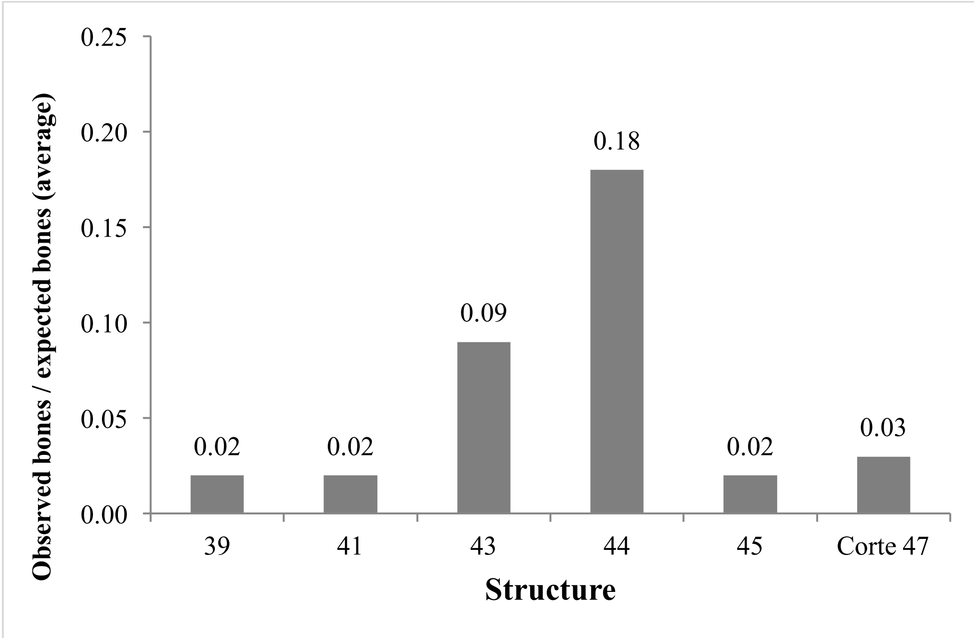
Skeletal Completion for Necropolis 2

All mortuary structures at N2 showed low levels of skeleton completion (Figure 7.10). Due to the commingling of N2 remains in prehistory and during museum storage, % expected MNE values had to be calculated with reference to structure MNIs, rather than by individual. For example, since the MNI estimate for Structure 39 was 3 individuals, the expected number of bones was calculated by multiplying 192 (the number of bones expected in a single individual) by three. Since only 9/576 bones were recovered from this structure, it contained only 20% of its expected element count. The structure that came closest to achieving expected MNE was Structure 44 (16% expected MNE); however, the values for Structure 44 still fell short of the primary burial average from N1 of 41%. Instead, the average % expected MNE value of 8% fell below even the secondary burials from N1, which average 16% of their expected MNE (Table 7.18).

Table 7.18 Quantitative summaries of Necropolis 2 adults and subadults

Category	Adults		Subadults		Total	
	Count					
No. individuals	25		8		32	
Average no. bones	18.4		2.3		14.5	
Average no. teeth per individual	7.3		1.5		6.2	
Total no. of teeth	191		12		203	
	%					
Average level of completion	10 %		1 %		8 %	
	Count	%	Count	%	Count	%
No. teeth in articulation	36	18%	0	0%	36	18%

Figure 7.10 Average anatomical completion by structure for Necropolis 2



Dental Completion for Necropolis 2

The teeth for N2 display a pattern that echoes the secondary burials from N1. Dental preservation was markedly poorer at N2 than at N1, with only 186 permanent teeth, 16 developing permanent teeth, and 1 deciduous tooth preserved for the entire necropolis. Expected counts for permanent teeth were calculated by factoring in antemortem tooth loss using the same process as at N1. N2 alveolar bone preserved 89 observable sockets 12 (13%) of which were resorbed. The expected count for N2 permanent teeth was thus reduced by 13%.

Nearly all permanent teeth for N2 were loose, so it was not possible to confidently associate permanent teeth with either adult or subadult individuals. However, preliminary analyses of attrition suggest that most permanent teeth from this necropolis were more heavily worn than developing permanent teeth (Table 7.19). Using the modified Smith and Scott systems outlined in Buikstra and Ubelaker (1994:52–53), the average wear score for all observable permanent teeth was 3.3 for non-molars (N = 102) and 3.4 for molar cusps (N = 73). In contrast, the average wear score for developing permanent non-molars was 1.3 (N = 7), and for developing permanent molars was 2.0 (N = 8). Variance in wear for the developing permanent sample was 1.108; variance in wear for the permanent sample was 2.736. Because sample parameters were unequal, a non-parametric Wilcoxon Rank Sum test was used to test for differences in sample means for each entire sample (non-molars and molars). The results (W=526, p-value = 0.0001168) showed significant differences between the wear scores of each sample. These results provide evidence that makes it possible to suggest that the majority of the permanent teeth from N2 are from older individuals who experienced dental attrition. As such, all permanent teeth from N2 were counted as adult teeth. Four developing permanent second and third molars were also counted as adult teeth as their estimated ages were ≥ 18 years.

Table 7.19 Summary statistics for wear scores from permanent and developing permanent teeth from Necropolis 2

Group	Variance	Mean	Mode	Minimum	Maximum
N2 Permanent	2.736	1.68	1	1	4.5
N2 Developing Permanent	1.108	3.33	1	1	8.5

N2 burials showed lower levels of dental preservation than N1 (Table 7.20), with less than one third of the expected teeth observed for either adults or subadults. These values fall in line with N1 secondary burial completion values.

Table 7.20 Adult and subadult dental completion values from Necropolis 2

Sample	MNI	Expected teeth	Observed teeth	Observed / expected
Adults	25	696	191	0.27
Subadults	8	208	12*	0.06

*Note: In Beck 2015, 17 subadult teeth are listed for N2. However, the use of AlQahtani et al. (2010) age estimates moved five of these teeth (45.16, 45.44, 47.02, 47.03 and 44017.01, all second and third molars) into the ≥ 18 year age category. The subadult tooth counts for N2 have been adjusted to reflect this change, and all of these teeth have been added to the N2 adult observed teeth.

Lower levels of completion are particularly apparent for the incisors. While the mortuary sample at N2 represents almost 80% of the mortuary sample at N1 (32 individuals at N2 relative to 42 individuals at N1), the teeth from N2 preserves only 31% of the incisors represented at N1 (37 incisors at N2 relative to 118 incisors at N1). This pattern persists when the sample of *only* developing permanent and deciduous subadult incisors is examined. The mortuary sample of subadults at N2 represents 73% of the mortuary sample of subadults at N1 (8 subadults at N2 versus 11 subadults at N1), but the subadult teeth from N2 preserves only 5% of the incisors represented at N1 (1 subadult incisor at N2 versus 20 subadult incisors at N1). This sample is too small to subject to chi-square analysis, but patterning is clear across both necropolises – regardless of age, the mortuary population at N1 preserved a far greater proportion of its incisors relative to MNI than does N2, particularly the primary burials from N1.

Mortuary Treatment at Necropolis 2

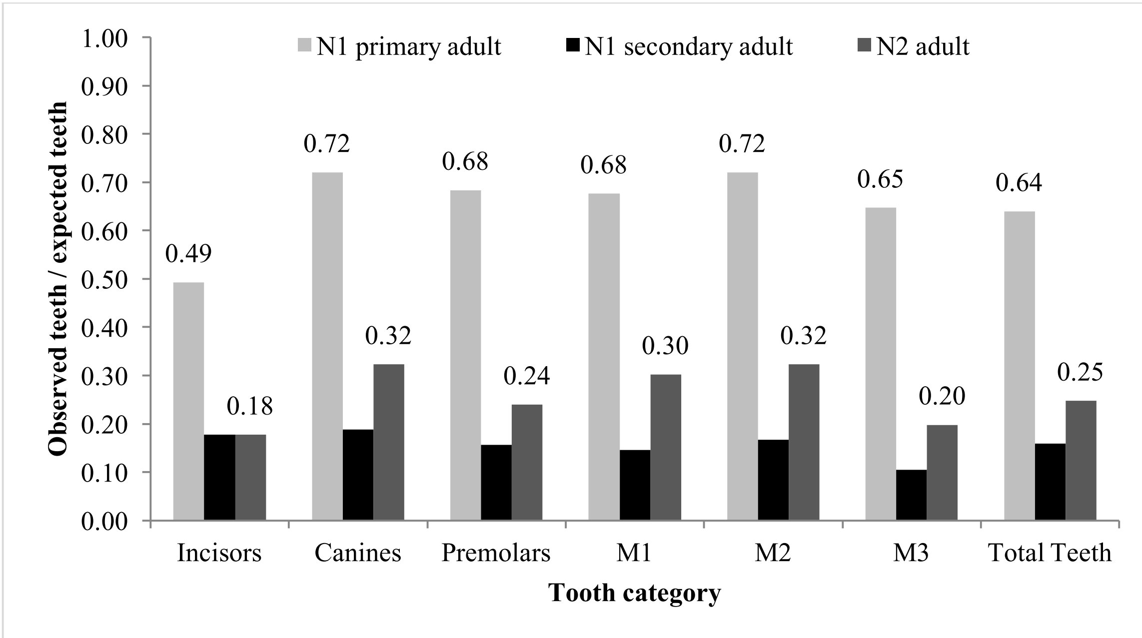
All burials from N2 show relatively low levels of dental and skeletal completion, making it likely that this mortuary area contained predominantly secondary burials. At N2, the structure that came closest to achieving its expected MNE (Structure 44, with 16% of its expected MNE) fell short of the primary burial average of 41% completion from N1. All other structures at N2 show only 2% levels of skeletal completion, and the teeth from N2 also displays a secondary pattern, with particularly low levels of incisors represented. In order to establish whether the N2 dental signature fell closer to the N1 primary burial signature or N1 secondary burial signature, expected tooth counts were calculated relative to the adult skeletal MNI for each mortuary area (N1 primary = 17, N1 secondary = 12, N2 = 24, subtracting the Unit 47 cranium because a portion of the associated teeth were not yet apex complete).

For every tooth category, N2 observed values fall closer to observed values for N1 secondary burials than to N1 primary burials (Figure 7.11). On the whole, the N2 signature is comparable to the N1 secondary burial signature (Table 7.21) with low levels of completion, lower numbers of teeth per burial, and few teeth found in articulation.

Table 7.21 Quantitative differences between secondary adult burials from Necropolis 1 and Necropolis 2

Category	N2		N1	
	Count			
No. individuals	33		18	
Average no. bones	14.5		16	
Average no. teeth per individual	6.2		5.1	
	%			
Average level of completion	8		16	
	Count	%	Count	%
No. teeth in articulation	36	17	10	16

Figure 7.11 % expected teeth for primary and secondary burials from Necropolis 1 and 2



Pathology and Dental Pathology at Necropolis 2

Levels of skeletal pathology were also very low at N2, particularly when treated as a percentage of the total number of adult and subadult bones from this mortuary area (N = 478) (Table 7.22). Pathologies are not listed as percentage of adult MNI affected since the remains at N2 were so commingled in both their archaeological and museum contexts that it was not possible to ascertain whether the bones affected by insults came from a single individual or from multiple individuals. The most frequently occurring insult is osteoarthritis, which affected only 2% of the bones in the N2 sample.

Table 7.22 Number of bones affected by pathology at Necropolis 2

Structure	OA	ABF	ABL	VP	Fractures	Sacralization of L5
39	0	0	0	0	0	0
41	0	0	0	0	0	0
43	2	0	0	0	0	0
44	9	0	0	0	1	0
45	0	0	0	0	0	0
Unit47	0	0	0	0	0	0
No. bones affected	11	0	0	0	1	0
% bones affected	0.023	0.000	0.000	0.000	0.002	0.000

Dental pathologies at N2 were more frequent in adults than in subadults, though at this mortuary area this is likely related to the much smaller sample of erupted and observable subadult teeth (10 erupted subadult teeth at N2, relative to erupted subadult 74 teeth at N1) (Table 7.23). The most frequently documented insult was dental calculus, which affected 44/201 (22%) total observable teeth. None of the 10 erupted subadult teeth showed calculus. Calculus frequency was scored by dividing the number of affected teeth/number of total teeth observable for calculus. Frequencies of caries and hypoplasias were calculated according to the guidelines outlined in Chapter 7.

The most common score for calculus was 1 (N = 32), followed by 2 (N = 11), and 3 (N = 1). All 20 caries were from adults, found on 18/201 observable teeth (9%). Hypoplasias were more frequent at N2 than at any other mortuary area, affecting 1 subadult and 15 adult teeth, or 16/114 enamel observable teeth (14%). The most commonly affected tooth type was the left lower permanent canine – 3/5 (60%) were affected by hypoplasias. Less common dental pathologies observed in the N2 sample included 1 mandibular abscess and one lower supernumerary tooth from Structure 44. Two right and left upper central incisors from Structure 45 showed shoveling.

Table 7.23 Dental pathology at Necropolis 2

Pathology	Observation	Adults		Subadult	
		Count	Frequency	Count	Frequency
Calculus	Teeth Affected	44	0.23	0	0.00
	Total Teeth	191		10	
Caries	Teeth Affected	20	0.09*	0	0.00
	Teeth Caries Observable	191		10	
Hypoplasias	Teeth Affected	15	0.14	1	0.11
	Teeth with Observable Enamel	105		9	

*The N2 adult teeth have 20 caries total, but only 18 teeth are affected. At N2, rates of AMTL were highest for the LlM3 (2/3 – 67%), LlM1 (2/3 – 67%), LlM2 (2/5 – 40%), and LlP4 (33%). AMTL frequencies at N2 appear elevated relative to N1 and N4 because so little alveolar bone was preserved for this mortuary area. In total, 12/81 (15%) observable sockets were resorbed.

Comparisons: Mortuary Treatment at Necropolis 1, 2, and 4

The complete bioarchaeological analyses conducted for N1 and N2, combined with the carefully drawn maps and photos of the initial condition of these mortuary areas, made it possible to establish the nature of the mortuary treatment used in each area (i.e. primary burial vs. secondary burial). After identifying primary and secondary burials, differences in the pattern of dental preservation between the two types of mortuary treatment were explored using the dental data from N1 and N2. This provided a set of comparative signatures that could be used to examine the dental signature from N4, where preservation in dental patterning is the only possible window into mortuary treatment in the caves. Only dental MNI estimates could be calculated for N4, so in order to make the N1 and N4 data sets explicitly comparable, dental MNI estimates, rather than skeletal MNI estimates, were used to produce expected counts of teeth.

To compare how many of the expected teeth were observed for N1, N2 and N4, an adult dental MNI was calculated for all mortuary areas using all observed adult teeth, factoring in the AMTL frequency. Here, data on all resorbed sockets for N1, N2, and N4 were combined to produce an expected amount of resorption by individual tooth category. The percentage of teeth which were resorbed for a given tooth category was then subtracted from the expected counts produced using the dental MNI for the mortuary area. This strategy is different from the strategy initially used to calculate expected tooth counts for N1 and N2 (see section "Calculating Expected Tooth Counts for Necropolis 1 and 2”), as previously the overall frequency of resorption was calculated from N1 or N2, and subtracted from the overall expected count for all teeth.

At N1 and N2, the dental MNI was calculated by structure, using the most commonly represented tooth to estimate the MNI. The dental MNI estimates calculated for N1 and N2 always fell short of skeletal MNI estimates (Table 7.24). However, the dental MNI estimate for N4 also likely underestimates the skeletal MNI, and there is currently no means of comparing a dental and skeletal signature for this area. As a result, the use of the dental MNI at N1 and N2 provides a commensurate signature that can be used to establish the nature of patterning in primary versus secondary burials.

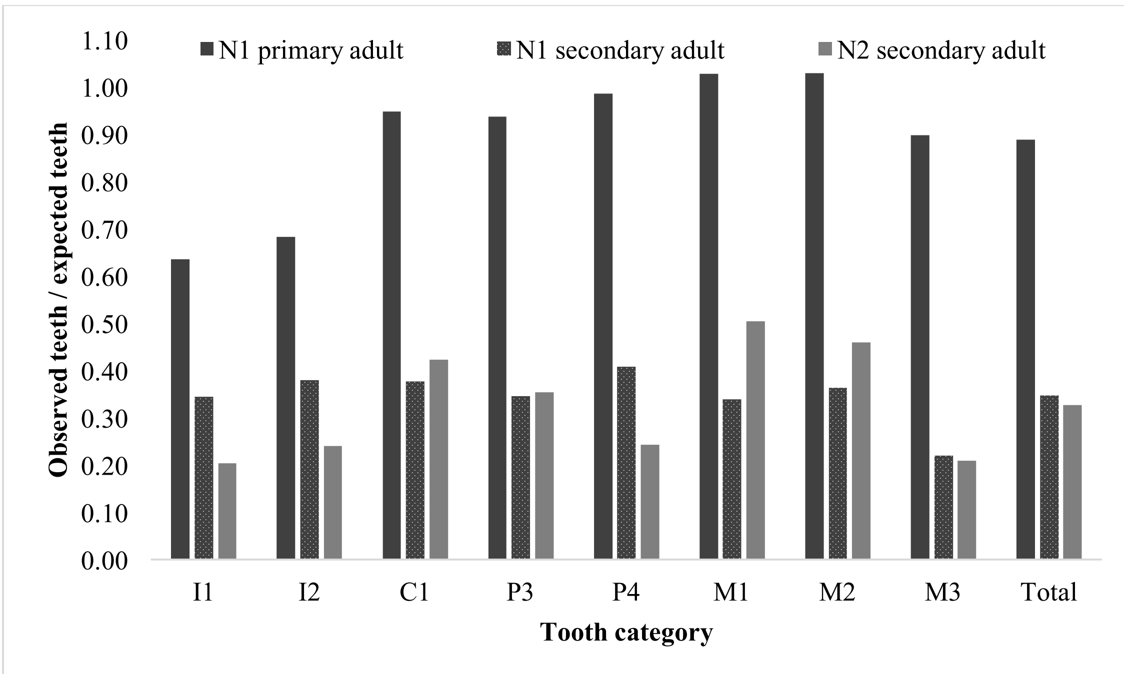
Subadult expected tooth counts were calculated using the London Atlas (AlQahtani 2009). A separate expected tooth count was calculated for each one-year category. Deciduous teeth were included as expected counts in a given age category once they reached stage Ri (as this was the youngest developmental stage for which deciduous teeth were recovered at N4). Developing permanent teeth were included in the age category once the median stage of Cr3/4 was achieved – this stage was selected as a developmental baseline because it comprises the largest proportion of developing permanent teeth at a younger level than Ri for N4, so it is clear that developing crowns of this size are archaeologically recoverable. Once developing permanent teeth reached the developmental stage of apex complete they were excluded from the age category count, as all loose permanent teeth at level Ac were treated as adult analyses of loose teeth.

Table 7.24 Dental and skeletal MNI for Necropolis 1, 2, and 4 adults

Mortuary area	Skeletal MNI	Dental MNI	Dental MNI basis	Skeletal MNI / dental MNI
N1 Primary	17	14	RlM3,RuM3, RuC1	0.82
N1 Secondary	12	6	RlM3,RuM3, RuC1	0.50
N1 Total	31	20	RlM3,RuM3, RuC1	0.65
N2	25	19	RuC1,RuI1, LlM2	0.76
N4	NP	145	RuC1	NP

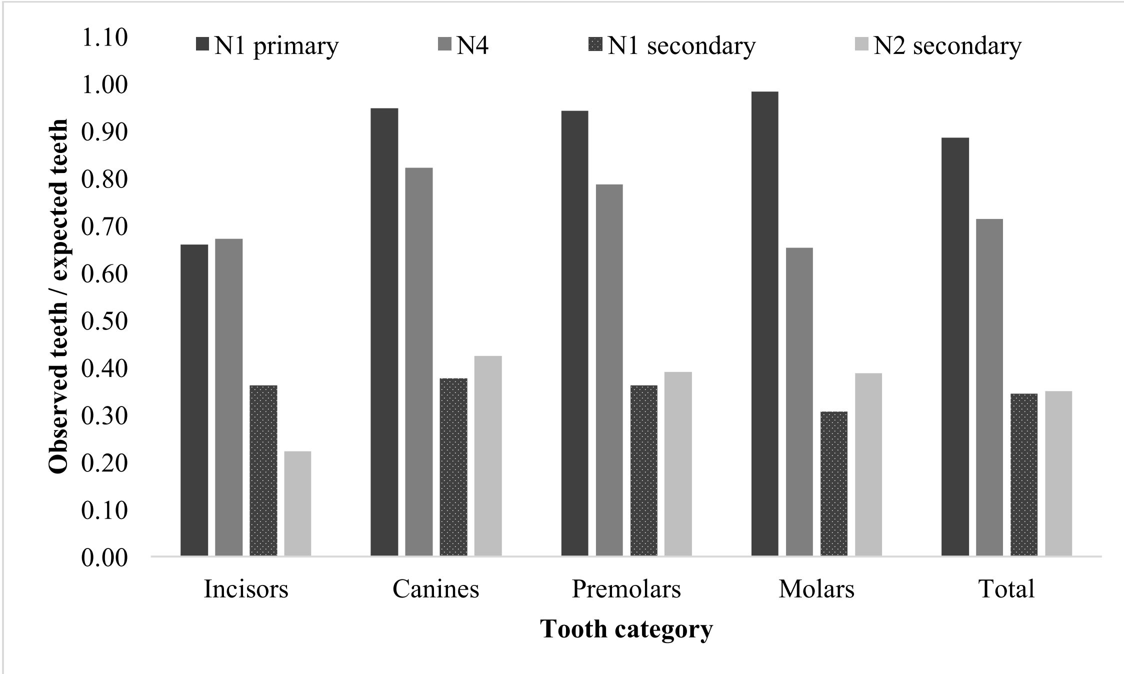
Adult primary burials at N1 showed a far higher % of expected values (89%) compared to either adult secondary burials from N1 (35%), or adult secondary burials from N2 (33%) (Figure 7.9). All broad tooth categories (combined upper and lower) for secondary burials showed values of ≤ 50% expected, with permanent central incisors the most poorly represented tooth for all known burial types (64% for N1 primary, 34% for N1 secondary, and 20% for N2 secondary). The best represented tooth category was the first molar for all N1 primary burials (103%) and N2 secondary burials (50%), and the fourth premolar for N1 secondary burials (41%) (Figure 7.12).

Figure 7.12 Dental completion by tooth category for Necropolis 1 and 2



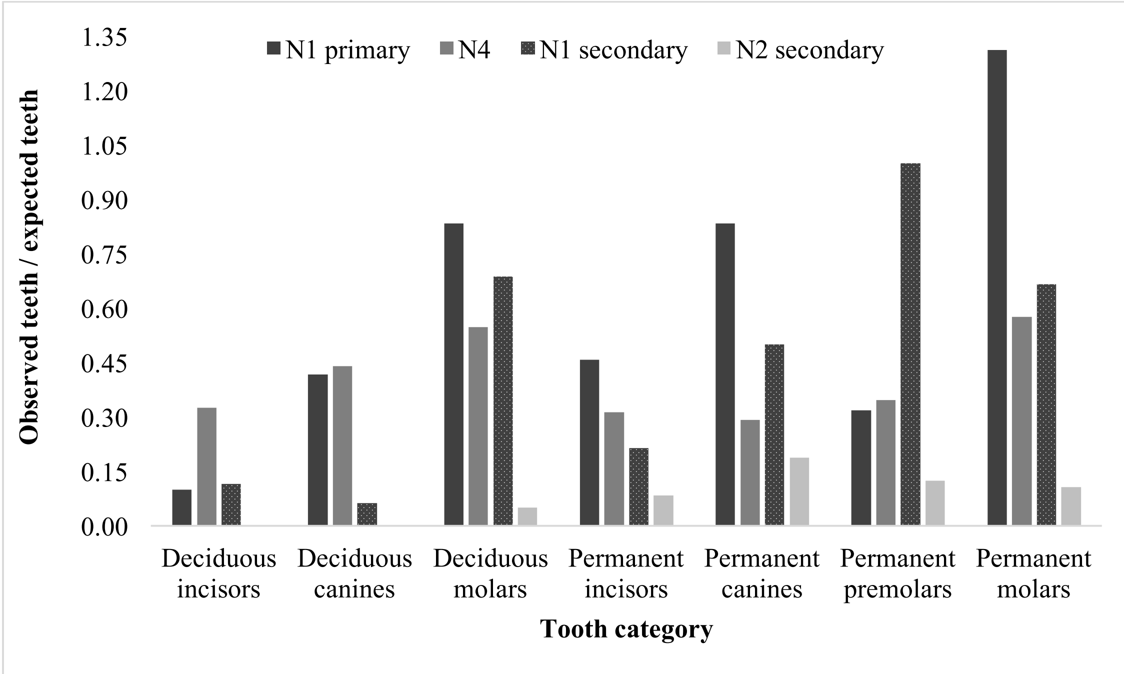
For all broad tooth categories listed in Figure 7.12, and for all collapsed tooth categories (incisors, canines, premolars and molars), the N4 % expected values fell either above primary values (I1) or between primary and secondary values (I2-M3) (Figure 7.13). For individual broad tooth categories, the N4 expected values were closer to the N1 expected values for all of the mesial teeth (I1, I2, C1, P3 and M1), and closer to the secondary signature for most of the distal teeth (P4, M2 and M3).

Figure 7.13 Dental completion for Necropolis 4



The results produced by comparing observed and expected subadult tooth counts are less clear, in part because of the limitations related to calculating subadult expected tooth counts (Figure 7.14). Expected counts for subadult teeth were calculated using the London Atlas (AlQahtani 2009; AlQahtani et al. 2010), and included all of the developing deciduous, deciduous, and developing permanent teeth that would be present at a given age stage. Because the analyses of loose teeth from N2 and N4 set the cut-off for inclusion in the adult category as apex complete for permanent teeth, any permanent teeth that were apex complete were not counted in a given age category, because the analyses of loose teeth treat these as adult teeth. However, articulated subadult teeth from N1 and N4 would necessarily preserve some of these apex complete permanent teeth in the alveolar bone. As a result, the current subadult expected tooth counts underestimate the number of expected teeth for articulated teeth, producing results like the 131% expected value for subadult permanent molars (Figure 7.14).

Figure 7.14 Expected vs. observed tooth counts for subadults



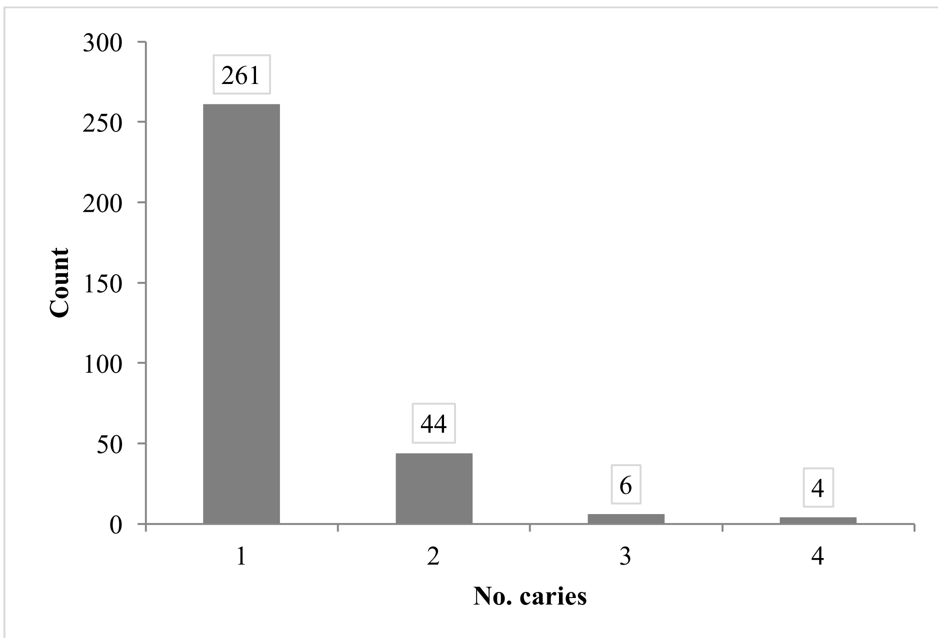
Future work is needed to develop and compare strategies that produce separate expected counts for articulated subadult and loose subadult teeth. To apply such a strategy here would require the calculation of separate loose and articulated subadult MNI estimates for N4, which would artificially inflate the subadult MNI for this mortuary area. For now, the adult observed and expected tooth counts provide the clearest signature of prehistoric mortuary treatment. Overall, the dental signature at N4 falls closer to the N1 primary burial signature, which suggests that the majority of interments at N4 were likely primary burials. However, because the N4 values are intermediate between the primary and secondary signatures, it is likely that a portion of individuals from this mortuary area were secondary burials.

Comparisons: Dental Pathology at N1, N2, and N4

Three types of dental pathology – caries, calculus, and hypoplasias – were preserved in high enough numbers that comparisons between all mortuary areas were possible. All three pathologies are affected by diet, and are informative about potential dietary differences between individuals and mortuary populations in prehistory. Because it was not possible to associate complete sets of teeth with specific individuals at N1 or N2, the analyses presented in this section refer to the frequency of insults relative to the total number of teeth, rather than the total number of individuals.

The frequency of caries was comparable in the three mortuary areas –47 teeth had caries at N1, 18 teeth had caries at N2, and 221 teeth had caries at N4. In total, 286 teeth had 315 caries. Ninety-one percent of affected teeth only had one caries, and 9% of affected teeth had more than one caries (Figure 7.15).

Figure 7.15 Number of caries per tooth for Necropolis 1, 2, and 4



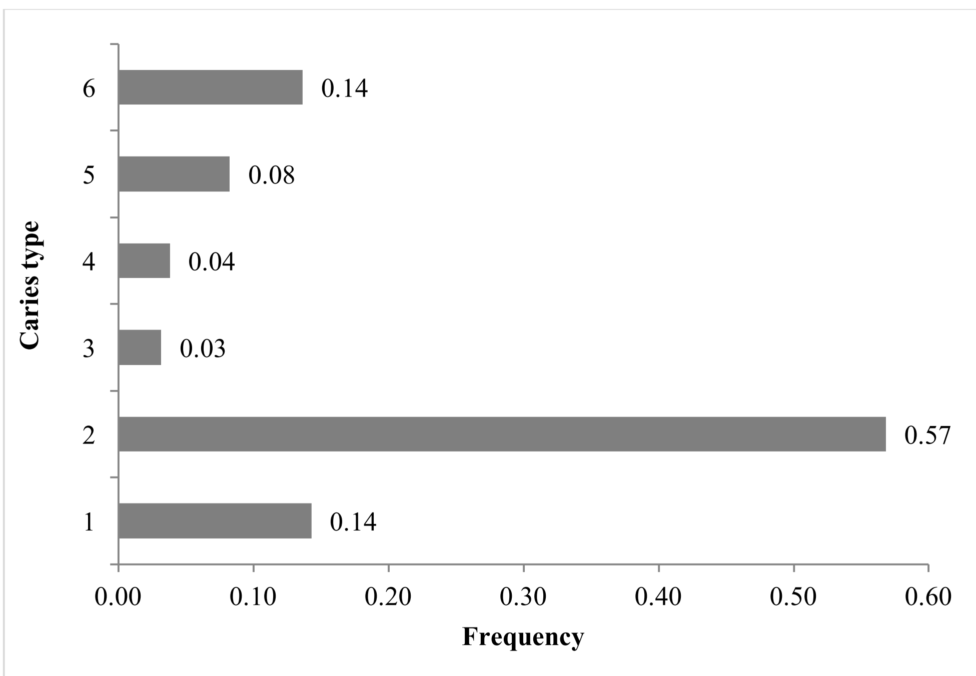
Chi-square tests showed no significant differences between the number of adult teeth affected by caries in each mortuary area ($\chi^2 = 3.7503$, df = 2, p-value = 0.1533), and Fisher's Exact tests showed no significant differences between the number of subadult teeth affected by caries at N1 vs. N2 (p = 1), N1 vs. N4 (p = 0.1169), or N2 vs. N4 (p = 1). Caries were scored according to the protocol outlined at the ASU FS Kampsville (Table 7.25), based on the caries designations defined by Buikstra and Ubelaker (1994:54).

Table 7.25 Caries types

Type	Description of insult and location
0	No caries
1	Occlusal surface, including the pits, fissures and exposed dentine
2	Cervical regions, mesial and distal (excluding interproximal points of contact)
3	Smooth surfaces of buccal and lingual aspects, excluding fissures
4	Cervical regions, buccal and lingual, excluding interproximal areas
5	Root caries, below the cervical area
6	Large caries, have destroyed so much of the crown that point of origin is unclear
7	Interproximal surfaces at the contact points between teeth
8	Caries of the protostylid pit or circular caries (of hypoplasia)
9	Pulp exposed by attrition, not really caries

The most common type of caries in all three mortuary areas was Type 2 (interproximal surface caries), followed by Type 1 (occlusal surface caries) and Type 6 (Large Caries) (Figure 7.16).

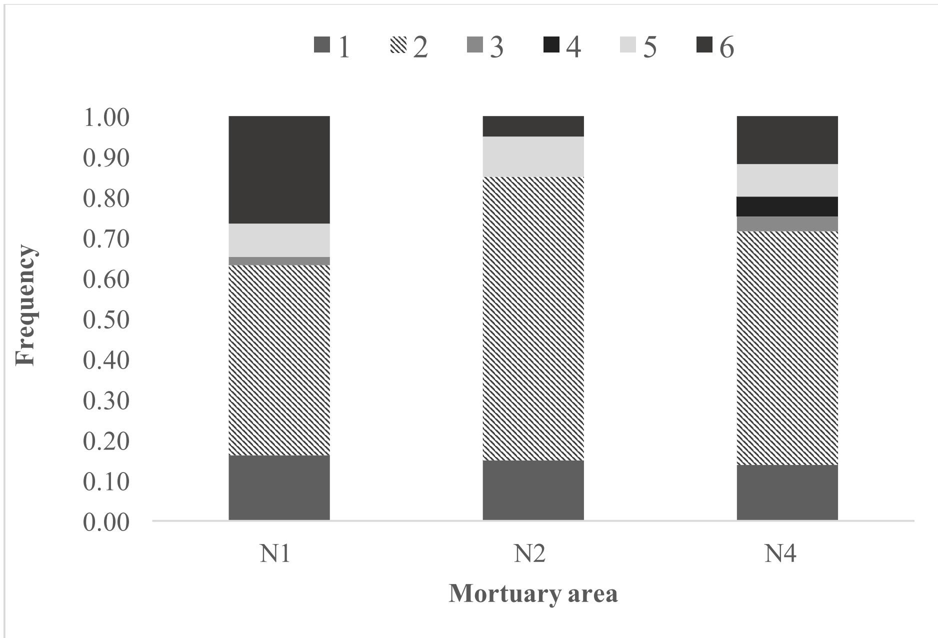
Figure 7.16 Frequency of caries types for for Necropolis 1, 2, and 4 (N = 315 caries)



The proportion of of different caries types was similar across all mortuary areas, with Type 2 the most frequent type at all sites, comprising 23/49 caries at N1, 14/20 caries at

N2 and 142/246 caries at N4 (Figure 7.17).

Figure 7.17 Caries type frequency by mortuary area



The frequency of hypoplasias differed significantly between mortuary areas (Figure 7.18); 17 teeth at N1, 16 teeth at N2, and 142 teeth at N4 were affected by hypoplasias, with adult teeth preserving a similar frequency of hypoplasias (136/2932, 5% of observable) to subadult teeth (39/757, 5% of observable). Fisher's Exact tests showed significant differences between the number of adult teeth affected by hypoplasias at N1 vs. N2 ($p = 0.001$), and at N2 vs. N4 ($p = 4.606e-05$), but not at N1 vs. N4 ($p = 1$). These tests reveal that N2 adult teeth showed a significantly higher frequency of hypoplasias than either N1 or N4 adult teeth. In contrast, Fisher's Exact tests showed no significant differences between the number of subadult teeth affected by hypoplasias at N1 vs. N2 ($p = 0.358$), at N1 vs. N4 ($p = 1$), or at N2 vs. N4 ($p = 0.373$). The most common type of hypoplasias at all three mortuary areas are Type 1 (linear horizontal grooves), followed by Type 5 (single pits) and Type 3 (linear horizontal pits) (Figure 7.19). See Buikstra and Ubelaker (1994:56) for a full description of hypoplasia types.

Figure 7.18 Frequency of hypoplasias by age and mortuary area

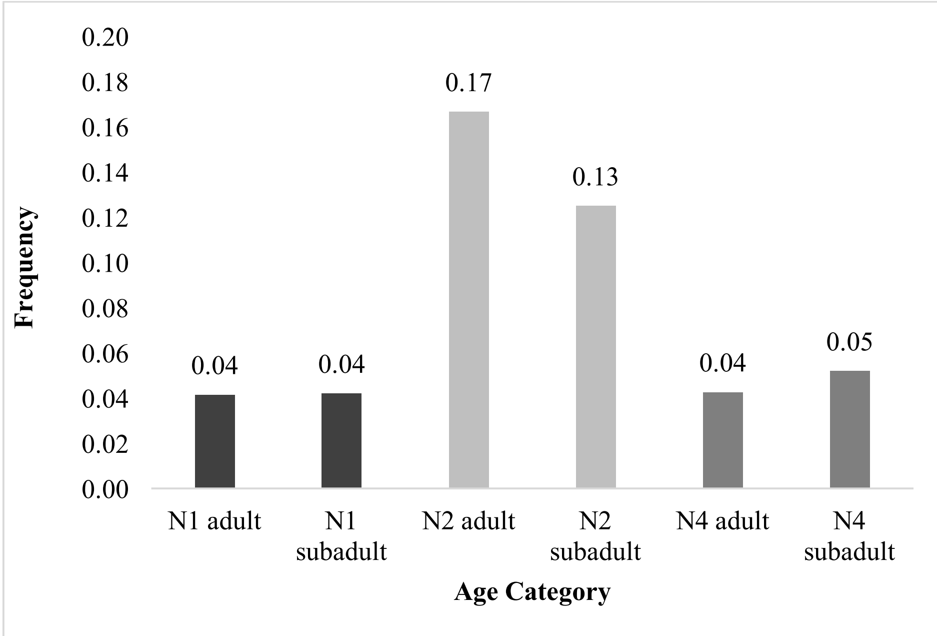
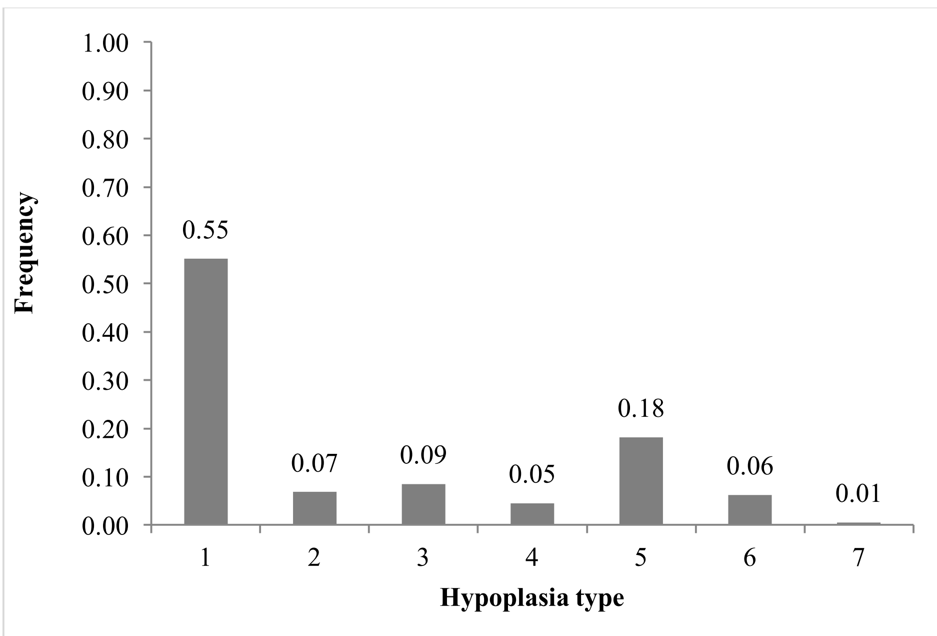


Figure 7.19 Frequency of hypoplasias by type (N = 175)



The number of teeth affected by calculus also differed significantly between mortuary areas. Overall, 47% (1655/3496) of observable teeth from Marroquíes Bajos were affected by calculus. Only 7% (30/461) of observable subadult teeth were affected, while 53 % (1625/3035) of adult teeth were affected. This result is not unexpected given that calculus builds up over time, and adult individuals will have curated permanent teeth for longer periods than subadult individuals.

Of the adult teeth for which it was possible to observe calculus (e.g. teeth with surfaces that were not obscured by taphonomic issues), a chi-square test showed significant differences in the number of adult teeth with calculus and the number of adult teeth without calculus between N1, N2 and N4 ($\chi^2 = 201.03$, df = 2, p-value < 2.2e-16). Subsequent tests revealed that the N1 and N2 comparison was significant ($\chi^2 = 5.0101$, df = 1, p-value = 0.0252), the N4 and N2 comparison was significant ($\chi^2 = 97.767$, df = 1, p-value < 2.2e-16), and the N1 and N4 comparison was also significant ($\chi^2 = 125.61$, df = 1, p-value < 2.2e-16) (Figure 7.20). Fisher's Exact tests also showed a significant difference between the counts of subadult teeth with calculus at N1 vs. N4 (p-value = 0.01825), but no significant difference between the counts of teeth with calculus at N1 vs. N2 (p-value = 0.3445), or N4 vs. N2 (p-value = 1). The significant difference is likely related to the higher rates of calculus in N1 subadults (14% of teeth affected), relative to N4 subadults (5% of teeth affected).

One hypothesis to explain this difference is that articulated teeth may preserve more calculus. Preservational conditions that favor articulation could also favor the preservation of calculus, while taphonomic conditions that lead to disarticulation could destroy calculus. While the proportion of teeth with calculus at N1 and N2 seems to reflect the proportion of teeth articulated, this relationship does not hold for N4, which preserves proportionally fewer articulated adult teeth than N1, yet has a significantly higher proportion of adult teeth affected by calculus (Figure 7.21). This difference is particularly marked for the subadult teeth from N4; N4 subadult teeth show the highest levels of articulation (32%), yet still preserve proportionally fewer teeth with calculus than N1.

Figure 7.20 Frequency of teeth affected by calculus, by age and mortuary area

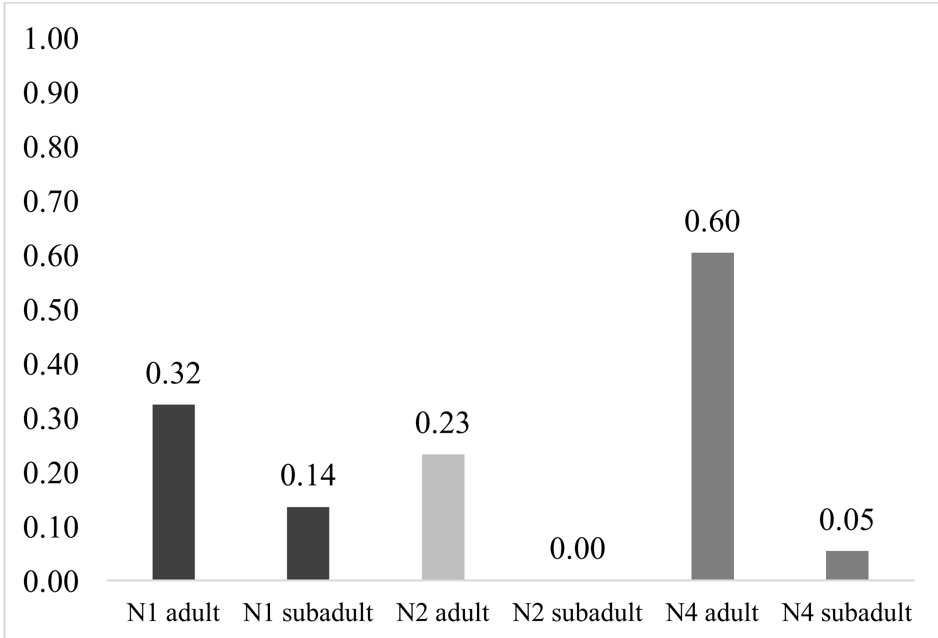
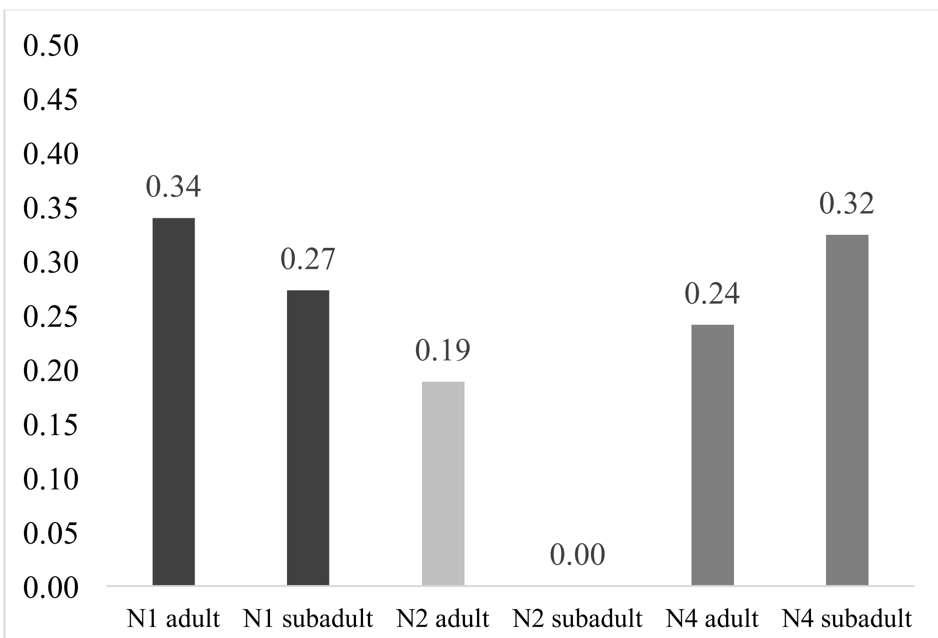


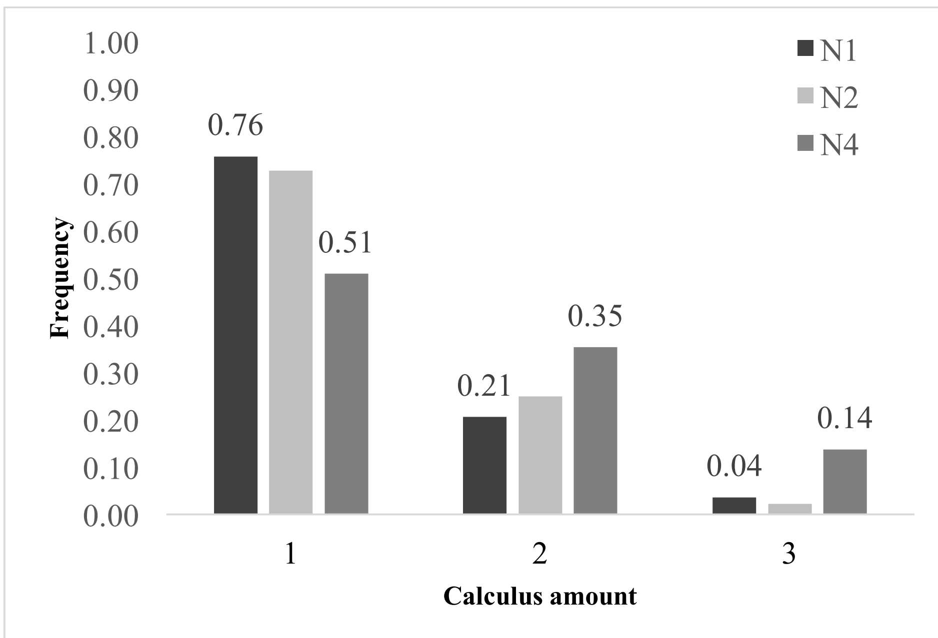
Figure 7.21 Frequency of articulated teeth by age and mortuary area



The amount of calculus present on affected teeth also differed by mortuary area. Comparisons of Calculus 1 (small amount) and Calculus 2 (moderate amount) revealed significant differences between N1, N2 and N4 (χ^2 = 46.434, df = 4, p-value = 2.001e-

09). Subsequent Fisher's Exact tests revealed no significant differences between scores of Calculus 2 and Calculus 3 (large amount). However, a Fisher's Exact Test showed significant differences between scores of 1 and 3 for N1 vs. N4 (p-value = 4.212e-07), a Fisher's Exact Test showed significant differences between scores of 1 and 3 for N2 vs. N4, (p-value = 0.00739) (Figure 7.22). These results suggest that N4 has a higher proportion of affected teeth preserving a large amount of calculus, and a lower proportion of affected teeth preserving a small amount of calculus, relative to N1 or N2 teeth.

Figure 7.22 Calculus amount by mortuary area (frequency of teeth affected)



Overall, the comparisons between N1, N2 and N4 suggest significant differences between mortuary areas in both the number of teeth showing signs of nutritional stress, and the number of teeth preserving calcified dental plaque. A significantly higher frequency of hypoplasias is observed for N2 adult teeth than for N1 or N4 adult teeth, while a significantly higher frequency of dental calculus is observed for N4 adult teeth than for N1 or N2 adult teeth. For all pathologies, a higher frequency of insults was recorded for adult teeth than for subadult teeth.

Comparisons: Demography at N1, N2, and N4

Two points must be stressed before comparing the distribution of ages for N1, N2, and N4. First, the *proportion* of the MNI that can be aged varies widely between mortuary areas – 81% of individuals from N1, 42% of individuals from N2, and 83% of individuals from N4 could be aged. Second, the resultant *sample sizes* of age estimates also vary widely between mortuary areas – age could be estimated for 34 individuals from N1, 14 individuals from N2, and 171 individuals from N4.

Cámara Serrano et al. (2012) published their demographic data from N3 using seven broad age categories, requiring the use of a similar structure for this set of age estimates. In addition to the need to compare these data to demographic data from N3, the sample size for N2 is markedly smaller than the other two mortuary areas – approximately half that of N1, and one tenth that of N4 – meaning that use of one-year age categories would produce many empty categories that could not be compared to N1 or N4. As a result of these considerations, midpoint age estimates were collapsed into eight broader age categories: pre-term infant (prenatal), child (birth–6.9 years), juvenile (7-12.9 years), adolescent (13-17.9 years), young adult (21-40 years), middle adult (41-60 years) and old adult (61+ years) (Cámara Serrano et al. 2012:54). However, because I defined subadult as an individual < 18 years of age, based on the assumption that individuals in this age range would have been considered social adults, I added a new age category of very young adult (18-20.9 years). This allowed me to compare the frequencies of subadults < 18 years of age between N1, N2 and N4, while still being able to collapse the "Adolescent" and "Very Young Adult" categories to compare the age distributions from N1, N2, and N4 to those from N3.

Overall, the three mortuary areas show similar patterning, with between 24% and 29% of the total MNI composed of subadults (Table 7.26). A chi-square test showed no significant differences in the proportions of adults and subadults across N1, N2, and N4 (($\chi^2 = 0.45441$, df = 2, p-value = 0.7968).

Table 7.26 Adult and subadult MNI by mortuary area

Mortuary area	Adult	Subadult	Total	% subadult
N1	31	11	42	0.26
N2	25	8	33	0.24
N4	145	60	205	0.29
N1, N2, N4 Total	201	79	280	0.28

Patterning is also relatively similar when the seven broad age categories are examined. No pre-term infants, and very few children under the age of 2.5, occur at any mortuary areas (Figure 7.23). The adult assemblage is dominated by young adults aged 20-40, and middle and old adults are rare. The age categories that show the most proportional variation between all three mortuary areas are juvenile and young adult, with proportionally more juveniles and fewer young adults represented at N2 than the other mortuary areas. However, when the counts themselves are examined, these discrepancies seem more likely related to the disparity in sample sizes between mortuary areas (Table 7.27).

Figure 7.23 Proportion of Necropolis 1, 2, and 4 individuals by age category

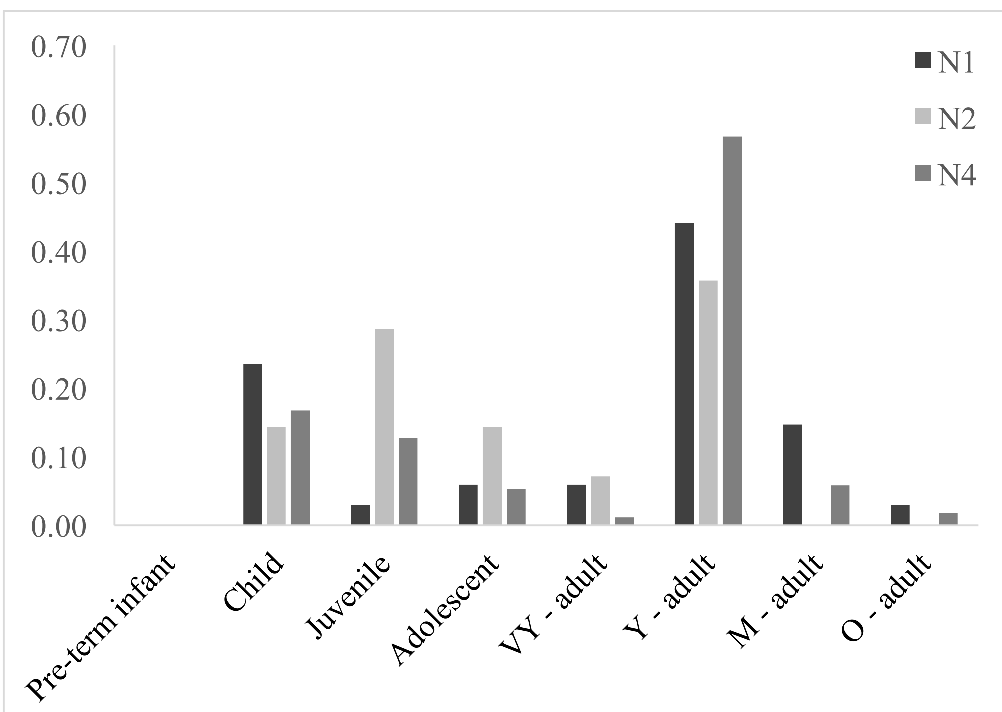


Table 7.27 Counts of age categories from Necropolis 1, 2, and 4

Mortuary Area	N1	N2	N4
Pre-term infant	0	0	0
Child	8	2	29
Juvenile	1	4	22
Adolescent	2	2	9
Very young adult	2	1	3
Young adult	15	5	98
Middle adult	5	0	7
Old adult	1	0	3
Total	34	14	171

Some of the patterning in age distribution is also related to the use of the Gilmore and Grote molar wear aging scheme. An examination of Gilmore and Grote's Figure 4 shows an adult peak at between 25 and 30 years, and the authors underscore that in their distribution of estimated ages "most ages fall between 20 and 40 years with very few older individuals…the rarity of older individuals (> 40 years) does suggest that, like the Miles method and other skeletal aging methods, this modification may underestimate age in older individuals" (Gilmore and Grote 2012:187). Within the N1, N2 and N4 samples, this adult peak occurs at between 25-30 years for all samples, with the exception of N4 where the peak occurs at 30-35 years (Figures 7.24 –7.27). The adult peak for the Marroquíes mortuary populations described below matches the peak at 25-30 years demonstrated by the Gilmore and Grote samples. This peak occurs for the combined N1, N2, and N4 sample, the N1 sample and the N4 sample. The absence of this peak in the N2 sample most likely reflects the small sample of adults that could be aged for this mortuary area, rather than a true demographic difference.

Figure 7.24 All midpoint age estimates for Necropolis 1, 2, and 4

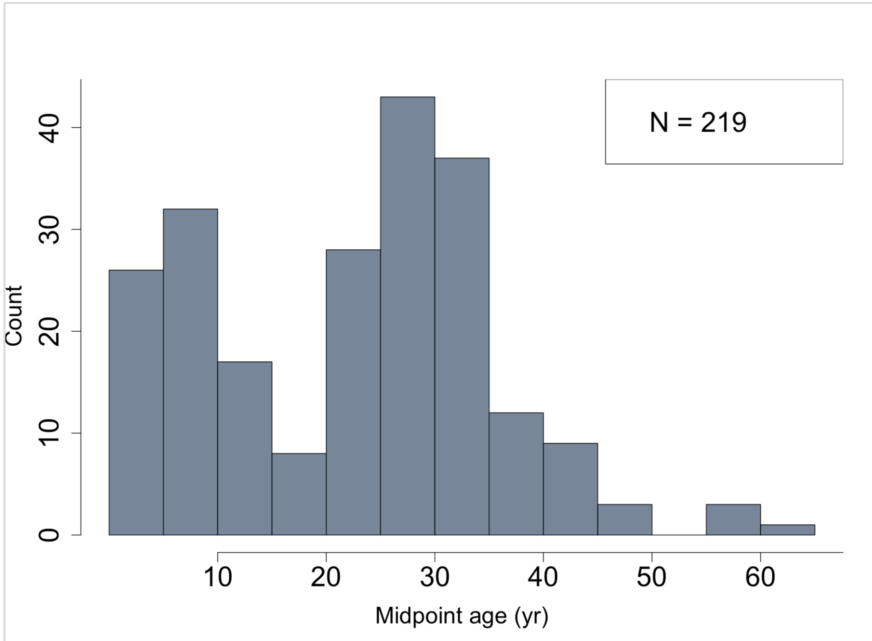


Figure 7.25 All midpoint age estimates for Necropolis 1

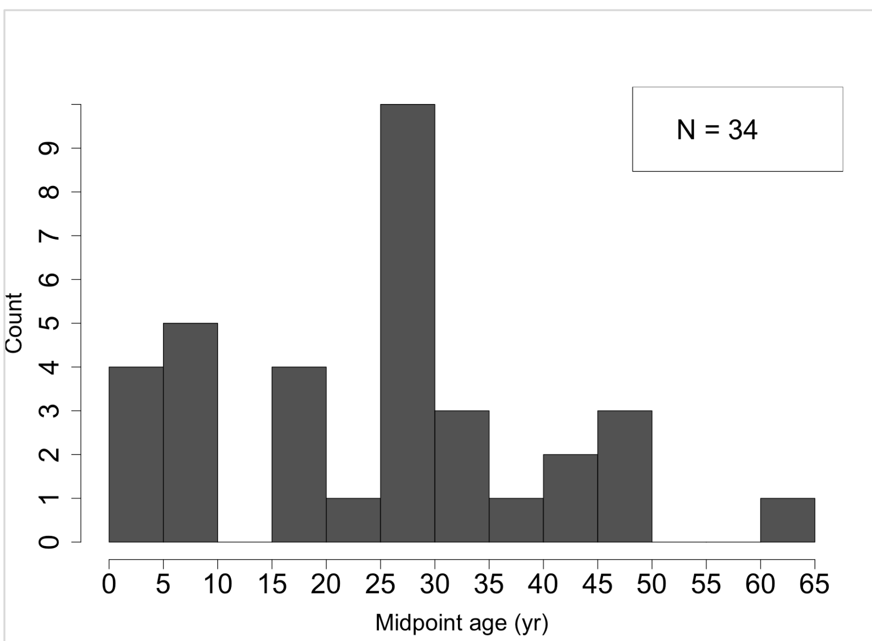


Figure 7.26 All midpoint age estimates for Necropolis 2

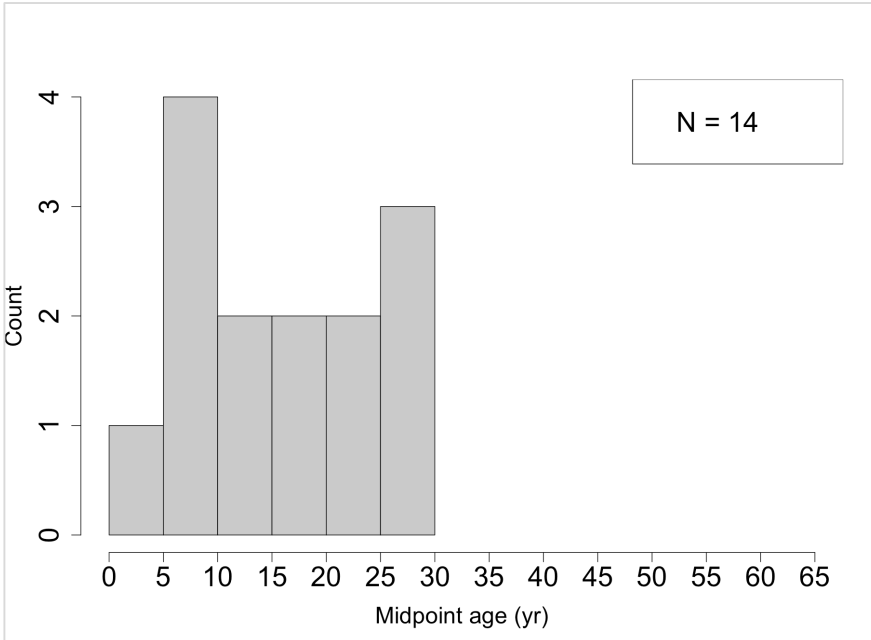
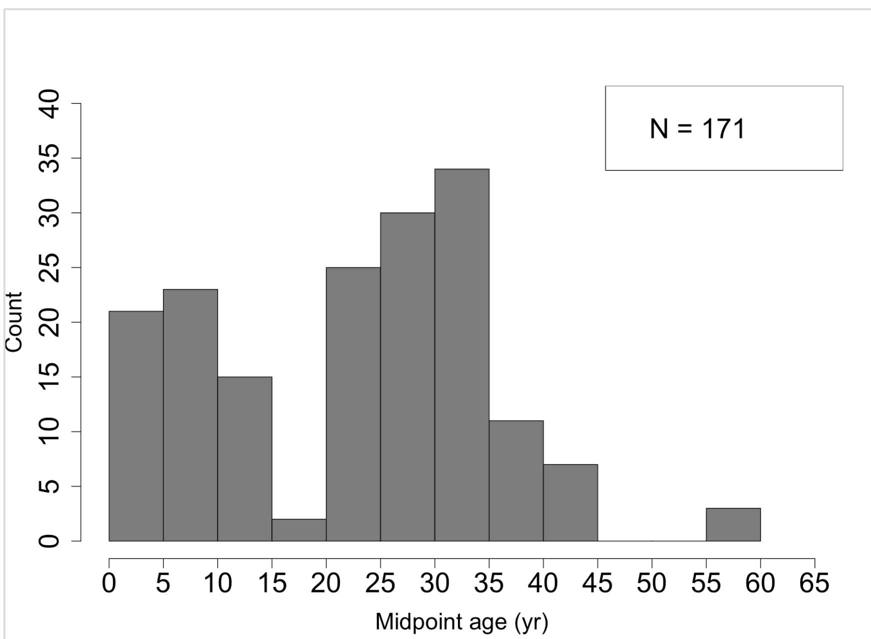


Figure 7.27 All Necropolis 4 age estimates



Estimates of sex are only available for a fraction of the adult sample, with an estimate of 10 females and 7 males at N1 (based on skeletal analysis), 1 male and 1 female at N2 (based on skeletal analysis), and 46 females and 40 males at N4 (based on the bimodality of the canine area metric). However, Fisher's Exact tests found no significant differences in sex between N1 vs. N2 (p-value = 1), N2 vs. N4 (p-value = 1), and N1 vs. N4 (p-value = 0.7927).

Conclusions

The combined bioarchaeological results from Chapters 6 and Chapter 7 allow us to offer key insights into mortuary practices at Marroquíes Bajos.

First, there are broad similarities in the inclusive demographic make-up across the three mortuary areas. All mortuary areas include children, juveniles, adolescents, and adults. Pre-term infants are missing from all mortuary areas, corresponding to a broader pattern within Late Prehistoric Iberia (Waterman and Thomas 2011). The poorer representation of middle and old adults relative to young adults is also true of all three mortuary areas. The preponderance of adults aged 21- 40 is likely an artifact of the limitations of bioarchaeological methods for estimating age, rather than a true absence of older adults. Finally, while very few estimates of sex are possible for N2, all mortuary areas show the presence of both males and females.

Second, there are distinct differences in the frequency of dental pathology between the mortuary areas. Chi-square and Fisher's Exact tests revealed significant differences in the number of teeth affected by calculus for all mortuary areas, which is potentially indicative of prehistoric differences in diet. N2 also showed a significantly higher frequency of hypoplasias than either N1 or N4, which may be related to differences in the level of nutritional stress experienced by these three mortuary populations. In contrast to dental pathology, levels of skeletal pathology are exceedingly low for both N1 and N2. While the low levels of osteoarthritis, fractures, vertebral pathology, abnormal bone formation, and abnormal bone loss at N2 may be related to the fragmentary nature of the human remains from that site, the similarly low levels of these insults at N1 suggest that this mortuary population was not subject to a high level of skeletally observable infectious disease or pathology.

Third, these results reveal that multiple methods of interment were practiced at Marroquíes Bajos. The extremely low levels of skeletal completion for all structures at

N2, and in particular the near emptiness of Structure 52, demonstrate the degree to which human remains were being moved and manipulated in prehistory. At N1, the co-existence of both primary and secondary burial may reveal the simultaneous presence of multiple mortuary treatments, or may be a snapshot of a trajectory from primary to secondary burial, with both ends of the spectrum represented. The intermediate dental signature at N4, falling in between the primary and secondary dental signatures from other mortuary areas, suggests that both primary and secondary burials are interred in the caves.

Finally, these results provide a methodological demonstration of the amount of information that can be recovered from dental analyses of human remains, and an archaeological test of recent approaches to the estimation of sex (Gonçalves et al. 2014) subadult age (AlQahtani 2009, AlQahtani et al. 2010) and adult age (Gilmore and Grote 2012) from human teeth. Overall, this analysis suggests that a dental approach to large salvage-excavated and commingled collections can provide very important bioarchaeological evidence of demography, health, and mortuary treatment in prehistoric populations.

Chapter 8

Chemistry, Chronology, and Continuity: Results of Isotopic Analyses and Radiocarbon Dating

> *Finally, it goes without saying that, as in any science, strontium isotope data are most effective as part of multiple independent lines of evidence…especially the contexts of the burials and other archaeological evidence that bring the isotope data to life.*
>
> – *R. Alexander Bentley, Strontium Isotopes from the Earth to the Archaeological Skeleton: A Review, (2006:179)*

The titles of studies focused on anthropological applications of isotope analyses often incorporate variations on the theme of "you are what you eat" (Schutkowski 1995; Fuller et al. 2004, 2005; Tykot 2004, 2007, 2009). However, when it comes to the human skeleton, bones are not only what people eat, but also what they drink, where they travel, and when they lived. In recent decades, isotope studies have made significant strides in illuminating ancient diets (Ambrose et al. 2003; Tykot 2004; Honch et al. 2006), patterns of mobility (Price et al. 2001; Bentley et al. 2008; Gerling et al. 2012; Waterman et al., 2014), use of water resources (Knudson and Price 2007; Eckhardt et al. 2009; Buzon et al. 2011), weaning practices (Richards et al. 2002; Pearson et al. 2010; Tsutaya and Yoneda 2014), and establishing the chronology of multi-phase cemeteries with the application of radiocarbon dating techniques (Quinn 2015)

At the site of Marroquíes Bajos, this isotopic toolkit is particularly important for establishing both the variable nature of lived experience at the site, and the chronological duration of the various necropolises relative to the settlement itself. Understanding whether individuals in Necropolis 1 (N1), Necropolis 2 (N2), and Necropolis 3 (N3) experienced marked differences in diet (as determined by analyses of carbon and nitrogen isotopes), or whether these mortuary areas reveal variable levels of in-migration (as determined by oxygen isotope and strontium isotope ratio analyses), is key for establishing whether social differentiation is a primary factor structuring mortuary practices at this settlement.

The use of AMS radiocarbon dating will also help differentiate among explanations for the use and presence of multiple cemeteries. In particular, dates from human bone allow for differentiating between two broad explanatory hypotheses for mortuary variability at this site. If individuals are buried in different necropolises as a result of social differentiation (related to kinship or lineage group, social status, or regional affiliation), the expectation is that all mortuary areas will show significant chronological overlap. In contrast, if the necropolises reflect change over time at this site, the expectation is that each mortuary area will have been used for a relatively discrete period of time, with little temporal overlap between mortuary areas. Finally, radiocarbon dates of these three necropolises are essential for untangling the competing unitary and accretional models of the overall trajectory of the settlement of Marroquíes Bajos itself (Chapter 3).

The preceding chapters detailed the results of bioarchaeological analyses of N1, N2, and N4. In this chapter I describe the sample of human and faunal remains used for isotopic analyses, outline the data collection protocol used for carbon, nitrogen, oxygen, and strontium isotopes, and describe the statistical analyses used to evaluate inter-individual and inter-necropolis differences in diet and mobility. After the discussion of the isotopic results from Marroquíes, I move on to describe the strategy used to select samples for AMS radiocarbon dating, and model the resultant chronology of the three necropolises. The raw data for the isotopic results, linked to bioarchaeological information about age, sex, and provenience are available in Appendix D. Appendix E has a similar structure to Appendix D, and contains the AMS radiocarbon dating results for each sample.

Isotopic Samples

There are several potential diagenetic issues that occur when analyzing prehistoric human or faunal remains including microbial attack, collagen loss due to temperature and time, crystallinity increase, dissolution related to water movement, and uptake of groundwater solutes (Hedges 2002). The potential for strontium uptake can be addressed with the use of laboratory decontamination procedures such as acetic acid washes, but such uptake remains a serious concern for archaeologists. The use of enamel, rather than bone, helps to solve this problem because enamel is less susceptible to diagenetic contamination than bone (Slovak and Paytan 2012). It is worth noting that this form of contamination will only produce a Type II error – misidentifying immigrants as locals rather than the reverse (Anna Waterman, personal communication). An additional concern with respect to isotopic analysis of bone comes from the potential for non-organic carbonates to leach into bones from the burial environment. However, this is only an issue when analyzing bone carbonate and enamel, rather than collagen. These non-organic carbonates are removed during laboratory decontamination procedures, like those described above. Accordingly, following appropriate laboratory pretreatment protocols helps to ensure that the diagenetic processes that may affect bone do not affect the results for carbon, nitrogen, strontium, or oxygen isotope analyses.

One hundred and twenty samples (113 human, 7 faunal) were collected from all three mortuary areas at Marroquíes Bajos. The proportions of the human isotopic samples reflect the overall MNI distribution for the three sites based on a total MNI of 220 from N1, N2, and N4, with comparable proportionality of age groups, sexes, and mortuary areas (Table 8.1-8.2). To prevent double-counting individuals, all human samples were collected from the right mandibular arcade. Subadult samples were selected based on the presence of the right lower deciduous second molar, and adult samples were selected based on the presence of the right lower second molar. In addition, two edentulous samples were selected based on the portion of the mandible that would have contained the right lower second molar. 4% of the sample could not be aged, 28% of the sample consisted of subadult individuals, and 68% of the sample consisted of adult individuals, reflecting the overall age distribution of the N1, N2, and N4 mortuary populations (Chapter 7).

Table 8.1 Proportions of MNI relative to isotope sample

Category	% MNI	% isotopic sample
Adult	72	72
Subadult	28	28
Female/probable female	29	23
Male/probable male	24	21
Indeterminate	2	6
Sex not possible	46	49
N1	15	20
N2	12	11
N4	73	69

Table 8.2 Sample size by age category and mortuary area

Age Category	N1	N2	N4	Total Sample Size
Child	4	0	14	18
Juvenile	1	1	8	10
Adolescent	1	0	3	4
Subadult Total	**6**	**1**	**25**	**32**
Very Young Adult	1	1	2	4
Young Adult	12	8	49	66
Middle Adult	4	0	0	7
Adult Total	**17**	**9**	**51**	**77**
Not Possible	0	2	2	4
Faunal	0	0	7	7
Total Human	**23**	**12**	**78**	**113**

At N1, mandibles associated with individuals preserving non-metric traits of the cranium and pelvis were preferentially selected (see Chapter 7 for a detailed account of this process). Because of the fragmentary nature of the skeletal material from N2, it was not possible to estimate the sex of any of the 12 samples from this mortuary area. Finally, at N4, samples preserving the anterior-most portion of the mandible were preferentially selected for sampling. For this mortuary area, estimates of sex were based largely on the mental eminence, though for six samples, estimates of sex using the bimodal distribution of canine area were possible. One of the canine estimates of sex for N4 could not be compared to a mandibular estimate as the mental eminence was not available for this individual (MN.3.072.01). Of the remaining five estimates of sex based on the lower canines, 4 (80%) agreed with the assessment derived from the mandible, and 1

(MN.2.215.01) did not agree – the canine estimate was female, while the mandibular estimate was male. This individual was re-categorized as indeterminate. Of the N1 sample, 47% of adults were female or probable female, 41% of adults were male or probable male, and 12% of adults were indeterminate. For the N4 adult sample, 51% were not possible to estimate sex, 21% were female or probable female, 19% were male or probable male, and 9% were indeterminate (Table 8.3).

Table 8.3 Sex distribution of human isotopic samples

Sex	N1	N2	N4	Total Sample Size
Female/Probable Female	8	0	11	19
Male/Probable Male	7	0	10	17
Indeterminate	0	0	5	5
Not Possible	2	11	27	40
Subadult	6	1	25	32
Total	**23**	**12**	**78**	**113**

Isotope Methods

All 120 human and faunal samples were processed by Dr. Marta Díaz-Zorita Bonilla at the University of Tübingen Department of Geosciences[32]. Approximately 0.12mg of tooth enamel was sampled from each individual from the lower right second molar for adults, or the lower right first or second deciduous molar for subadults. For carbon and nitrogen, approximately 1 g of bone was used for analysis. Bone samples were washed using de-ionised water, while carbonates received the usual standard three step pretreatment: (1) cleaning with NaOCl (5% Cl) and de-ionised water; (2) using a CaAc/HAc Puffer; (3) agai cleaning with n de-ionised water. Standard methods for the extraction of collagen were applied (Longin 1971; DeNiro and Epstein 1981; Bocherens et al. 1997). The chemical composition (%C, %N, atomic C/N ratios) of all extracted collagen was measured and compared to that of collagen extracted from fresh bone to test the quality of preservation and the reliability of the isotopic results.

[32] Funding for this portion of the project was provided by the Spanish Ministry of the Economy and Competitiveness (Ministerio de Economía y Competitividad), project "Dieta y movilidad humana en la Prehistoria de la Península Ibérica (3100-1500 ANE. Los casos de la Cuenca media del Tajo y el Alto Guadalquivir (HAR2013-47776-R), directed by Dr. Pedro Díaz-del-Río.

Oxygen and carbon isotope analysis of archaeological hydroxyapatite carbonate ($\delta^{18}O$, $\delta^{13}C$) was performed using the Gasbench II Finnigan 252 at the Department of Geosciences at the University of Tübingen. The samples were calibrated using standard reference materials NBS-18 ($\delta^{18}O$ = -22.96‰, $\delta^{13}C$ = -5.00‰ V-PDB) and NBS-19 ($\delta^{18}O$ = -2.20‰, $\delta^{13}C$ = 1.95‰ V-PDB) with a reproducibility of ±0.1‰ for both $\delta^{18}O$ and $\delta^{13}C$ values. Oxygen and carbon isotope ratios ($\delta^{18}O$, $\delta^{13}C$) are expressed relative to the V-PDB (Vienna Pee-Dee belemnite) carbonate standard and reported in per mil (‰) according to the standard formula: $\delta^{18}O = (((^{18}O/^{16}O_{sample})/(^{18}O/^{16}O_{standard})) -1) \times 1000$ (Craig 1961; Coplen 1994). These values were then converted to V-SMOW (Vienna Standard Mean Ocean Water) following the formula: $\delta^{18}O_{SMOW}= (\delta^{18}O_{PDB} \times 1.03086) + 30.86$ (Coplen et al. 1983; Iacumin et al. 1996; Wolfe et al. 2001;Müller et al. 2003).

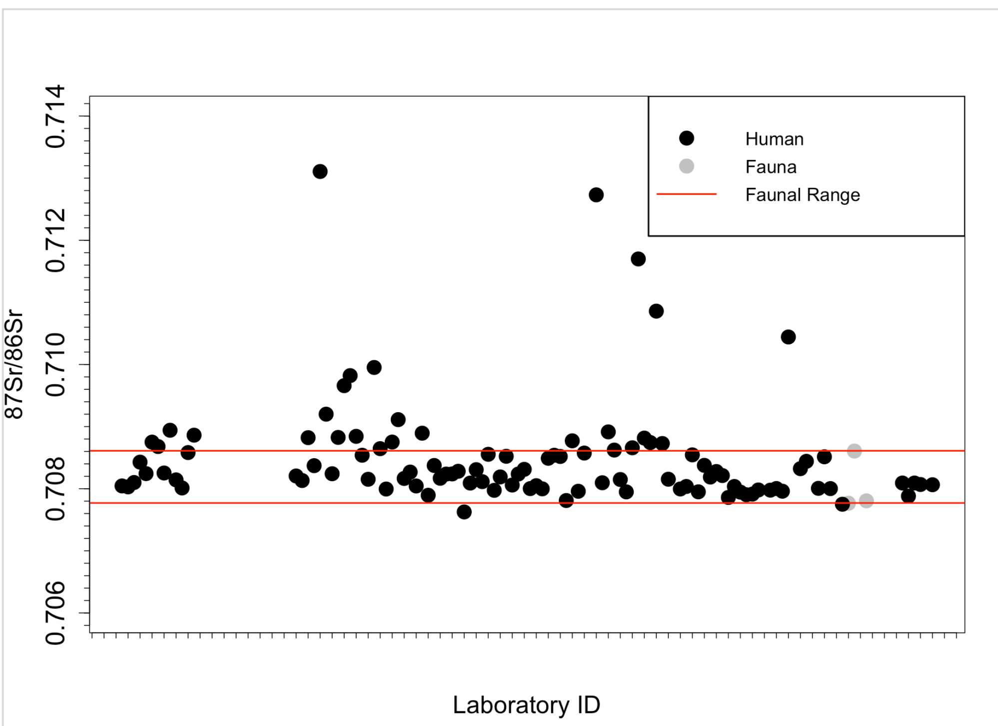
Strontium isotope ratio measurements were performed on the Finnigan MAT 262 Thermal Ionization Mass Spectrometer (TIMS) located at the Isotope Geochemistry Group of the University of Tübingen. Sample material was weighted into Savillex© Teflon beakers. Tooth samples were dissolved in HNO_3 (65%) in closed beakers on a hot plate at 80°C overnight and subsequently evaporated to dryness. Samples were then re-dissolved in 2.5M HCl for the separation of strontium by conventional ion exchange chromatography using quartz glass columns filled with BioRad AG 50W-X12 (200-400 mesh). Subsequent purification of strontium was achieved in micro-columns filled with Eichrom© strontium-spec resin. Strontium separates (~5 mg) were loaded with a Ta-activator on Re single filaments and isotope ratio measurements were performed in dynamic mode. Instrumental mass fractionation was corrected using an $^{88}Sr/^{86}Sr$ ratio of 8.375209 and an exponential law. External reproducibility for NBS SRM 987 (N = 5) was 0.710251±7 (1SD) for the $^{87}Sr/^{86}Sr$ ratio. Total procedural blank (chemistry and loading) was <145 pg for strontium.

Results of all isotopic analyses are available in Appendix D, with available bioarchaeological and provenience information listed for each sample.

Results of Strontium Isotope Analysis

One hundred and seven out of 120 (89%) of the N1, N2, and N4 samples were suitable for strontium (Sr) isotope analysis. The remaining 13 samples produced aberrant results, meaning that they either contained too little enamel for analysis, they lacked collagen, they needed to be re-analyzed because they had unacceptable C:N ratios, or, in the case of carbonates, they produced no results due to small sample size after pretreatment (> 5 mg) and needed to be re-sampled and analysed again (Marta Díaz-Zorita Bonilla, personal communication). The mean Sr isotope ratio for the faunal sample (N = 3) was 0.70806 ± 0.00047 (1σ), with a minimum value of 0.70777, and a maximum value of 0.70861. The mean human value (N = 104) was 0.70845 ± 0.00088 (1SD), with a minimum value of 0.70763, and a maximum value of 0.71302. Typically, contemporaneous small fauna are used to establish a "local range" for prehistoric populations (Waterman et al. 2014; Bentley et al. 2004; Bentley 2006). However, the sample of available fauna was so low (N = 3) for these three mortuary areas that it would have produced an artificially constrained local range, of only (0.70777-0.70861). This tight range would indicate that 28 of the human individuals sampled (27%) were non-local (Figure 8.1).

Figure 8.1 Local range established using faunal Sr isotope ratios



To combat this problem, the standard deviation of the human sample was calculated, producing values of 1σ = ±0.00087, and 2σ = ±0.00175. Price et al. (2001) recommend the use of a 2σ confidence interval around the mean to establish a local human range. However, because the N1, N2, and N4 Sr isotope ratios departed significantly from a normal distribution (Shapiro Wilk W = 0.62404, P = 3.773e-15), both a 1σ local range (0.70758 to 0.70932), and a 2σ local range (0.70670 - 0.71020) were employed here, in order to avoid under-estimating the number of non-local individuals. Using a local range of 0.70758 to 0.070932 resulted in identification of 8 non-local human individuals (Table 8.4, Figure 8.2).

Table 8.4 Non-local individuals at 1σ and 2σ

Field ID	Lab ID (Sr)	Provenience	$^{87}Sr/^{86}Sr$	Midpoint Age	Age Category	Sex	Significant at
25	238	N4	0.70966	34.3	Young adult	Not possible	1σ
33	239	N4	0.70982	34.3	Young adult	Not possible	1σ
50	243	N4	0.70995	26.6	Young adult	Not possible	1σ
78	312	N1	0.71044	6.3	Child	Subadult	2σ
12	290	N1	0.71086	47.1	Middle adult	Probable female	2σ
11	287	N1	0.71167	46.3	Middle adult	female	2σ
20	280	N1	0.71273	29.3	Young adult	Not possible	2σ
51	234	N4	0.71311	24.0	Young adult	Female	2σ

Both the 1σ outliers and the 2σ outliers represent relatively small components of the sample population – 7.7% and 4.8% respectively. Of the 80 adult individuals analyzed for Sr, estimates of sex were only possible for 36 (45%). Estimates of sex were made using the mental eminence, the bimodal categorization method for canine area (see Chapter 6), or non-metric traits of the pelvis and cranium (see Chapter 7). As a result, assessments of sex were only possible for 3/7 adult outliers (43%). All three of these individuals were estimated to be female or probable female (Figure 8.3).

Figure 8.2 **Human Sr outliers at 1σ and 2**

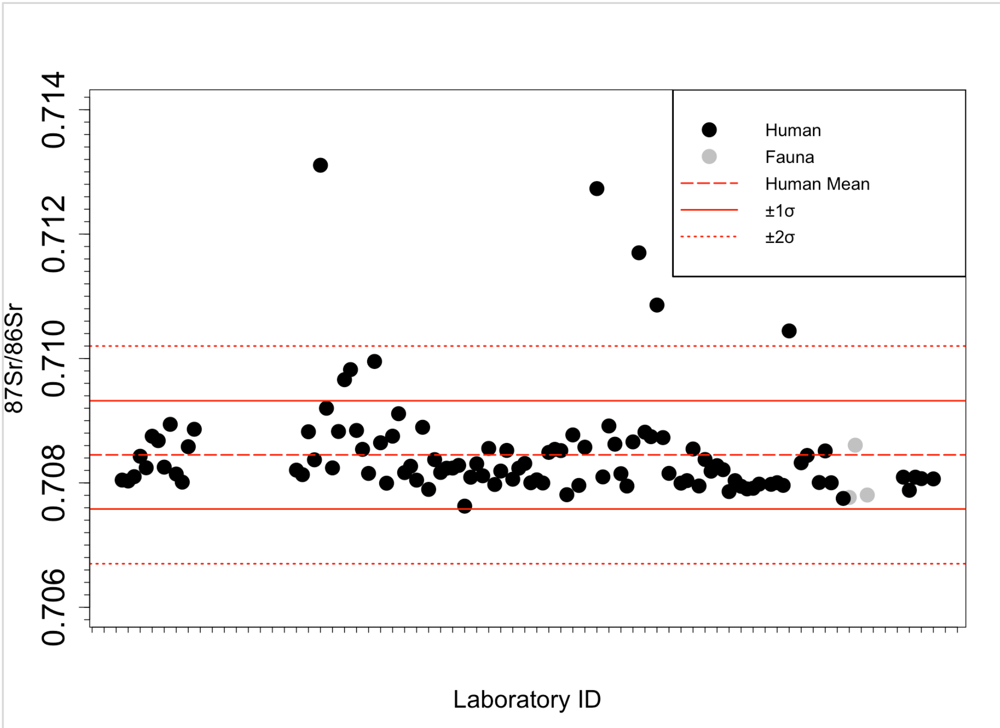
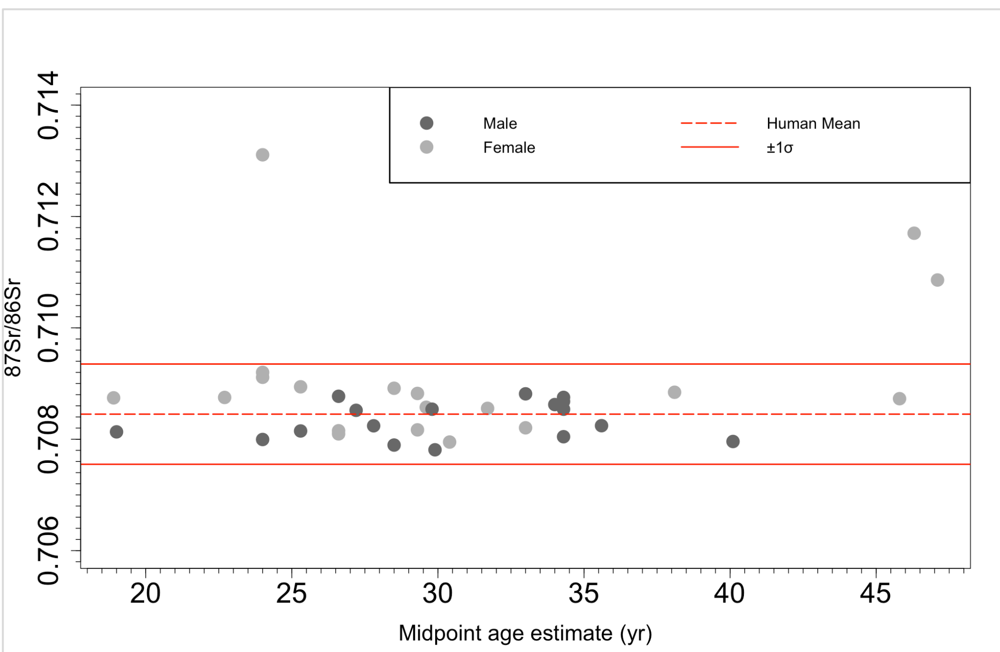


Figure 8.3 Sr isotope ratios by estimates of sex for adults



The 1σ non-local individuals include one child, two young adults, and two middle adults. Figure 8.4 shows the age distribution of Sr isotope ratios, with midpoint age estimate shown on the x-axis, and age category (child, juvenile, adolescent, very young adult, young adult, middle adult, and old adult) shown with point color. The presence of a non-local child buried at N1 is particularly intriguing, as it suggests that adults were not the only individuals on the move in south-central Copper Age Spain.

Finally, when it comes to the distribution of non-local Sr isotope ratios by mortuary area, half (N = 4) come from N1, while the other half (N = 4) come from N4; none come from N2 (Figure 8.5). It was possible to sample 21 human individuals from N1 and 76 human individuals from N4, so non-locals comprise 19% and 5% of the Sr sample populations respectively. None of the sampled individuals from N2 (N = 7) showed non-local Sr isotope ratios. A Shapiro-Wilks normality test on the human Sr isotope ratios revealed that this distribution departs significantly from a normal distribution (W = 0.61976, P = 5.162e-15), requiring the use of non-parametric statistics to test for significant differences in Sr isotope ratios between the three mortuary areas. A Kruskal-Wallis test produced results that bordered on significance (Kruskal-Wallis chi-squared = 5.9564, df = 2, P = 0.051).

Figure 8.4 Sr isotope ratios by estimates of age for human adults

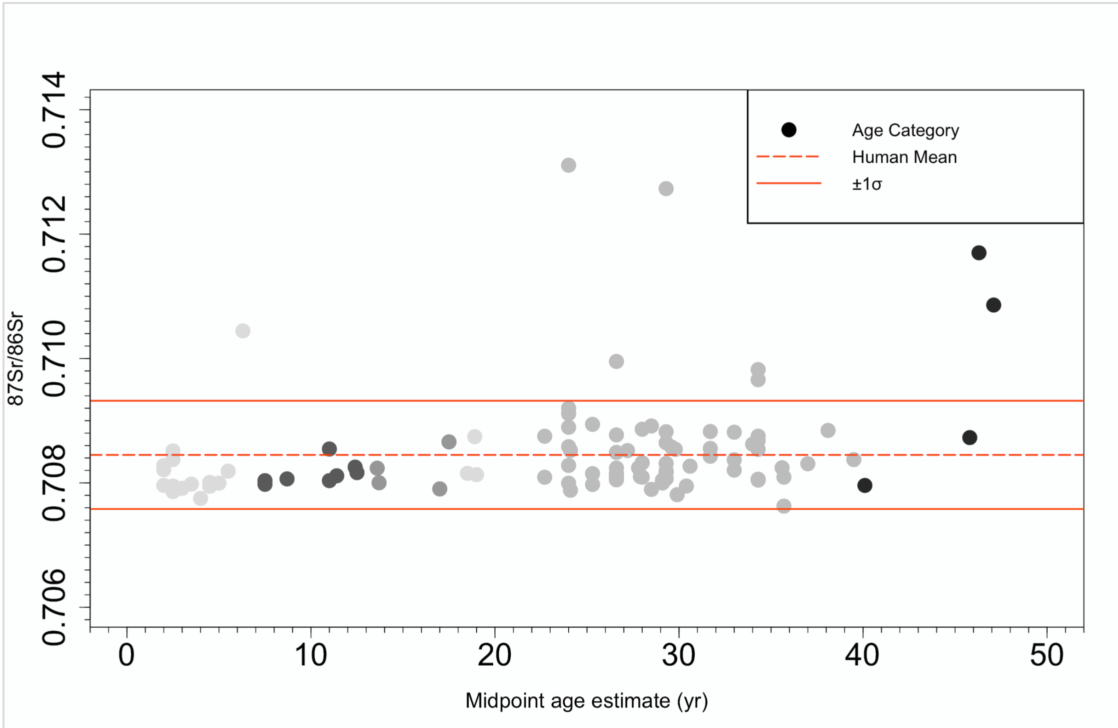
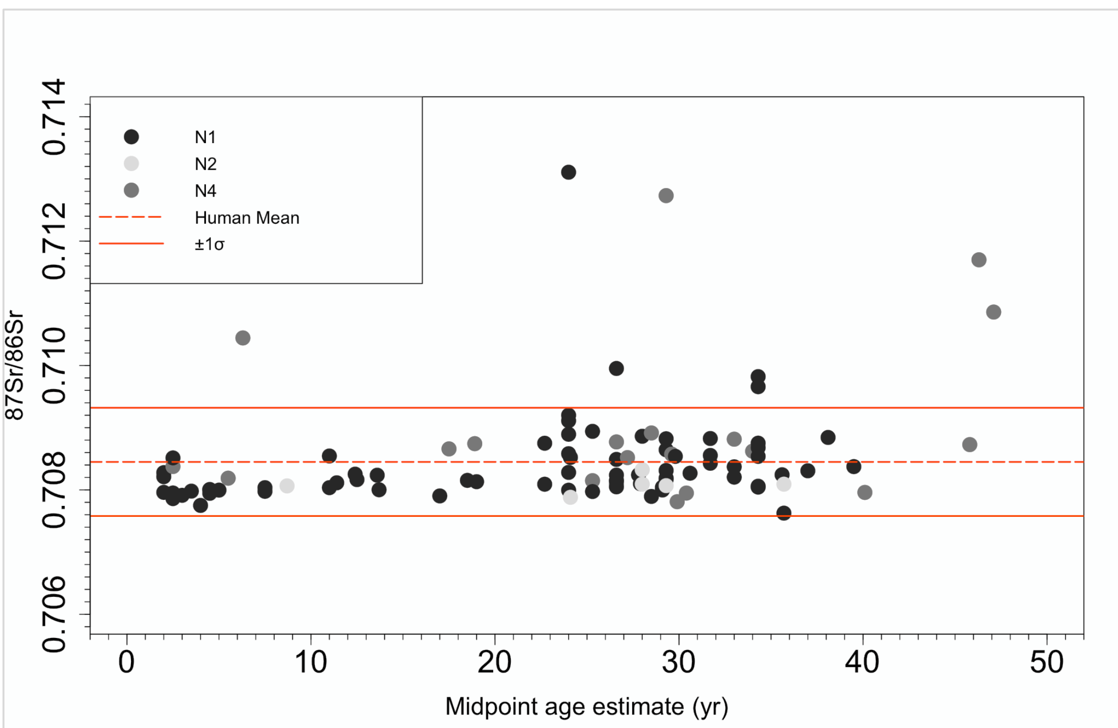


Figure 8.5 Sr isotope ratios by mortuary area



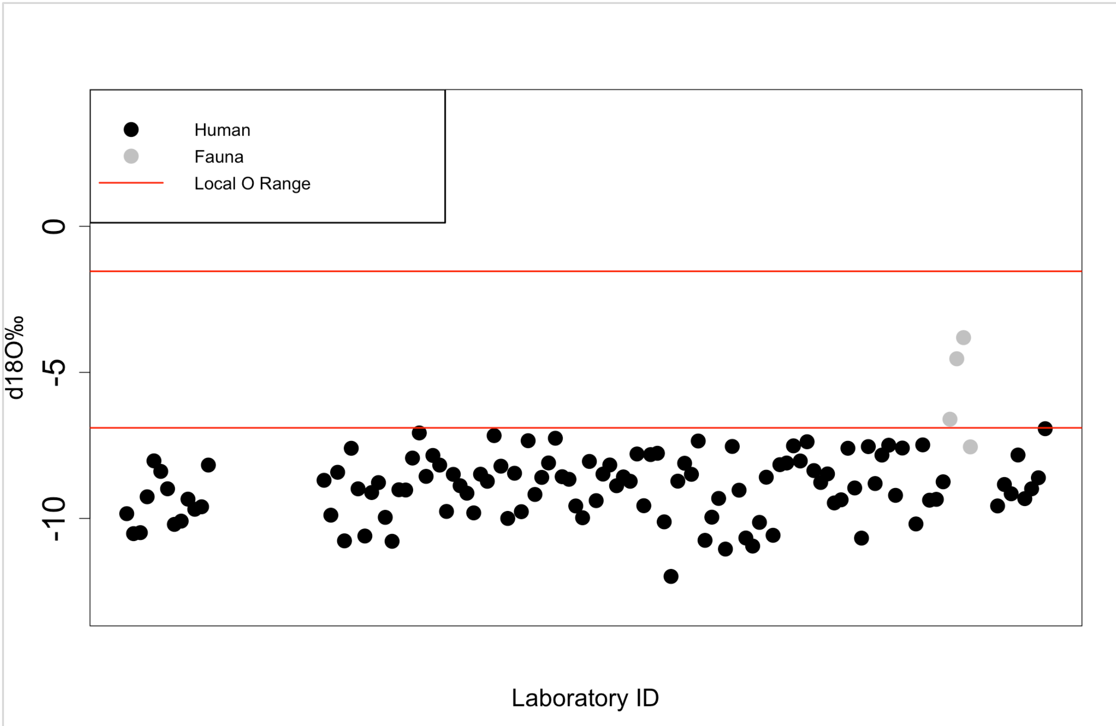
Results of Oxygen Isotope Analysis

Dental enamel was also used for oxygen isotope analysis. 117/120 (89%) of the N1, N2, and N4 samples could be analyzed for oxygen (O) signatures. Because there is a known level of fractionation when humans consume water (Chenery et al. 2012), these values were converted to reflect drinking water using the formula described in the Isotope Methods section ($\delta^{18}O_{SMOW}$= ($\delta^{18}O_{PDB}$ x 1.03086) + 30.86). The mean $\delta^{18}O$ value for the faunal sample (N = 5) was -5.63 ± 1.75 (1σ), with a minimum value of -7.55, and a maximum value of -3.81. The mean human $\delta^{18}O$ value (N = 112) was -8.91 ±1.04, with a minimum value of -8.66, and a maximum value of -11.99.

For this study, human $\delta^{18}O$ values were compared to modern precipitation in an attempt to establish a range for local water sources. Values from the IAEA Water Resource Program (IAEA/WMO 2004) from the closest GNIP station, located at Almería airport (WMOCode 848700) showed an average of $\delta^{18}O_{V\text{-}SMOW}$ of -4.26‰ ± 2.7 (1σ). Using the IAEA data, the maximum $\delta^{18}O$ value in the local range is -1.54‰, and the minimum value is -6.9‰.

When the Almería IAEA values are treated as the local range for drinking water, all human individuals fall below this range, with the exception of tooth T.41.43 from Necropolis 2, which falls on the lower border (Figure 8.6). Because Almería is a coastal city around 150 km away from Jaén, this range for rainfall likely does not reflect $\delta^{18}O$ values for water consumed by individuals in the Jaén area. Values from Murcia, the second-closest site to Jaén, produce a similar local range. At other Spanish sites like the Argaric settlement of Gatas, similar issues are reported, with human corrected $\delta^{18}O$ values falling outside of the local range established with reference to modern precipitation averages (Marta Díaz-Zorita Bonilla, personal communication).

Figure 8.6 $\delta^{18}O$ values for human and faunal sample



Until more specific parameters are calculated for the prehistoric $\delta^{18}O$ range in Jaén with reference to modern precipitation from that area, it is impossible to specify a local range. However, a similar technique to that used for the Sr isotope ratios is one possible way to examine values that are markedly different than the $\delta^{18}O$ human average. When the distribution of values 1σ and 2σ from the human mean is examined, there are only two outliers, N1.CE14.09.1 (Field ID 15), a young adult female from Necropolis 1, with a value of -11.98‰, and N1.CE14.07, a very young adult female from Necropolis 1, with a value of -11.05[33]. However, these individuals have strontium isotope ratios that fall within the local range (Figure 8.7). The rest of the individuals appear to fall within this 2σ window, regardless of sex, age, or mortuary area (Figures 8.8-8.10). Finally, a Shapiro-Wilks normality test of the human $\delta^{18}O$ values showed that this distribution did not depart significantly from a normal distribution (W = 0.98206, p = 0.138). A

[33] This individual appears to fall on the lower 2σ line in the following graphs due to point size and axes size, but it readily apparent in Figure 8.11

subsequent ANOVA showed no significant differences between N1, N2, or N4 (F-value 0.77, Pr (>4) = 0.383).

When considering the lower value for N1.CE14.07 and N1.CE14.09.1, it is important to note that $\delta^{18}O$ values vary for many reasons as they are affected by altitude, storm track, precipitation amount, and temperature. Similarly, the use of different *types* of local water sources (e.g. wells versus small streams versus rivers), rather than individual regional mobility, could lead to disparate signatures. Finally, milk consumption can enrich $\delta^{18}O$ levels (Roberts et al. 1988; Wright and Schwarz 1998; Tsutaya and Yoneda 2014). The most careful interpretation of these data therefore requires correlating the $\delta^{18}O$ signatures of $^{87}Sr/^{86}Sr$ isotope ratios to identify individuals with outlier values for both Sr and O isotopes.

Figure 8.7 Human mean for $\delta^{18}O$, ± 1σ and 2σ

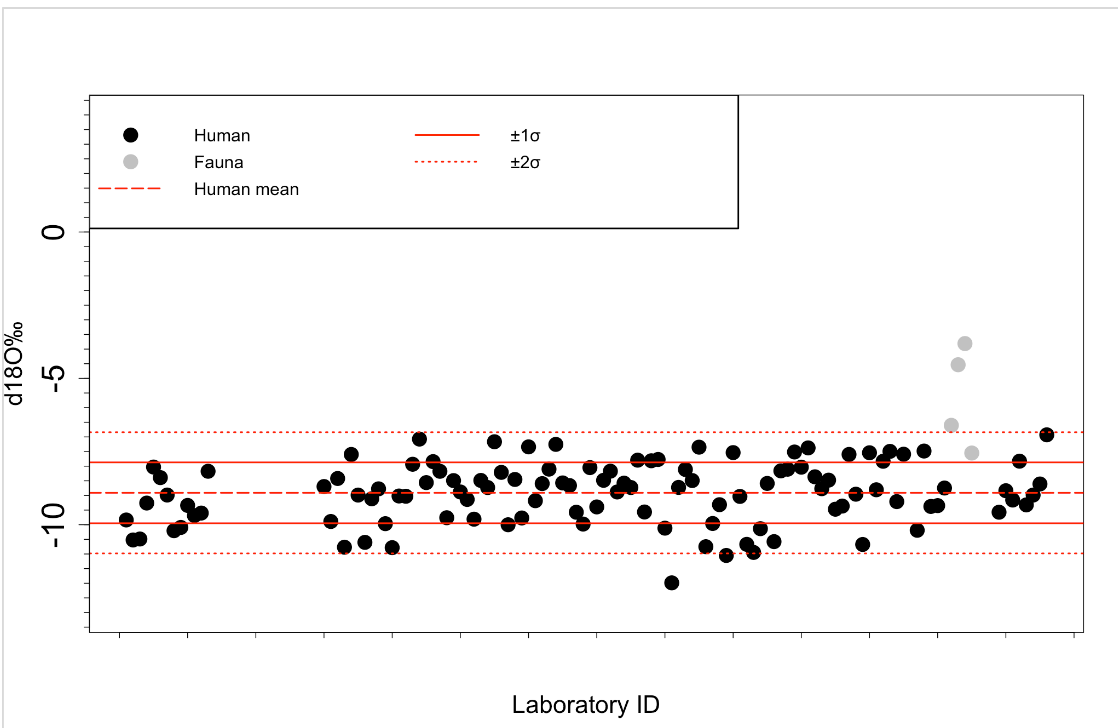


Figure 8.8 $\delta^{18}O$ values by sex

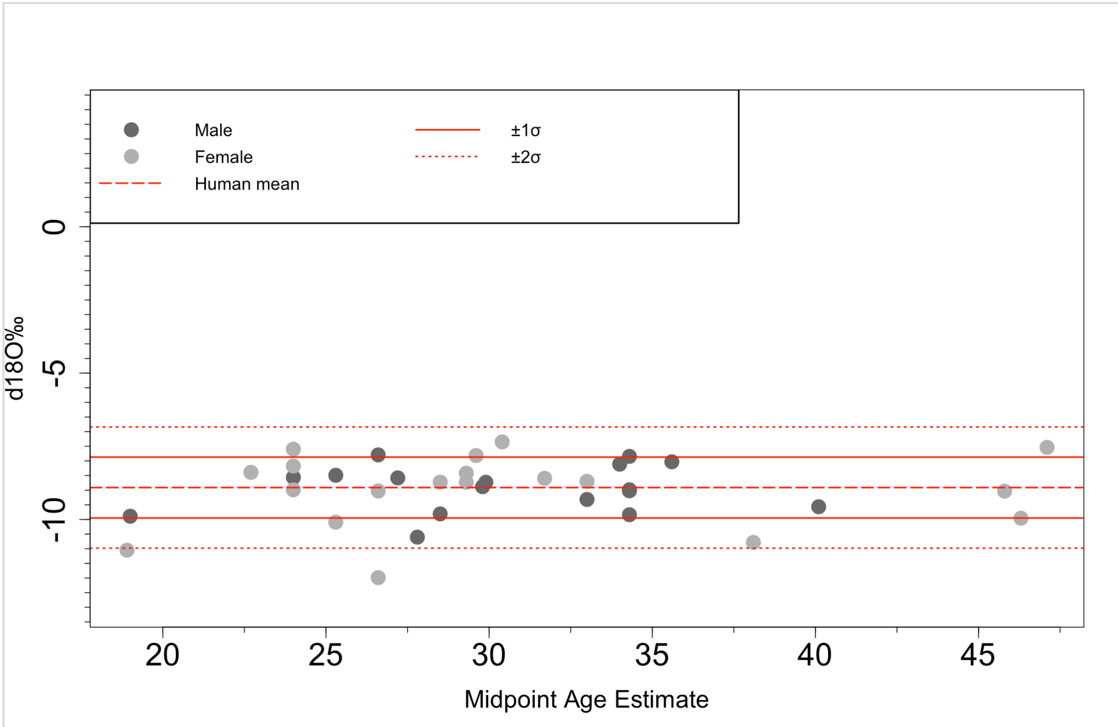


Figure 8.9 $\delta^{18}O$ values by age category

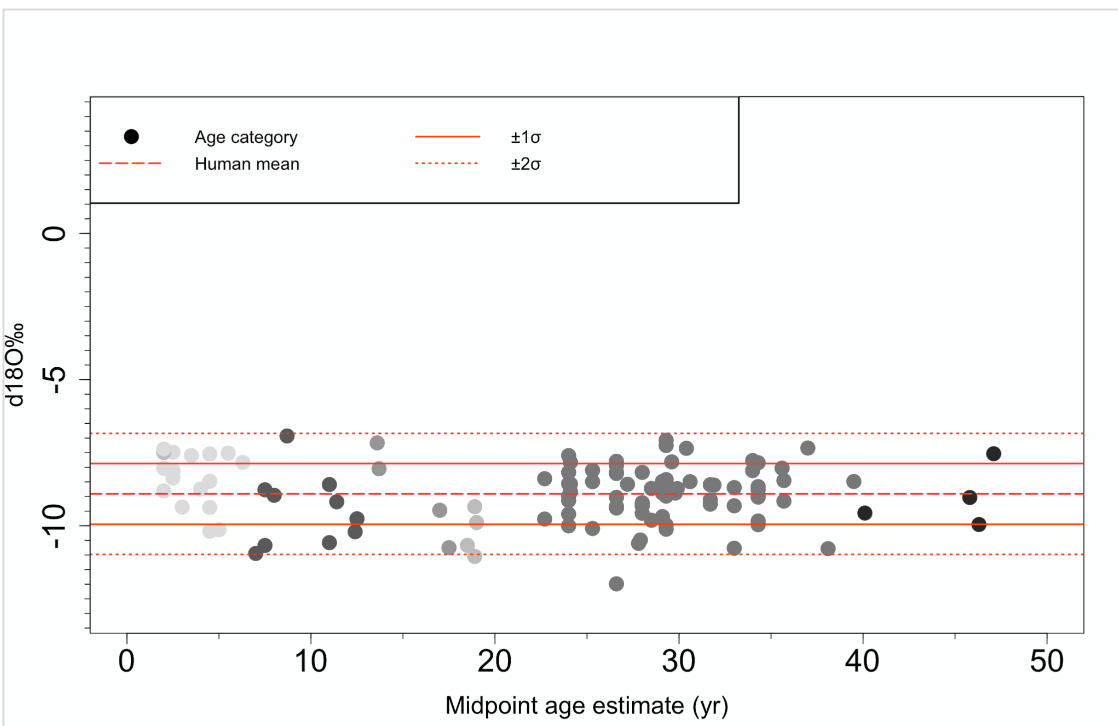
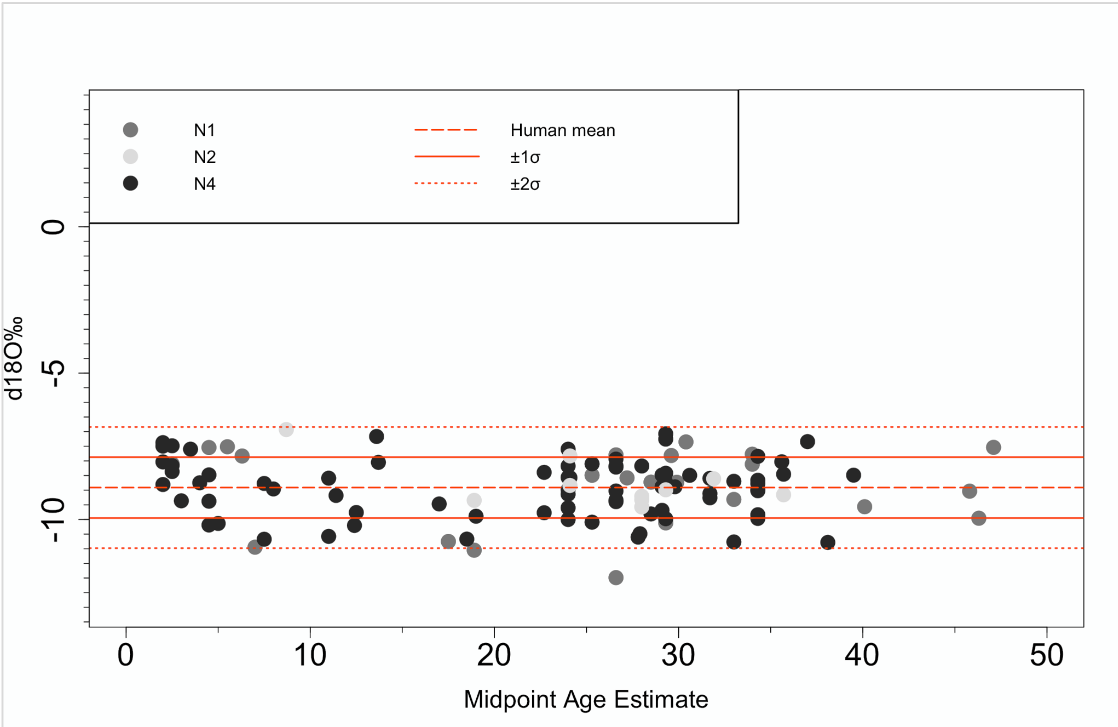


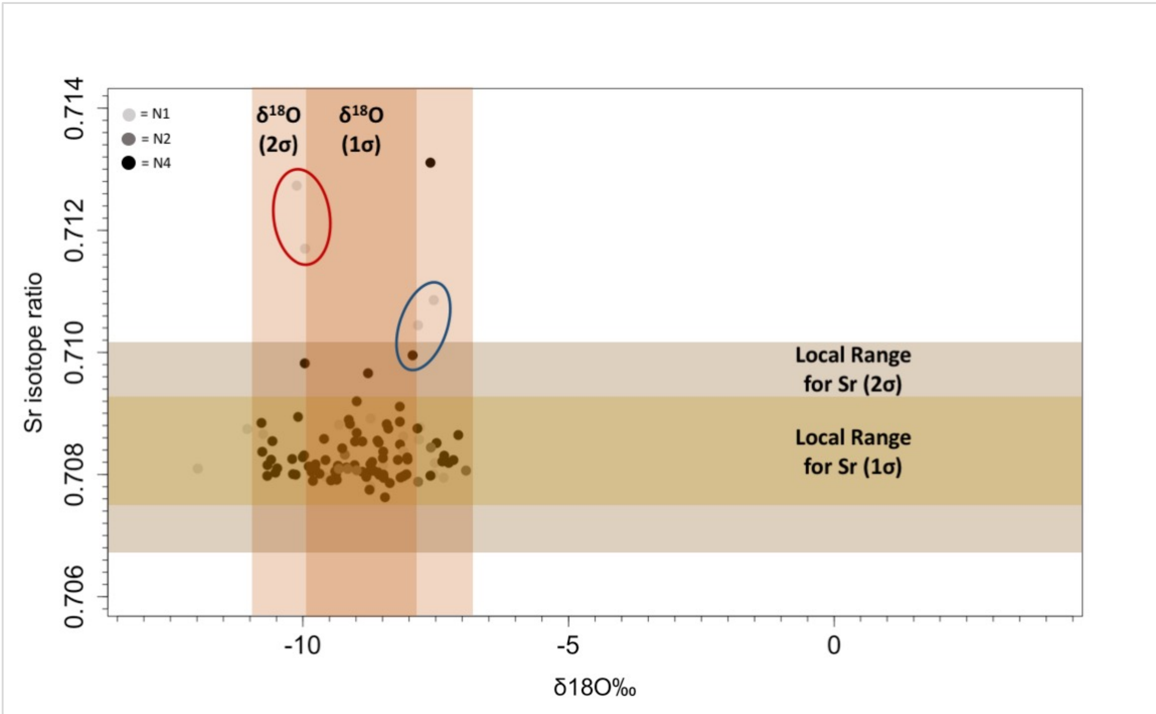
Figure 8.10 $\delta^{18}O$ values by mortuary area



Comparisons Between $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ Ratios

Plotting the $\delta^{18}O$ values against the Sr isotope ratios provides an opportunity to identify whether migrants are likely coming from the same home region (e.g. migrants with similar $\delta^{18}O$ and Sr isotope ratios), versus whether migrants come from different areas (e.g. variable $\delta^{18}O$ and Sr isotope ratios). Figure 8.11 shows the $\delta^{18}O$ values (at both 1σ and 2σ around the human mean) on the x-axis and the local Sr isotope ratio range (at both 1σ and 2σ around the human mean) on the y-axis. Two of the five individuals identified as non-local using strontium isotope ratios at 2σ share similar $\delta^{18}O$ values (red circle in Figure 8.11). Two additional individuals identified as non-local using strontium isotope ratios at 2σ, and another individual identified as non-local using strontium isotope ratios at 1σ, also share similar $\delta^{18}O$ values (blue circle in Figure 8.11). Accordingly, because both the Sr and O values are close for these two groups of individuals, is possible that they came from the same area.

Figure 8.11 $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values for Marroquíes humans



Results of Carbon and Nitrogen Isotope Analysis

Carbon and nitrogen analysis of mandibular bone collagen was only possible for N1 and N4, where 89 human mandibles preserved enough collagen for dietary isotopic analysis. Fifteen out of sixteen additional faunal remains from Ditch 4 also preserved sufficient collagen for incorporation into this analysis. Finally, of the 7 faunal samples taken from N4, 5 preserved enough collagen for analysis. When $\delta^{13}C$ and $\delta^{15}N$ values are plotted against each other, the dietary signature from the Marroquíes Bajos necropolises sampled is consistent with a diet consisting largely of C3 plants and terrestrial protein (Figure 8.12-8.15 – dietary boundaires in Figure 8.12 from Lai 2008).

Figure 8.12 $\delta^{15}N$ and $\delta^{13}C$ values for Marroquíes humans and fauna

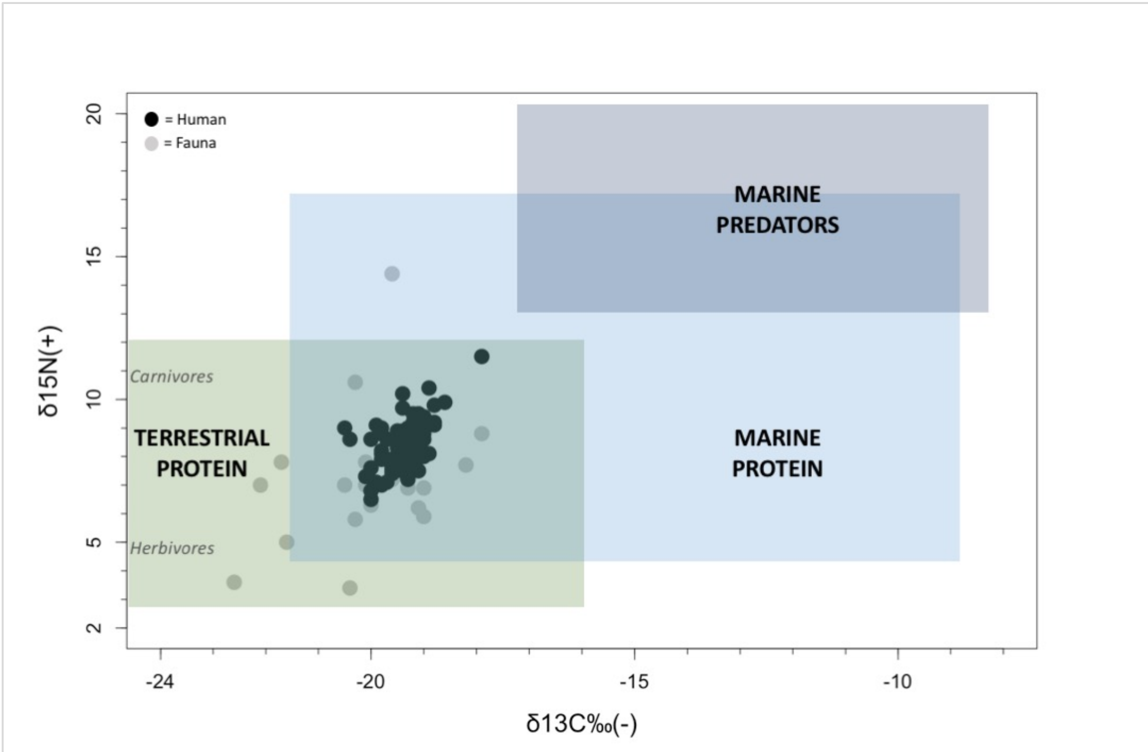


Figure 8.13 $\delta^{15}N$ vs. $\delta^{13}C$ by sex

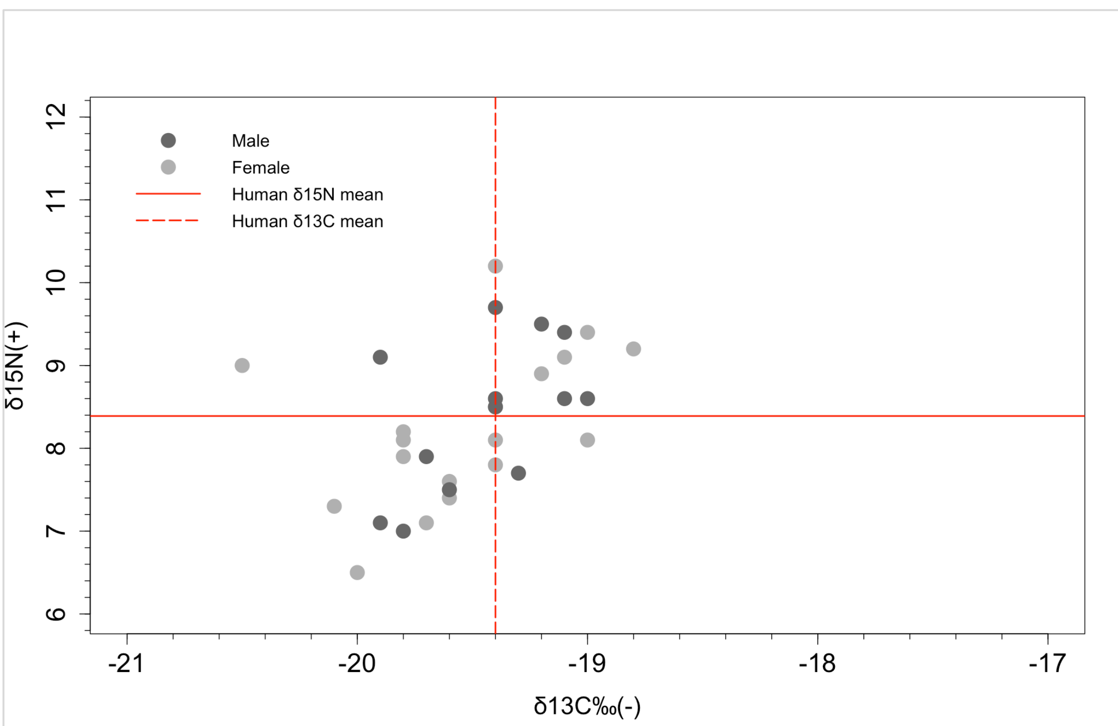


Figure 8.14 $\delta^{15}N$ vs. $\delta^{13}C$ by age category

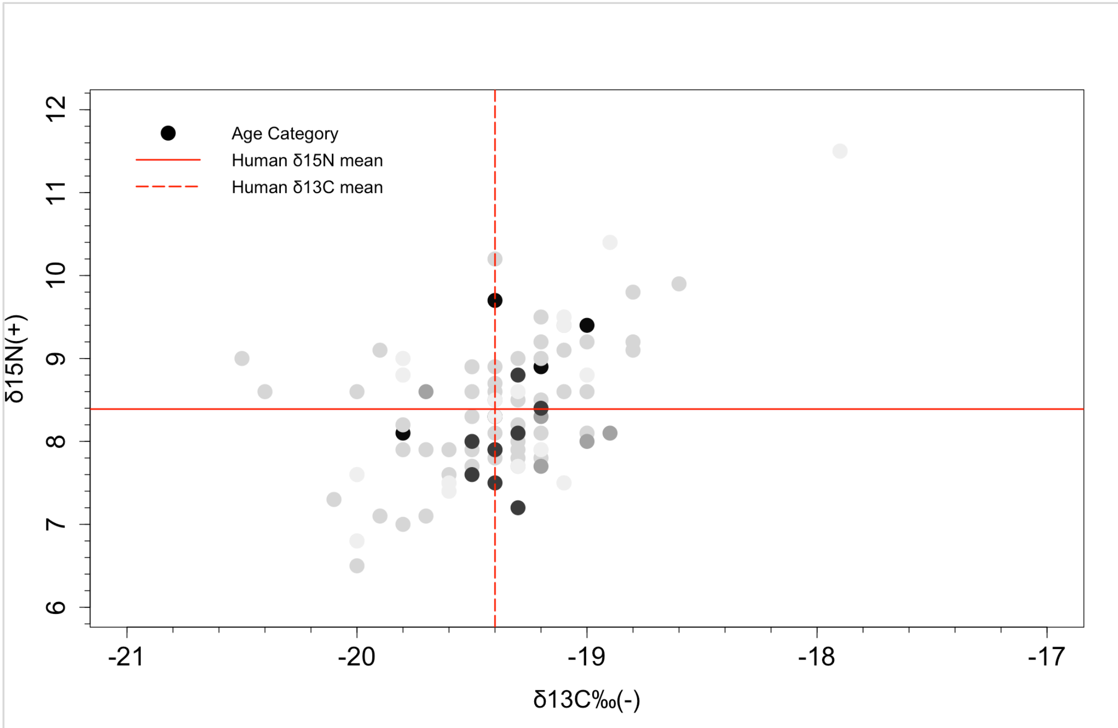
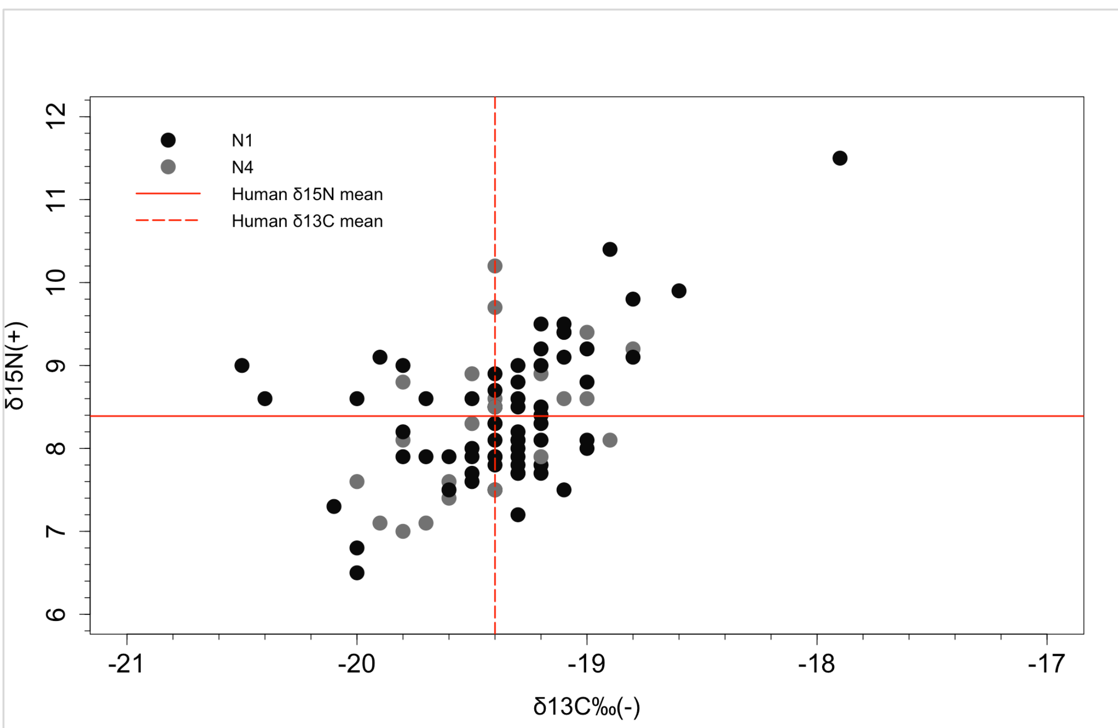


Figure 8.15 $\delta^{15}N$ vs. $\delta^{13}C$ by mortuary area



The combined human and fauna sample shows a mean $\delta^{13}C$ value of -19.4‰ ± 0.41, and the samples range from a minimum of -20.8‰ to a maximum of -17.9‰. The combined faunal remains (N = 20) showed an average $\delta^{13}C$ of -20.0‰ ±1.23 (1σ), and the samples range from a minimum of -22.6‰ to a maximum of -17.9‰. Imposing a range of two standard deviations away from the human mean (-18.6 to -20.2) reveals that four human values are outliers (Table 8.5). The human range overlaps the faunal range at the higher end, but the faunal range contains four values that fall below the lower end of the human spectrum (Figure 8.14). Estimation of sex was possible for only one of these outliers, and the estimated sex for this individual was female (Table 8.5). This individual (Field ID 51) also had a non-local strontium isotope ratio, so the lower $\delta^{13}C$ values may be related to non-local status. Three outliers are young adults, while the remaining individual is a child (Table 8.5). A Shapiro-Wilks normality test shows that the human $\delta^{13}C$ distribution departs significantly from a normal distribution (W = 0.93893, *P* = 0.0004001. A subsequent Mann-Whitney-Wilcoxon test showed no significant differences between N1 and N4 in the distribution of human $\delta^{13}C$ values (W = 658.5, p = 0.3456).

Table 8.5 Human $\delta^{13}C$ values >2σ or <2σ from human mean

Field ID	Lab ID (C/N)	Provenience	$\delta^{13}C$ Corrected	Midpoint Age	Age Category	Sex
34	3	N4	-20.8	27. 9	Young Adult	NP
51	34	N4	-20.5	24.0	Young Adult	Female
43	11	N4	-20.4	29.1	Young Adult	NP
115	100	N4	-17.9	2	Child	Subadult

The human mean $\delta^{15}N$ value was 8.4 ± 0.91(1σ), with a minimum value of 6.5 and a maximum value of 11.5 (range = 5). The faunal mean was 7.1 ± 2.35 (1σ), with a minimum value of 3.4 and a maximum value of 14.4 (range = 11). One value from a young adult female fell 2 standard deviations below the human mean (Table 8.6). Of the four human values that were more than two standard deviations above the human mean, two were subadult children with midpoint ages at 2 and 2.5, likely reflecting nitrogen enrichment related to nursing (Fogel et al. 1989; Waters-Rist and Katzenberg 2010). The remaining human value that fell more than two standard deviations below the human mean was a young adult for which estimation of sex was not possible.

Table 8.6 Human $\delta^{15}N$ corrected values >2σ or <2σ

Field ID	Lab ID (C/N)	Provenience	$\delta^{15}N$ Corrected	Midpoint Age	Age Category	Sex
57	62	N4	6.5	31.7	Young Adult	Probable Female
117	102	N4	10.4	2.5	Child	Subadult
115	100	N4	11.5	2	Child	Subadult
34	3	N4	11.8	27. 9	Young Adult	NP

As in Waterman et al.'s (2015) examination of 81 individuals from Late Prehistoric Portuguese mortuary sites, two of the highest $\delta^{15}N$ values in the N4 sample come from young children with midpoint estimated ages of 2.5 years, likely reflecting breast milk consumption. At N1, there is a 3.2‰ range in $\delta^{15}N$ values, from a low of 7.0‰ and a high of 10.2‰, representing a full trophic level difference between the lowest and highest values. At N1, the four highest and the four lowest values (each set of 4 individuals representing 17% of the N1 sample) all belong to adult individuals, meaning that this difference is not related to developmental differences in diet (e.g. breastfeeding). Of the four adults with values falling more than one standard deviation above the mean, two are "middle adults" (40-60 years age-at-death), and 3/4 (75%) of the middle adults sampled fall above the mean value for the N1 sample, indicating that meat consumption may have increased with age. Alternatively, if status was achieved at Marroquíes Bajos, rather than ascribed, these age-related differences may reflect dietary differences related to status (which would like increase with age).

At N4, where the average $\delta^{15}N$ value was 8.4 ± 0.84 (1σ), three individuals fell more than one standard deviation below the mean (two subadults and two young adult females), while nine individuals fell ≥ one standard deviation above the mean. Of these nine individuals, five were children, and four were young adults. Sex estimation was not possible for two of the young adults; the remaining two were estimated to be male. While the possibility of sex-based differences in diet are intriguing, the four $\delta^{15}N$ values from N1 which fall below the mean for this mortuary area are equally divided between individuals estimated to be male (N = 2), and individuals estimated to be female (N = 2). Accordingly, a larger sample size is necessary before making any claims about sex and diet.

The ranges and standard deviations of the $\delta^{13}C$ and $\delta^{15}N$ values are also comparable to other samples from Late Prehistoric Iberia (Waterman et al. 2014 a, b, 2015). The average $\delta^{13}C$ values from bone collagen for the Late Neolithic and Early Copper Age Portuguese mortuary sites of Paimogo I (c. 3300-2500 BC) and Feteira II (c. 3700-2900 BC) are slightly lower than the Marroquíes mean of 19.5 ± 0.4‰, at -20.2 ± 0.5‰ and -20.2 ± 0.3‰, respectively (Waterman et al. 2014). The Marroquíes $\delta^{15}N$ average falls between the average value for Paimogo I (8.5 ± 0.8‰,) and Feteira II (8.2 ± 0.5‰) (Waterman et al. 2014). However, the Marroquíes results do show a higher standard deviation of 0.9‰, perhaps indicating greater dietary variability in this sample (Table 8.7).

Table 8.7 $\delta^{13}C$ and $\delta^{15}N$ averages and standard deviations, by necropolis and in combined sample

Mortuary Area	N1	N4	All Humans (N1 + N4)
$\delta^{13}C$ average	-19.43	-19.38	-19.51
$\delta^{13}C$ σ	0.33	0.43	0.41
$\delta^{15}N$ average	8.33	8.46	8.42
$\delta^{15}N$ σ	0.86	0.93	0.91

Some of the faunal and human values show directional enrichment. For example, one human $\delta^{15}N$ value falls close to the marine protein boundary (Figure 8.14), while one faunal value (Field ID 110, the tibia of a small animal from Necropolis 4 unidentified to species) falls outside of the terrestrial protein boundary and within the marine protein boundary. The high $\delta^{15}N$ values for the faunal outlier may be related to consumption of human food waste, making the value likely to come from a more omnivorous domesticate such as a dog or a pig. The highest $\delta^{15}N$ human value is from MN.2.205.05 from Necropolis 4. This mandible was from a child 1-3 years of age, meaning that the nitrogen enrichment here is likely related to breast-feeding. The rest of the human sample has a more constrained $\delta^{15}N$ range than the faunal sample, but still shows a range of variation of 3.9‰, which is greater than a single trophic level.

Lovell et al. (1986) have suggested that standard deviations of < 0.3‰ for $\delta^{13}C$ datasets drawn from bone collagen are indicative of a population consuming a relatively homogeneous diet, while $\delta^{13}C$ standard deviations > 0.3‰ indicate a greater degree of dietary heterogeneity within the sample population. At Marroquíes, the $\delta^{13}C$ standard deviations for both N1 and N4 are > 0.3‰, but N1 is much closer to the cut-off (Table 8.7). This may indicate a slightly more heterogeneous diet at N4. Finally, the $\delta^{13}C$ and $\delta^{15}N$ values do not differ significantly between mortuary areas. A Shapiro-Wilks test for normality reveals that the human $\delta^{15}N$ values do not depart significantly from a normal distribution (W = 0.97315, P = 0.06, Figure 8.16). In contrast, the $\delta^{13}C$ values do depart significantly from a normal distribution (W = 0.93893, P = 0.0004, Figure 8.17). Both a T-Test of the $\delta^{15}N$ values (t = -0.36642, df = 37.977, P = 0.716) and a Wilcoxon Rank sum test of the $\delta^{13}C$ values showed no significant difference between values for N1 and N4.

Figure 8.16 Distribution of human $\delta^{15}N$ values

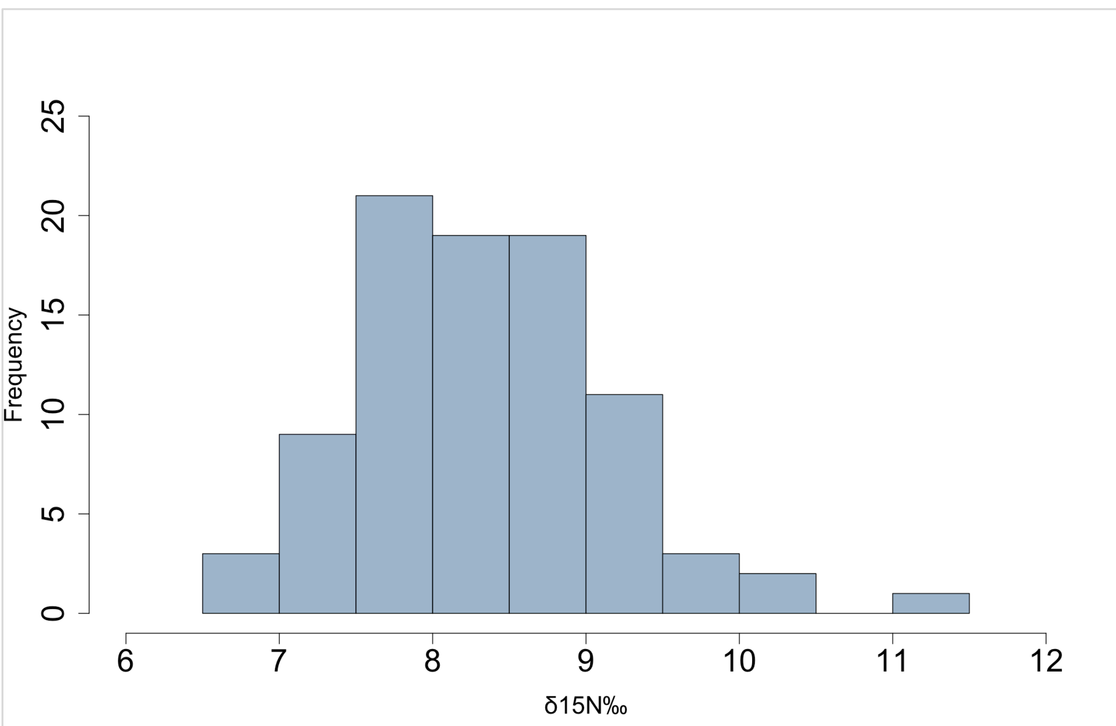
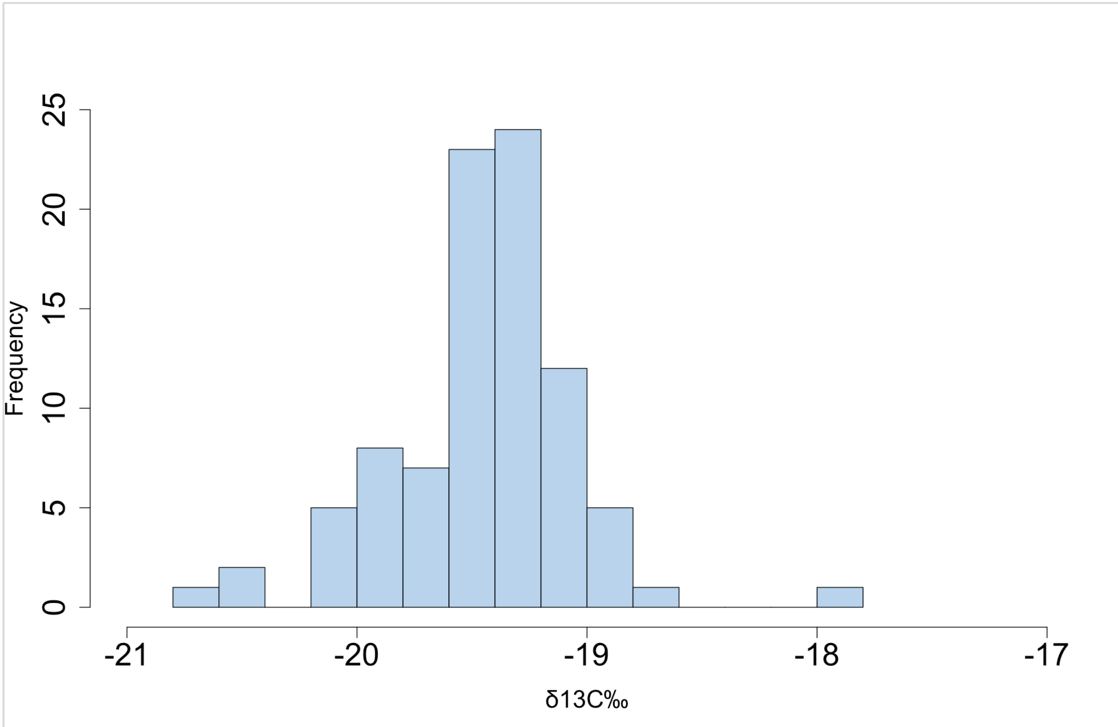


Figure 8.17 Distributions of human $\delta^{13}C$ values



Conclusions from Isotopic Analyses

Overall, the isotopic results demonstrate that the majority of the Marroquíes Bajos population likely spent their childhoods in relatively close proximity to the settlement. With the exception of the entirely local strontium isotope ratios for the Necropolis 2 population, there are no significant differences between mortuary areas in terms of the strontium isotope ratios. Given that only four individuals (12% of the necropolis MNI) were sampled for Necropolis 2 area, this result may be related to the small sample size for this mortuary area. While Necropolis 1 and Necropolis 4 both contained non-local individuals, these areas showed low levels of in-migration, with only 17% of the N1 sample and 5% of the N4 population identified as migrants due to non-local strontium isotope ratios. The high $^{87}Sr/^{86}Sr$ ratios expressed by non-local individuals, ranging from 0.710443-0.713107, fall within the range for other regions in Iberia, particularly the Central Range to the far north (Díaz-Zorita Bonilla 2013) or the Extremadura to the northwest (Waterman et al. 2014). While estimation of sex was possible for only 36/77 (47%) of the adult sample, all non-local strontium isotope outliers were female. This matches the pattern of female mobility that occurs at other Copper and Bronze Age Iberian sites (Díaz-del-Río et al. n.d. under review), as well as the pattern of female exogamy prevalent at Late Prehistoric sites in other regions of Europe (Seielstad et al. 1998; Price et al. 1998, 2001; Bentley et al. 2002; Bentley et al. 2008).

The results from the oxygen isotope analyses reveal the potential for inaccuracy in determining local prehistoric ranges using modern IAEA precipitation data. This analysis highlights that alternate strategies must be developed, particularly when no local IAEA sites are available. A process similar to that used for strontium, where boundaries are established for $\pm 1\sigma$ and $\pm 2\sigma$, produced a local range that aligned much more closely with the distribution of $\delta^{18}O$ values in the sample. It is also promising that this method showed some potential groupings of individuals by geographic origin based on both strontium isotope ratios and $\delta^{18}O$ values (Figure 8.11).

Only two individuals fall outside of the 2σ range for $\delta^{18}O$. However, as these individuals have strontium isotope ratios within the local range, this variability could be related to type of water source (e.g. natural streams or rivers relative to wells), location of water source (e.g. local water from the lowlands relative to local water from higher altitudes in the Sierras de Jaén), or differences in individual consumption of dairy products. Unfortunately, without more detailed data on the oxygen signatures for local water sources, it is not yet possible to parse out these different, but potentially overlapping factors, and this may provide a productive avenue for future research. Based on paleoclimatic data from Iberia Yanes et al. argue that "it seems logical to assume a paleoclimatic scenario for Jaén where the rain $\delta^{18}O$ values and the ambient temperatures at ~4470-3880 cal BP were relatively similar to those observed at present" (2013:84), so it is less likely that variability in human $\delta^{18}O$ values is related to changes in climate or rainfall during the occupation of the site.

The $\delta^{15}N$ and $\delta^{13}C$ values reveal a diet comprised largely of terrestrial protein, with enrichment at the level of a marine diet only recorded for one faunal sample (Figure 8.12). In regards to $\delta^{13}C$, T-tests and Wilcoxon Rank Sum tests showed no significant differences in signatures between N1 and N4. The N1 human $\delta^{13}C$ standard deviation is low (±0.33‰), close to the Lovell et al. (1986) cut-off point for a high degree of dietary homogeneity. The human $\delta^{13}C$ standard deviation is higher for N4 (±0.44‰), suggesting a slightly more heterogeneous plant diet at this area.

Finally, $\delta^{15}N$ values do not differ significantly between N1 and N4. However, for both necropolises, variation between individuals is greater than, or equal to, one trophic level (N1=3.2‰, N4 = 3.9‰)[34]. This suggests that some individuals (the right tail of the distribution in Figure 8.16) consumed a much greater amount of protein than others (the left tail of the distribution in Figure 8.16). Based on the lack of statistical significance for the N1 versus N4 values, this difference does not appear to be related to membership in the social groups responsible for burial in each necropolis. Instead, variability in protein consumption may be related to achieved status, as at both N1 and N4 all adults with $\delta^{15}N$ scores > 9‰ have estimated midpoint ages of > 27 years, while all subadults in this range with are young enough (≤ 2.5 years) that this signature most likely reflects breastfeeding.

The AMS Radiocarbon Sample

There have been two rounds of radiocarbon dating for the Marroquíes Bajos sample from N1, N2, and N4. The first set of dates was taken on 3 samples of post-cranial human bone from N2, and processed and analyzed at the University of Heidelberg. The second set of dates was taken on 33 human mandibles and 1 human tooth from N1, N2, and N4. These 34 samples were analyzed at the University of Arizona.

In regards to the first set of radiocarbon dates, in the fall of 2013 I selected three samples of well-preserved post-cranial bone from three different mortuary structures at Necropolis 2. I chose anatomically overlapping portions of femoral shafts from discrete individuals – a left femur from Structure 45, a right femur from Structure 39, and a right femur from Structure 44 (Figure 8.18). The two right femoral shafts from Structure 39 and Structure 44 mirrored existing left femoral shafts from the same mortuary structure in their size, robusticity, and taphonomy, so the left femoral shaft from Structure 45 is from a different individual.

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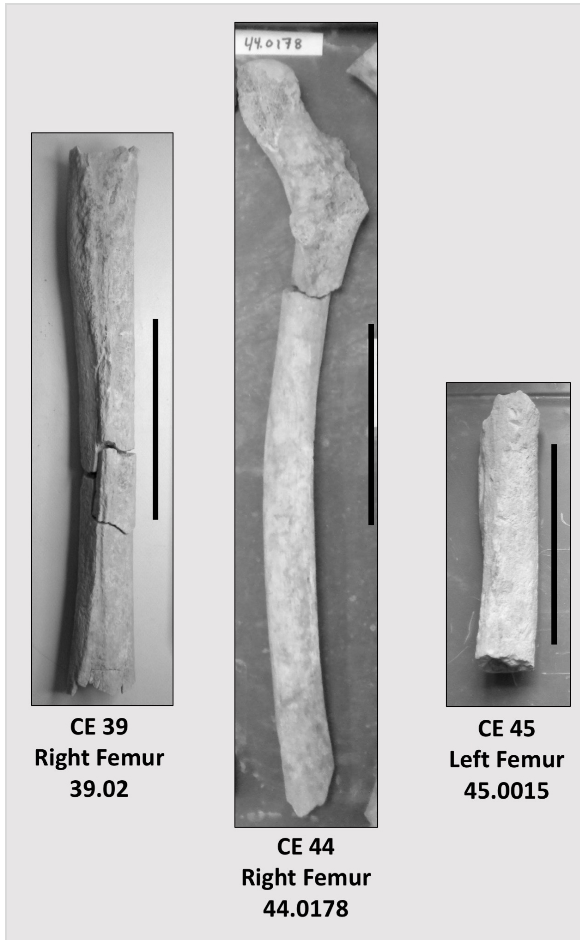
[34] This range does not include the most enriched child value of 11.5‰ from the N4 data set. If this value is included, the N4 $\delta^{15}N$ range rises to 5‰.

Figure 8.18 Femoral shafts sampled for radiocarbon dates, Fall 2013



These three mortuary contexts were chosen to (1) ensure that the conditions of preservation for human bone from N2 would allow the material to be radiocarbon dated, and (2) to examine whether these structures overlapped in time. Structure 39 was the sole interment from N2 (MAMS20041) that contained no grave goods, so it was selected in order to determine whether this represented a diachronic shift in mortuary practices, or whether the mortuary structures with grave goods chronologically overlapped with the mortuary structures without grave goods. Structure 44 (MAMS20042) contained a copper halberd, an artifact more typical of the Bronze Age in the region. However, the ceramics recovered from this structure were typologically Copper Age, so establishing the chronology of this mortuary area was important. Finally, Structure 45 (MAMS20040) contained many ceramic sherds, as well as a bone *punzón* (hair pin or awl), but no elaborate grave goods comparable to the copper halberd. A radiocarbon date from this structure could be used to resolve the degree of overlap between the three mortuary structures. Funding for these three samples was provided by Dr. Isabel Martínez-Navarrete's project *Provincias metalúrgicas Euroasiática y Europea del II milenio a.n.e.: investigación de sus interacciones a partir de métodos científico-naturales* (2010RU0086). These samples were processed by the Klaus Tschira Archaeometry Center laboratory at the University of Heidelberg.

In the fall of 2014, an additional 34 samples were selected from Necropolis 1, 2, and 4 for AMS radiocarbon dating. All samples were drawn from the larger isotopic sample of 113 human individuals described in the discussion of isotopes. The entire second radiocarbon sample is thus a sub-sample of the right mandibular bodies containing RlM2s or Rldm2s, or individual RlM2s or Rldm2s. Out of the 113 human samples, Dr. Marta Díaz-Zorita Bonilla identified 41 samples that were the best candidates for AMS radiocarbon dating due to their quality, level of preservation, and amount of collagen. Within this list, I selected samples with the broad aim of choosing dates that were roughly proportional to site MNI (e.g. the greatest number from N4, followed by N1, and N2).

At Necropolis 1, samples were selected with the goal of targeting multiple mortuary structures, investigating the history of use of individual structure floors, radiocarbon dating adult individuals of both sexes, and dating non-local outliers for strontium. Samples from N1 come from all mortuary structures from which human remains were recovered, with the exception of Structure 52, which contained only a partial human fibula shaft. Three samples were taken from Structure 13, four samples were taken from Structure 14, one sample was taken from Structure 21, and one sample was taken from Structure 27. The dates from Structure 13 are taken from peripheral primary burials N1.CE13.11 (AA107186) and N1.CE13.12 (AA017182), and peripheral secondary burial N1.CE13.11 (AA107185). These three burials are located on the same level (Floor II) of Structure 13, providing information about whether burials on individual structure levels were the result of a single inhumation episode, or whether these floors were re-used over generations.

There are four dates from Structure 14. N1.CE14.05 (AA017187) and N1.CE14.08 (AA017188) are primary burials from Floor I, located in the center of a cluster of multiple inhumations, while N1.CE14.13 (AA017183) and N1.CE14.14 (AA017184) are central primary burials from Floor III. The dates from Structure 14 therefore provide insight into the chronology and duration of structure floor use. Finally, the two additional dates from Structure 22 (AA017181) and Structure 27 (AA107189) provide information about the use and organization of the entire necropolis. It is particularly important to establish the chronology of Structure 22 relative to the other mortuary structures, as Structure 22 is unique due to both its central position in the necropolis, and because it contains only one individual, a young adult (probable male).

I selected two additional samples from N2 with the goal of expanding the coverage of the site and testing the chronology of individual mortuary structures. In addition to the previous dates on femoral shafts from Structure 39 (MAMS20041), Structure 44 (MAMS20042), and Structure 45 (MAMS20043), I selected an additional tooth from Structure 41(AA107213) in order to understand whether the mortuary structures were used simultaneously or sequentially. I also selected a mandible from Structure 44 (AA107212) to test whether the use of this mortuary structure was of short duration (e.g. limited to a generation), or whether this mortuary structure was re-used over the entire Marroquíes Bajos occupation.

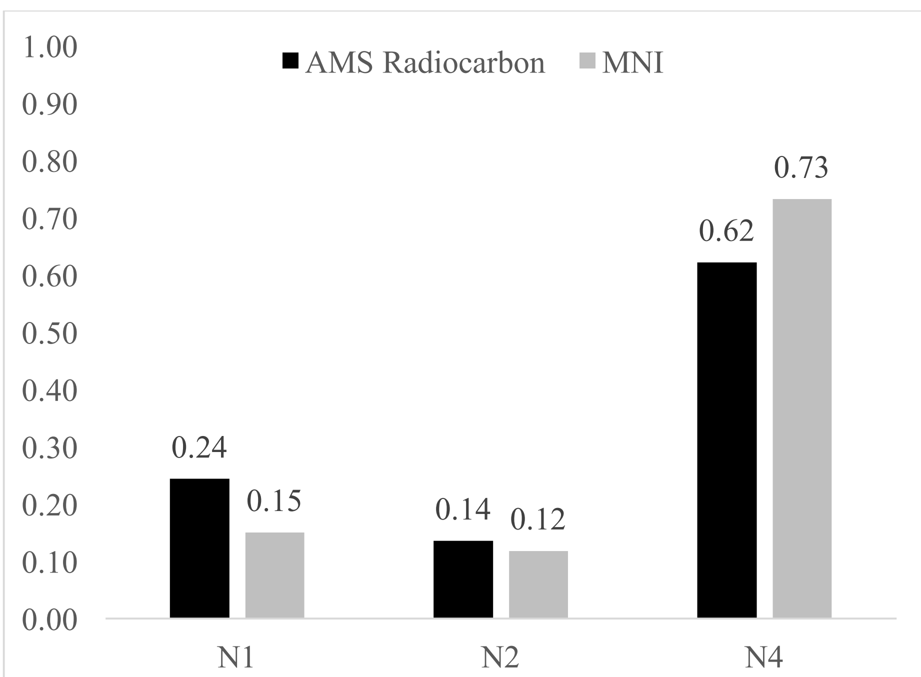
Sample selection for N4 was more difficult, due to the complicated excavation and re-excavation history at this mortuary area (Chapter 4). Here, samples were selected from both Tomb I (N = 16) and Tomb III (N = 7). Unfortunately, none of the isotopic samples from Tomb II (The Cave of the Child) preserved sufficient collagen for AMS radiocarbon dating. At Tomb I, all samples were drawn from *in situ* layers that were not excavated until 2001, taken from both the chamber (N = 6) and the corridor (N = 10). Tomb III was not excavated until 2001, so all of the samples from this area are taken from *in situ* layers. The field maps available for this tomb suggest three different use phases. The first represents a disordered jumble of bones. The second occurred after the first burials in the chamber (Stratigraphic Unit 6) had been removed and covered by a layer of dirt. A new layer of human remains was deposited in the corridor during this phase. This phase was capped by deliberate dumping of stones inside the burial. Finally, in the third phase, a new layer of human remains was deposited by removing dirt and stones in extreme opposite ends of the chamber, against the northeastern side of the entrance. This final third phase of use was covered with a layer of dirt, which represents the final mortuary use of this cave. The six individuals sampled for AMS radiocarbon dating come from all three of these phases. The distribution of dates by necropolis, age category, and mortuary area are described in Table 8.8. The sample proportions roughly parallel the MNI proportions estimated for these three mortuary areas (Figure 8.19).

Table 8.8 Description of the 34 dates drawn from the isotopic sample

Provenience	N1	N2	N4	Total
Number of Dates	9	2	23	34
Adults	9	2*	17*	28
Subadults	0	0	6	6
Males/ Probable Males	4	0	5	9
Females/Probable Females	4	0	2	6
Indeterminate	0	0	1	1
Sex Not Possible	1	2	9	12

*One of the individuals from N2 (N2.44.A4) and one of the individuals from N4 (MN.3.140.01) are of indeterminate age, but are likely adult due to either resorption of alveolar bone (N2.44.A4) or presence of the RlM3 socket (MN.3.140.01).

Figure 8.19 % MNI and % AMS radiocarbon sample, by mortuary area



Results of AMS Radiocarbon Analysis

All three samples sent to the University of Heidelberg laboratory returned dates. Two out of the thirty-four of the samples sent to the University of Arizona laboratory (AA107212 from N2, and AA107197 from N4) did not preserve sufficient amounts of collagen, and did not return dates. Four of the samples did not yield enough collagen to produce $\delta^{15}N$ and C/N ratios, so the ^{14}C measurement was used for these dates. One date (AA107190) had a C/N ratio of 3.9, higher than the theoretical value of 3.2-3.3, and outside of the acceptable window referenced in van Klinken (1999). Results of the dates are shown by provenience in Table 8.9 and 8.10 and Figure 8.20. Results are also available in Appendix F, where detailed provenience information, age, sex, pathology, and biochemical and geochemical isotopic results are also available.

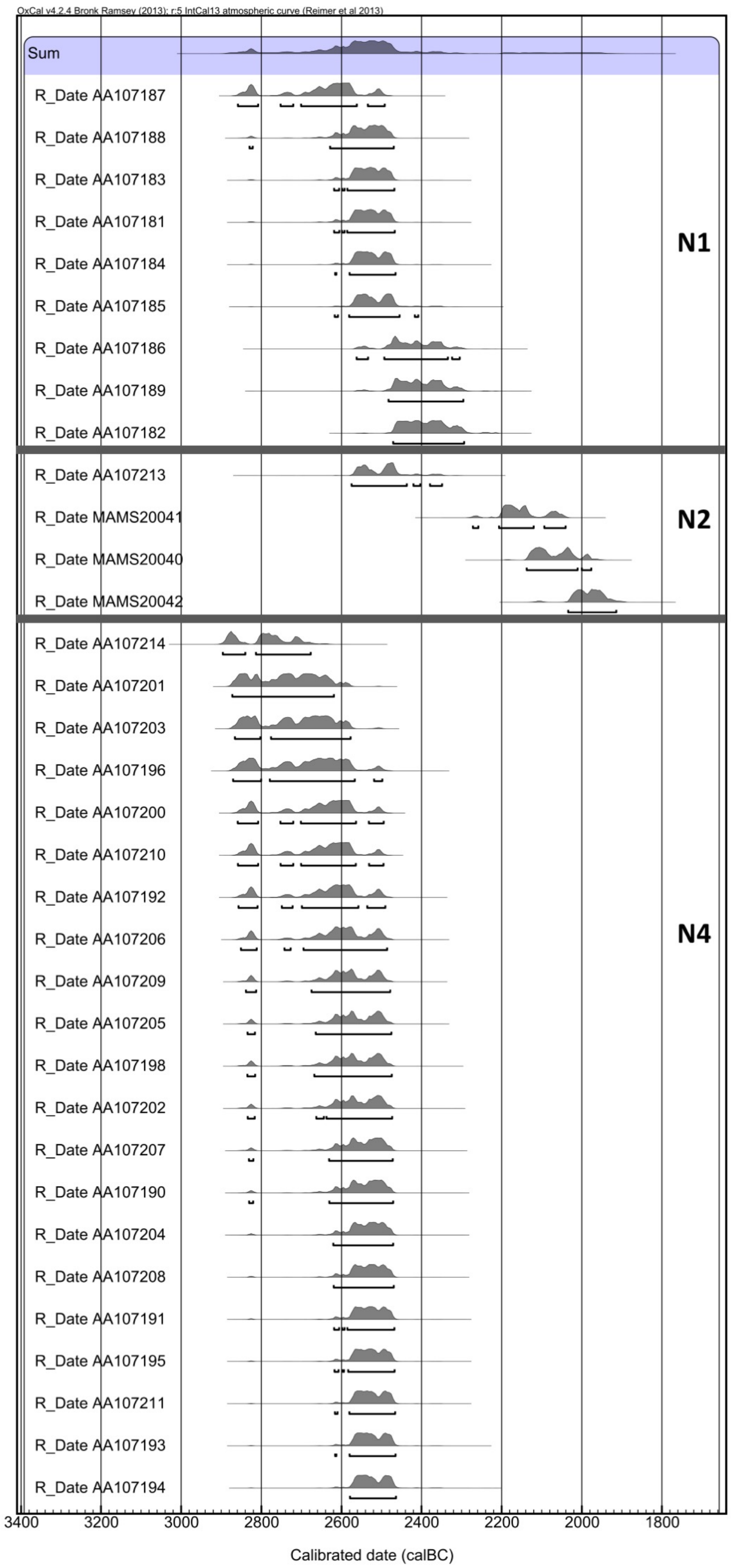
Table 8.9 Uncalibrated AMS radiocarbon dates for Necropolis 1 and 2

Sample ID	Uncalibrated ^{14}C Date	±	Provenience	Structure or Tomb	Element ID	Sex	Age Category
AA107182	3902	32	N1	Structure 13	N1.CE13.12	Probable Female	Middle Adult
**AA107189	3919	32	N1	Structure 27	N1.CE27.A27.01	NP	Young Adult
AA107186	3934	32	N1	Structure 13	N1.CE13.11	Male	Young Adult
**AA107185	3987	34	N1	Structure 13	N1.CE13.13	Probable Female	Middle Adult
**AA107184	4002	32	N1	Structure 14	N1.CE14.14	Female	Middle Adult
AA107181	4011	33	N1	Structure 22	N1.CE22.01	Probable Male	Young Adult
AA107183	4013	32	N1	Structure 14	N1.CE14.13	Male	Young Adult
AA107188	4027	34	N1	Structure 14	N1.CE14.08	Female	Young Adult
AA107187	4080	33	N1	Structure 14	N1.CE14.05	Probable Male	Young Adult
MAMS20042	3621	21	N2	Structure 44	44.0178	NP	Adolescent/Adult
MAMS20040	3675	22	N2	Structure 45	45.0015	NP	Adolescent/Adult
MAMS20041	3745	23	N2	Structure 39	39.02	NP	Adolescent/Adult
AA107213	3970	32	N2	Structure 41	T.41.16	NP	Young Adult

Table 8.10 Uncalibrated AMS radiocarbon dates for Necropolis 4

Sample ID	Uncalibrated 14C Date	±	Provenience	Structure or Tomb	Element ID	Sex	Age Category
AA107199	3952	32	N4	Tumba I	MN.2.195.02	Subadult	Juvenile
AA107194	3997	32	N4	Tumba I	MN.4.065.05	NP	Young Adult
AA107193	4002	32	N4	Tumba I	MN.4.065.04	NP	Young Adult
AA107211	4004	32	N4	Tumba III	MN.3.203.02	Subadult	Juvenile
AA107195	4011	32	N4	Tumba III	MN.3.065.01	Probable Male	Young Adult
AA107191	4013	32	N4	Tumba I	MN.4.065.02	NP	Middle Adult
AA107208	4019	32	N4	Tumba I	MN.2.141.02	Subadult	Juvenile
AA107204	4023	32	N4	Tumba III	MN.3.078.01	NP	Young Adult
AA107190	4031	33	N4	Tumba III	MN.3.033.01	NP	Young Adult
AA107207	4035	33	N4	Tumba I	MN.2.294.01	Female/ Probable Female	Young Adult
AA107202	4044	33	N4	Tumba I	MN.4.091.01	Indeterminate	Young Adult
AA107205	4049	31	N4	Tumba I	MN.2.280.01	Male/ Probable Male	Young Adult
AA107198	4049	33	N4	Tumba I	MN.2.194.01	NP	Young Adult
AA107209	4057	31	N4	Tumba I	MN.2.197.01	Subadult	Child
AA107206	4064	32	N4	Tumba I	MN.2.286.01	Male	Young Adult
*AA107192	4075	34	N4	Tumba I	MN.4.065.03	NP	Young Adult
AA107210	4084	32	N4	Tumba I	MN.4.073.01	Subadult	Child
*AA107200	4084	33	N4	Tumba I	MN.2.205.03	NP	Young Adult
AA107196	4102	41	N4	Tumba III	MN.3.072.01	Male	Young Adult
AA107203	4119	32	N4	Tumba III	MN.3.140.01	NP	NP
**AA107201	4136	31	N4	Tumba I	MN.2.205.06	Female	Young Adult
AA107214	4204	32	N4	Tumba III	MN.3.129.03	Subadult	Child

Figure 8.20 Summed dates for Necropolis 1, 2, and 4



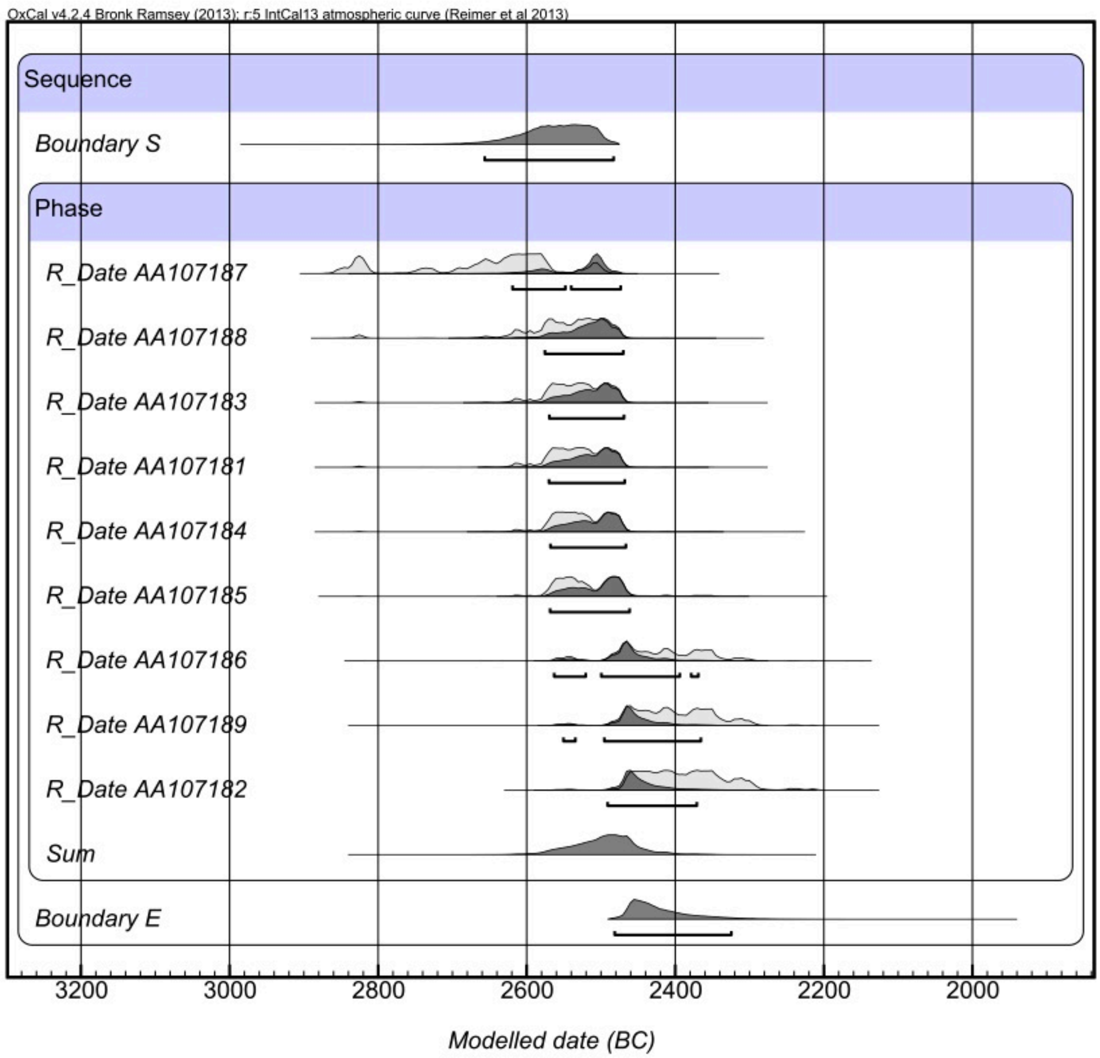
The dates agree with the existing Copper Age chronology of the site, establishing a peak of activity in N1 and N4 between 2600 and 2400 cal BC (see posterior sum density curve from OxCal at the top of Figure 8.20). These dates fall earlier than the unitary model of site formation developed by Hornos Mata et al. (1998) and Zafra de la Torre et al. (1999, 2003) would suggest. These archaeologists argue that the peak of construction and mortuary activity at the site occurred during the ZAMB 3 phase, from approximately 2460-2310 BC (Chapter 3). The dates from N1 and N4 fall slightly earlier than the posited peak of activity during ZAMB 3: only the later dates from N1 overlap with this "peak range," meaning that some activity at this mortuary area could have been contemporaneous with the large-scale ditch construction. In contrast, the dates from N4 suggest that this mortuary area was used earlier than the posited peak period of activity, and was likely contemporaneous with the construction of the first enclosure and beginnings of Copper Age occupational activity at the site.

N2 presents a clear exception to this pattern, as these three dates fall later, from c. 2250 – 1900 cal BC. In contrast, none of the dates from N1 or N4 fall after 2350 cal BC (1σ). These dates suggest that each mortuary area was used for between 40 and 380 years at 1σ, or between 2 to 16 generations (when treating 25 years as the span of one generation). In the following sections, the dates for Necropolis 1, 2, and 4 are discussed separately, before being compared to the rest of the existing dates from the site

Dates from Necropolis 1

When a single phase model is run in OxCal 4.2 to test whether the Necropolis 1 dates could come from a single phase, the results show a relatively high A index (A_{model}=101.8, $A_{overall}$=100.5); thus, the hypothesis of multiple deposition events can be rejected. At 2σ, these dates suggest that mortuary activity started at between c.2660-2480 cal BC, and ceased at between c.2480-2330 cal BC. This sample of dates is internally coherent, and compatible with a single-phase model. The posterior sum density calculated for the Necropolis 1 single phase model departs from a standard growth and decline model; these results suggest a relatively slow tempo of initial deposition at c.2580 cal BC, followed by a period of increased use from c.2560 cal BC onwards, before a rapid decline in use at c.2460 cal BC (Figure 8.21). This period of use of around 100 years suggests employment of this necropolis by multiple generations.

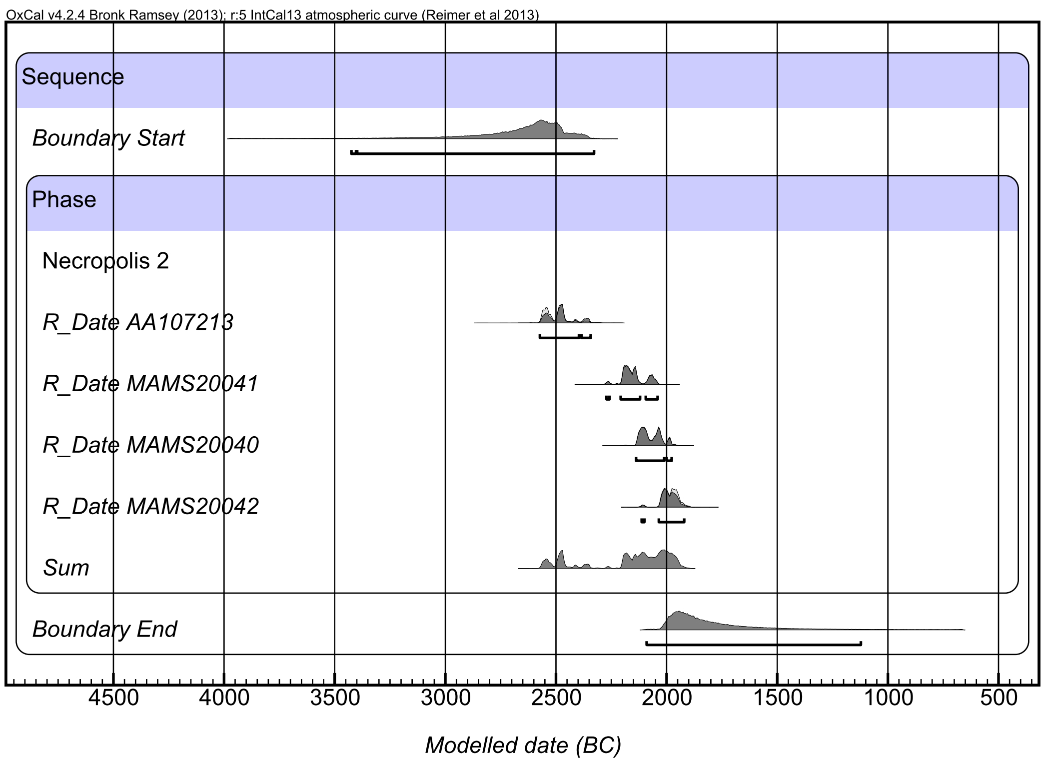
Figure 8.21 Posterior sum density for Necropolis 1, single phase model



Dates from Necropolis 2

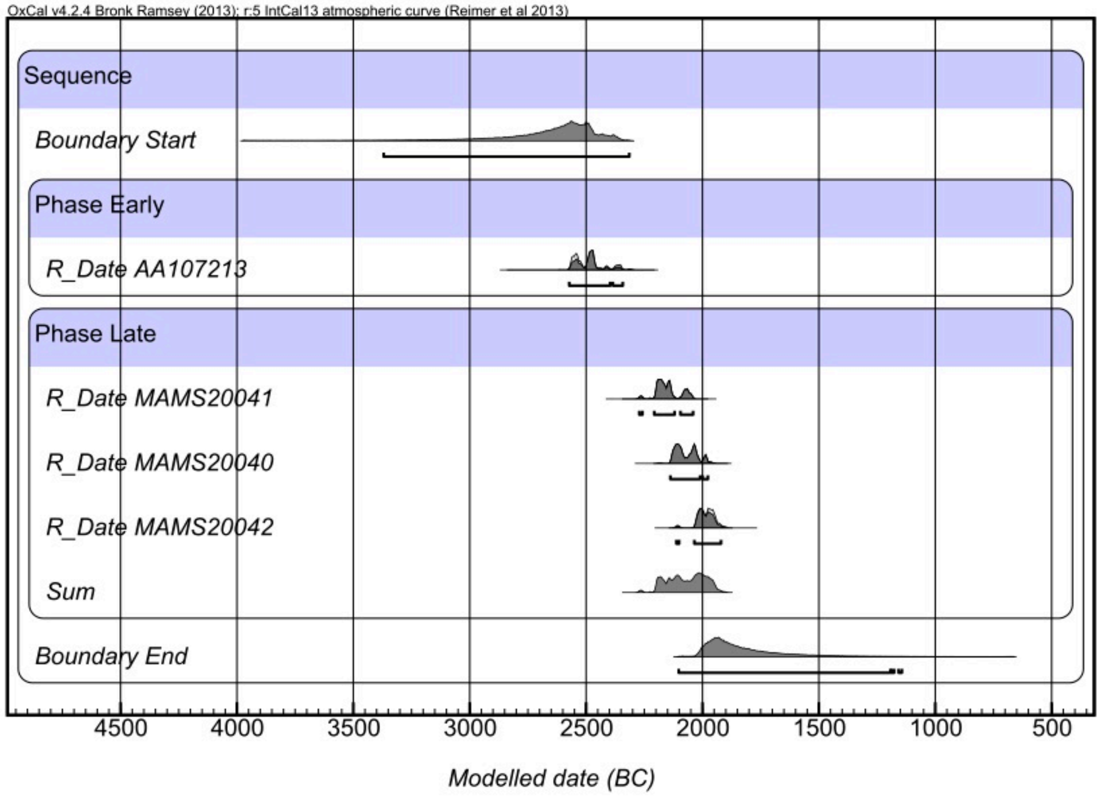
When a single phase model is run for Necropolis 2, the A-index is lower than that for Necropolis 1, (A_{model} = 94.2, $A_{overall}$ = 94.4) but does not provide evidence against a single phase of use. At 2σ for the single phase model, these dates suggest that mortuary activity started at between c. 3370-232- cal BC, and ceased at between c.2090-1130 cal BC. The ranges for the boundary start and end in OxCal are likely so broad because the date for AA107213 falls far earlier than the remaining three dates. When the posterior sum density is calculated for the single phase model for N2, it shows two distinct periods of use: an earlier phase from either c.2500-2550 cal BC, or c.2500-2450 cal BC, and a later phase from c.2250–1950 BC. (Figure 8.22).

Figure 8.22 Posterior sum density for Necropolis 2, single phase model



When a two-phase model is employed, the dates from N2 cluster around an early phase at either c.2500-2550 cal BC or c.2500-2450 cal BC, and a later phase at c.2200-1950 (Figure 8.23). There could be a number of explanations for this chronological pattern, especially given the small sample size for this necropolis (N = 4). Possible explanations include (1) Repeated and continuous use of Necropolis 2 over several hundred years; (2) Episodic re-use of this mortuary area both during and after the height of occupational activity at Marroquíes Bajos, and (3) The interment of a much older individual as a foundational deposit, explaining the several hundred-year discrepancy between AA107213 and the other dates.

Figure 8.23 Posterior sum density for Necropolis 2, two phase model



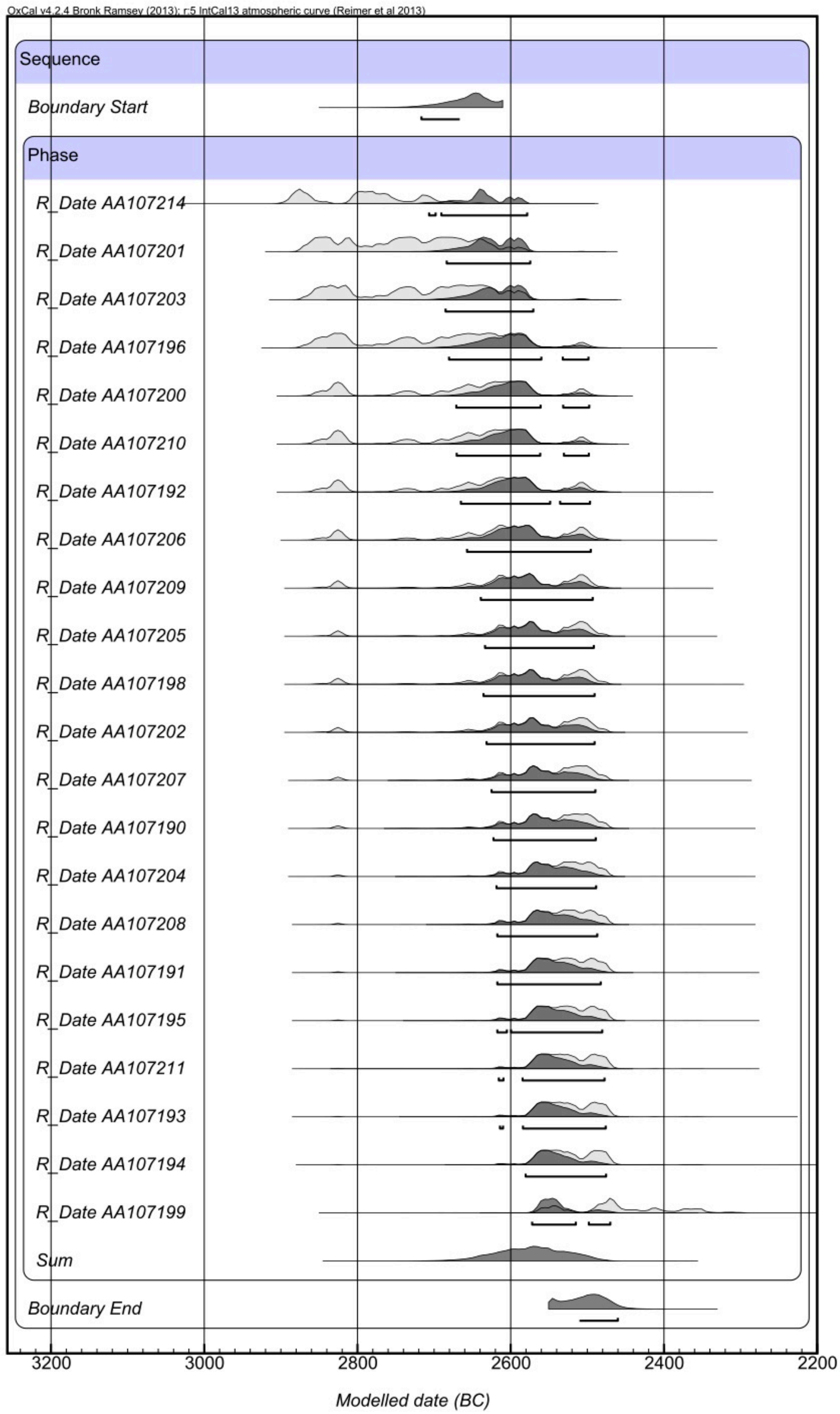
The differences between dates for structures at N2 are not unanticipated given the information provided by the site report (Chapter 4). Structure 41, which contains the earliest radiocarbon date for this mortuary area, has a distinct from the later mortuary structures. Instead of an oval pit excavated into bedrock, Structure 41 was described as "an accumulation of ceramic [sherds] and some bone," found during excavations of the ditch itself. In contrast, Structures 39, 44, and 45 were all circular or oval structures that were deliberately dug out in prehistory. Structure 44 contained complete ceramics and a sword with rivets (*una hoja de una espada con remaches*), an assemblage which lead the archaeologists who excavated the site to relative date the mortuary structure to the Early Bronze Age (Figure 8.24). Structure 45 also contained complete ceramics, although no metal artifacts were reported. In contrast, Structure 39 contained no artifacts, so absolute dating is the only method that can establish a time frame for the interments in this structure.

Figure 8.24 Structure 44, Planta III (courtesy of the *Consejería de Cultura de la Junta de Andalucía - Delegación Provincial de Jaén*)

Dates from Necropolis 4

When a single phase model is run for Necropolis 4, the A index value suggests that these dates are compatible with a single episode of use (A_{model} = 70, $A_{overall}$ = 78.1). AA107214, an uncalibrated date of 4,204 ± 32), had an A index of 9, producing a warning for poor agreement in OxCal. All the remaining dates had A-indices of 67.6 or greater, with 18/21 showing A-indices > 100. However, though AA107214 contributes poorly to the model, the overall A-index is greater than sixty, suggesting that this early date is still not incompatible with a single phase model (Figure 8.25).

Figure 8.25 Posterior sum density for Necropolis 4, single phase model



At 2σ for the two phase model these dates suggest that mortuary activity started by c.2720 BC, and ended by c. 2460 cal BC. The highest plateau of the posterior sum density curve occurs at c.2660-2480 cal BC, so the necropolis was likely used during this time period. In contrast to N1, which shows an increasing rate of deposition followed by a steep drop, or N2, which shows multiple phases of use, the posterior sum density cover for N4 has a relatively even tempo of deposition, likely reflecting continuous use during the mid-third millennium.

Conclusions Concerning the AMS Radiocarbon Dates

During the first phase of occupation at Marroquíes Bajos, sometime between 3000 cal BC and 2500 cal BC, the site is characterized by small-scale domestic facilities like storage pits, refuse deposits and "underground huts" (Díaz-del-Río 2004:91). The new radiocarbon dates from Necropolis 1 and Necropolis 4 suggest that these mortuary areas were likely contemporaneous with this use of the site. Necropolis 4, in particular, may have been used when the first indications of Copper Age occupational activity, like the construction of the first ditch (Enclosure 0) occurred. Some of the later dates from N1 may be contemporaneous with increasing activity at the site, when Marroquíes Bajos increased to its largest spatial extent of 113 ha, and the number of contemporaneous sites inhabited in the surrounding landscape dropped to the lowest level in the entire Late Prehistoric sequence (Díaz-del-Río 2004). As most of the significant architectural elements that the site is known for – such as the ditches, the bastioned adobe wall surrounding the fifth ditch, and wooden palisades and bastions surrounding the fifth ditch – were likely already built by c. 2450 cal BC, these two necropolises appear to pre-date or coincide with the most significant period of construction at the settlement (Díaz-del-Río 2004).

In contrast to Necropolis 1 and 4, the majority of the dates from Necropolis 2 occur after the posited peak of activity at Marroquíes, falling between c.2250–1950 BC. These coincide with the later Phase IV, a period when the number of regional sites increases with occupation expanding throughout the *campiña* at a smaller scale than Phase III. During this period, medium-sized regional centers like Los Alcores and Albalete renew their fortified lines, while small-scale sites like the settlement of Cazalilla are also fortified, suggesting the possibility of a widespread need for defense in the area. These dates reveal a later, Early Bronze Age re-use of Marroquíes Bajos for mortuary purposes. It is unclear whether Structures 39, 44, and 45 were deliberately located in close proximity to earlier Copper Age interments, and this seems unlikely as the burials from Structure 41 were in fact interred within the ditch. Unless this tumulus was marked by surface indications of this presence (e.g. a cap of stones), it is uncertain as to how Early Bronze Age groups would have been able to identify its presence.

In regards to the two other mortuary areas that have previously been analyzed, the dates from Necropolis 1 and Necropolis 4 overlap with Cámara Serrano et al.'s (2012a) suggested earlier period of intensive use for Necropolis 3, between c. 2572-2465 cal BC. If accurate, the later dates from Necropolis 2 could overlap with the postulated later period of use for Necropolis 3 that occurs between c. 2351-2132 BC.

The majority of the new dates from Necropolis 1 and 4 occur before the period of depopulation and reduced activity at c. 2100 cal BC posited by Díaz-del-Río (2004) and Zafra de la Torre et al. (1999, 2003). Unfortunately, a larger sample of dates from Necropolis 2 is required before definitively defining a period of use for this mortuary area. Especially important is determining whether only Structure 41 is Copper Age, or whether undated Structure 43 is also Copper Age. Accordingly, these results suggest that two of the three major mortuary areas at Marroquíes (Necropolis 1, Necropolis 3, and Necropolis 4) were established and used prior to this point in time.

Accordingly, these new dates do not provide evidence against the hypothesized period of depopulation and reduced activity beginning at c. 2100 cal BC posited by Díaz-del-Río (2004) and Zafra de la Torre et al. (1999, 2003). While Cámara Serrano et al. (2012a, 2012b) have suggested a scenario in which "the town was maintained in the early second millennium, with structural transformations and the survival of certain ritual practices, [and there is the possibility that] ritual areas continued to be frequented and reused throughout the entire second millennium BC II" (Cámara Serrano 2012a:92, translation mine), there is no chronological evidence that suggests that either Necropolis 1 or Necropolis 4 was still being used during this later period.

Chapter 9

The Bioarchaeological and Mortuary Record at Marroquíes Bajos

> *Mortuary facilities and mortuary spaces are often portrayed as static receptacles for the disposal of the dead. Nothing could be further from the truth; mortuary spaces serve as arenas for continuing dialogue between the living and the dead, and among the living over their ties and access to the spiritual power of the dead.*
>
> – *Hutchinson and Aragon, Collective Burials and Community Memories: Interpreting the Placement of the Dead in the Southeastern and Mid-Atlantic United States with Reference to Ethnographic Cases from Indonesia, (2008:46)*

Exploring Jaén during the intense heat of an Andalucían summer belies the city's lengthy history; turn a corner in the Old Town and you confront the intricate 17th century façade of the famous Cathedral of Jaén; a glance upwards through a narrow alleyway reveals the imposing outline of the medieval Castle of Santa Catalina; descend a narrow flight of stairs and you are immersed in the murky grandeur of the Arab Baths. However, traces of prehistoric occupation are far more deeply buried. While the caves of Marroquíes Altos are located in a basement just across from the Museum de Jaén, they lie behind an unwelcoming locked door, inaccessible to the public. The necropolises of the lowlands have largely vanished, replaced by defunct tramway systems and modern apartment complexes.

To the casual observer, the Copper Age layers of Marroquíes would seem almost as inaccessible to the archaeologist. The massive scale of salvage excavations, long time span of research, and commingled or poorly preserved funerary deposits all pose significant challenges for scholars focused on reconstructing the history of the site and the lives of the people who lived there. However, as this dissertation demonstrates, the careful excavations of archaeologists, combined with bioarchaeological approaches to fragmentary human remains, provide a foundation on which to begin piecing together the prehistory of Jaén.

The Importance of Marroquíes Bajos

The site of Marroquíes Bajos presents a unique opportunity to examine how large-scale and complex settlements emerge in the apparent absence of institutionalized hierarchies. Marroquíes is one of a handful of settlements that appear during the Copper Age which are markedly distinct from the small-scale villages that characterized the Iberian Neolithic. Sites like Valencina de la Concepción, Los Millares, La Pijotilla, Cheles, Perdigões, and Marroquíes Bajos are all notable for their more complex organization, whether it is related to greater size, investment in site infrastructure, or fortifications. However, the social processes that underlay the emergence of these new "macro-villages" are not well understood. As Díaz-del-Río describes, this phenomenon is unique, even within the Iberian record:

> "In the whole of [Iberian] peninsular prehistory, population at the scale that appears to occur is a historical phenomenon that is rarely seen in the archaeological record. Viewed from this perspective, the occasional monumental scale of collective work is truly anomalous, not only in the prehistoric archaeological record, but in the whole of the Iberian record. Furthermore, the nature of its material is radically different from any other, whether Paleolithic, Neolithic, Iron Age, Roman, or Medieval" (2013:67, translation mine).

Los Millares is one of the most well-known sites in Spanish prehistory, and so has been extensively studied for over a century (Chapman 1981; Molina González et al. 1986, 2005; Micó Pérez 1995; Díaz-del-Río 2011), while large centers like Valencina de la Concepción have recently become the subject of extensive archaeological investigations (Nocete et al. 2008; García Sanjuán et al. 2013a). However, there is still little understanding of how these centers arose and operated. While they all emerge during the third millennium, it is unclear whether macro-villages reflect broader processes operating across the broader Iberian landscape (e.g., aggregation due to increased threat of violence, concentration for subsistence purposes), or the degree to which their trajectories are contingent on particular and localized circumstances that affect their emergence and success.

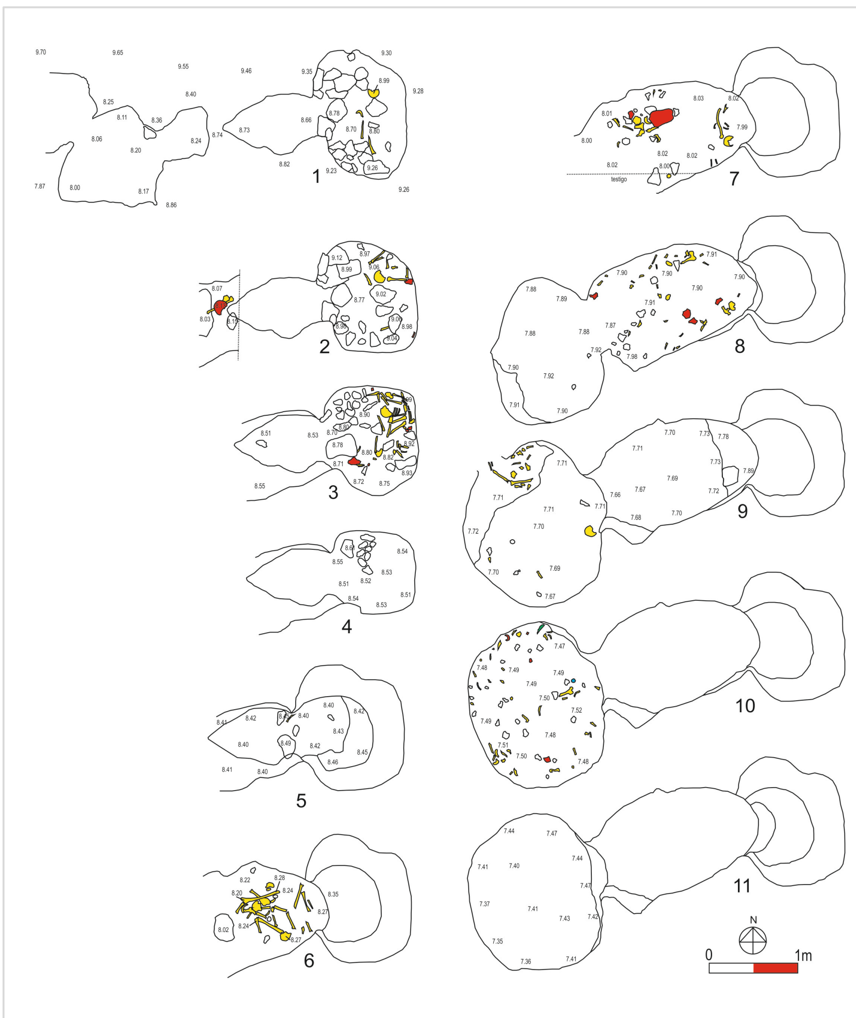
The unexplored variability in macro-villages is one reason that bioarchaeological analyses at Marroquís Bajos are key for answering questions about the pattern and process of macro-village emergence, maintenance, and collapse. Marroquíes shares a number of key traits with other large-scale settlements during the Copper Age, including its size, significant investment in site architecture, and the nature of its mortuary practices.

One common thread that links Marroquíes to other macro-villages, and indeed to most other Copper Age sites, is the formal characteristics of its mortuary practices. The site first became famous as a result of the discovery of artificial caves referred to as Necropolis 4. Espantaleón's romantic descriptions of the discovery of Marroquíes Altos reads like the introduction to an H. Rider Haggard novel (Chapter 4), and perfectly details how the unanticipated discovery, "macabre" setting, prehistoric material culture, and possible indications of prehistoric ritual sparked the imagination of Spanish archaeologists and laypeople.

What is perhaps most important for contemporary discussions, however, is the fact that the caves themselves mimic the form of other megalithic tombs popular during this time. As García Sanjuán notes (2006:153), artificial caves, or "*hypogea*" become more prominent during the Copper Age, replacing natural caves. One-third (10/30) of the dated Copper Age funerary contexts reported for the southwest come from such burial areas, most occurring after 2800 cal BC (García Sanjuán 2006). The organization of the caves of Marroquíes Altos mimics the environment of many megalithic tholos-type chambers, from their narrow passageways to the darkened interior and limited visual and spatial access (Figure 9.1). The use of this type of burial thus situates Marroquíes within a larger context of changing mortuary practices across Iberia.

However, Marroquíes is also unique in a number of important ways. For example, there are notable differences in material culture that distinguish Marroquíes from other macro-villages in third millennium Iberia. The megalithic funerary Structure 10042-10049 from Valencina de la Concepción has produced grave goods which include, but are not limited to, an unworked elephant tusk, an amber pommel, a carved vessel, a meticulously crafted ivory sheath, and a crystal dagger (García Sanjuán et al. 2013b). At Los Millares, Chapman (1981) describes how "a number of tombs contain a greater range and frequency of prestige grave goods than do other examples" (1981:402). This includes Tomb 40, which has more than one dozen ivory artifacts, ten copper objects, painted pottery and *symbolkeramik*, along with Tomb 12, which includes eleven ivory grave goods, 800 ostrich egg shell beads, fifteen jet beads, and five amber beads. The spatial concentration of exotic and often long-distance luxury items described for Los Millares and Valencina suggests that these centers were embedded in larger trade networks. In the case of Valencina, studies of the ivory artifacts show that they come from both African and Asian elephants (García Sanjuán et al. 2013b). Even if Valencina represents the end point of many long links in a chain of exchange, the sourcing studies still attest to the ability of such a center to attract travelers and traders from long distances.

Figure 9.1 The interior of Tomb III (map courtesy of Pedro Díaz-Del-Río, based on excavation maps by Ana Manzano Castillo and José Luis Martínez Ocaña)



While the mortuary areas at Marroquíes contain some instances of elaborate artifacts – for example, the anthropomorphic stone idols from Necropolis 4, or the sword blade with rivets from Necropolis 2 –the volume of luxury artifacts is relatively unimpressive compared to the aforementioned sites. As at N1 and N4, none of the artifacts are associated with individual burials. The taphonomy and deliberate movement of bodies at Necropolis 4 would of course prevent such associations, but the Copper Age structures from N1 and N2, which contain grave goods, contain no marked distinctions in material culture of this scope. Such differences suggest that Marroquíes did not have access to the same scope or scale of exchange networks as Valencina or Los Millares. The low number of non-local strontium isotope ratios at N1 and N4 suggest that most people buried in these two mortuary areas came from the surrounding area. Given that these necropolises were in use at the beginning of the aggregational process, these results suggest that Marroquíes Bajos had a predominantly local character from its very beginning. This presents a contrast to other large-scale villages like Valencina and La Pijotilla, which attracted a wider swathe of regional Iberian populations, with 30% of the analyzed sample showing non-local strontium isotope ratios (Díaz-Zorita Bonilla 2013; Diaz-Zorita Bonilla et al. 2014).

An additional characteristic which distinguishes Marroquíes Bajos from other macro-village sites is the spatial distinctions of its mortuary areas, where necropolises and mass burials are deliberately separated in space, which provides a means of examining how social groups used mortuary areas. At Los Millares, a single cemetery extends over a large area, while at Valencina, divisions of mortuary space are not as clear (Costa Caramé et al. 2010). Because Necropolis 1 and Necropolis 4 show a clean-cut spatial separation and some chronological overlap (Chapter 8), it is possible to compare aspects of diet, mobility, and health in the social units responsible for burial. Since there is increasing evidence that the site witnessed a mortuary re-use during the late third and early second millennium (Cámara Serrano et al. 2012, Chapter 8), the data from Marroquíes also enable us to make diachronic comparisons between the Copper Age and the Early Bronze Age.

One final intriguing difference stems from the demographic composition of the Marroquíes mortuary areas. While admitting that this may be related to issues of preservation, Costa Caramé et al. (2010) highlight that only 6.6% of the mortuary population at Valencina de la Concepción consisted of subadults. In his analysis of the Los Millares cemetery, Chapman draws attention to the apparent absence of subadults, though he does note that this bias may be related to the osteological analysis of the site, writing that "either children were not normally present in the tombs or Flores and Siret did not distinguish them from the adults" (1981:339). If this distinction is not merely an artifact of differential preservation and choices made during osteological analysis, it suggests that Marroquíes is characterized by a greater inclusion of a wider variety of ages than other macro-villages.

Accordingly, investigations of mortuary variability at Marroquíes Bajos shed light on the different social strategies that led to the rise of macro-villages in third millennium Iberia. Differentiating between the three models introduced in Chapter 2 – of diachronic change, a multi-stage mortuary program, and social differentiation – is a key step in understanding how Marroquíes was organized, and what kind of social strategies led to its emergence. Evidence from three separated domains (bioarchaeology, spatial organization and grave goods, and isotopic analyses and radiocarbon dating) is addressed separately. The final section of this chapter draws conclusions about the bioarchaeological and mortuary record of Marroquíes Bajos, and identifies avenues for future research.

Domain 1: Bioarchaeology

Sex

Patterns of representation at Necropolis 1, 2, and 4 suggest that mortuary practices at this Copper Age settlement incorporated a broad range of individuals of both sexes and almost all ages.

With respect to sex, both males and females were interred at all mortuary areas. At Necropolis 1, estimation of sex was possible for 17/31 adults, and revealed 10 females, 7 males, (a female to male ratio of 1:0.7) and 1 indeterminate individual. The fragmentary nature of the remains buried at Necropolis 2 meant that sex could only be estimated for three individuals, one male, one female (a female to male ratio of 1:1), and one indeterminate individual with non-metric traits that fell in the middle of the male and female ranges. At Necropolis 4 the bimodal distribution of right canine area produced an estimated ratio of 46 females to 40 males (a female to male ratio of 1:0.9), while the bimodal distribution of left canine area produced an estimated ratio of 44:31 (a female to male ratio of 1:0.7). No statistically significant differences were found between N1, N2, or N4 in regards to sex ratios.

Sex ratios from the three necropolises examined in this dissertation appear to be part of a larger pattern. There are also slightly more females than males in some areas of Necropolis 3, where Cámara Serrano et al. (2012) describe similar results. They divide adults into the categories "*adulto*" (adult) and "*maduro*" (older adult), which are combined in this analysis for the purposes of comparison. At Tramo 3 they document 49 female adults to 36 male adults (1:0.7), at Paseo Estación, 3 female adults and 4 male adults (1:1.3), and at García Triviño, 6 female adults and 6 male adults (1:1) (Cámara Serrano et al. 2012:57). For Tramo 3, which contains the greatest number of burials (N = 164), the authors note that an "imbalance in sex" is only recognized in Structure 4 (6 adult males, and 4 adult females) and Structure 2 (6 adult females, 6 indeterminate adults). Two things are important to note about these results. First, sex imbalances are relatively slight at all mortuary areas, and second, there are no collective inhumations where only one sex is represented, though this makes the assumption that in areas like Structure 2 from Tramo 3 in Necropolis 3, some of the indeterminate individuals would have been male.

The sole exception to this inclusive pattern is *Fosa Común* 2. Of the five individuals deposited in this area, four were adults, and the adult individuals were all male based on non-metric characteristics of the mandible such as everted gonial angles and prominent chins (Sánchez et al. 2005). However, *Fosa Común* 2 differs markedly from all of the necropolises referenced above in several important ways. Unlike the discrete mortuary structures excavated for Necropolis 1, 2, and 3, or the artificial caves of Necropolis 4, *Fosa Común* 2 is a simple deposition of human remains within the fifth ditch. This deposition was interred in a pit that was dug after the abandonment and destruction of a nearby fortified structure and the in-filling of the ditch itself. Though this deposition of disarticulated human remains is intermixed with faunal remains (perhaps echoing the fauna deposited at Necropolis 1 and 3), there are no artifacts present in contrast to all of the necropolises at Marroquíes Bajos. The radiocarbon dates for this area are taken from two well-preserved long bones, and the results – Ua-20267, 3885 ± 40 BP (2Ã 2470-2200 BC) and Ua-21455, 3775 ± 45 BP (2Ã 2340-2030BC) (Sánchez et al. 2005) – suggest overlap with mid-third millennium use of the area, although the probable contemporaneity of this deposit with the remaining mortuary areas should be addressed in the future using Bayesian modeling. However, the formal differences in the location and organization of the mortuary deposit, the limited number of individuals present in the interment, and the absence of grave goods all suggest that *Fosa Común* 2 represents a distinct social process from that responsible for the necropolises.

Within the necropolises themselves, the relatively even balance of male and female adults suggests that the construction and maintenance of this Copper Age center was not underlain by new gendered divisions of labor. This does not mean that gendered divisions of labor did not exist. There are indications of distinctions related to gender in the differential location of specific individuals. One example is the only individual burial from Necropolis 1. Structure 22, the central mortuary structure around which the other structures are organized, (Chapter 4, Figure 4.1) contains only a single burial of a probable male (estimate based on the GSN and mastoid processes), with an estimated midpoint age of 25 ± 4 years. Structure 22 presents a contrast to the surrounding structures, which all contain three or more individuals. The date for individual N1.CE22.01 – AA107181, 4011 ± 33 (2619-2467 cal BC, 2σ) – falls on the early end of the spectrum for Necropolis 1, 2, and 4. Given the spatial organization of the necropolis, the unique individual interment, and the chronology of this burial, this individual may have acted as some kind of foundational deposit.

Manzano Castillo and Martínez Ocaña (2001) describe the interior organization of Tomb I (Cave of the Column) in Necropolis 4 as a "chaotic" deposition of disarticulated human remains, in which the only deliberate internal organization seemed to be the concentration of crania and long bones against the walls of the chamber. The archaeologists observed only one individual that preserving any degree of articulation: a cranium with two articulated cervical vertebrae. This individual was centrally located within the tomb, and the preserved anatomical connections may have extended beyond the vertebrae; however, the remains were covered by a portion of the limestone roof that had fallen on top of the rest of the body. This degree of preservation suggested that this individual was deposited prior to skeletonization. This differential treatment and level of articulation led Manzano Castillo and Martínez Ocaña to posit that this may have been the final interment in the tomb:

> "we assume, taking into account that we are dealing with a case of collective burials and that it was found in the central place of the chamber, it was likely the last burial conducted in this tomb, that produced associated grave goods comprising a copper knife, ceramic objects, shells (located next to the cranium), flint tools; and the stacking or removal of earlier inhumations to the sides of the room, provided a position of privilege for this last inhumation" (2001:21, translation mine).

Figure 9.2 Skull of MN.2.267.01 from the Cave of the Column

Importantly, after examining the Necropolis 4 maps with Ana Manzano Castillo and José Luis Martínez Ocaña, I was able to use the provenience information on the bags to locate this particular skull. Subsequent bioarchaeological analysis revealed that this individual (MN.2.167) was a probable male, with an extremely well-preserved cranium, mandible, and teeth (Figure 9.2-9.3). Unfortunately, dietary isotopic analysis of carbon, and nitrogen and radiocarbon dating were not possible for this individual because collagen could not be extracted from the mandible. However, the $\delta^{18}O$ value (-12.96) and strontium isotope ratio (0.708679) for this individual fall within the local range. It was also possible to produce a midpoint age estimate in the young adult range using the molar wear model (Chapter 6) of 26 ± 4 years.

Figure 9.3 Cervical vertebrae preserved for MN.2.267.01

Only limited claims can be made with a sample size of only two individuals, but it is interesting to note that adult males appear to have been used for foundational or closing interments at two different necropolises. The number of adults with both estimates of sex and strontium isotope ratios available is similarly small. However, in the Sr sample of 36 adult individuals for which it was possible to estimate sex, the 3 non-local individuals were female, a result which agrees with other recent research on sex and mobility in Copper Age Iberia (Díaz-del-Río et al. n.d.), and may shed light on mobility related to patrilocality in Spain during this period. Finally, the grave goods at some mortuary areas (for example, the copper knife discovered in close proximity to MN.2.167.01, the central interment from the Cave of the Column in Necropolis 4), may have had gendered implications. Future efforts that focus on a full material cultural analysis of the artifacts included in these interments, particularly combining them with provenience and bioarchaeological information, may shed more light on the intersection of gendered identities and material culture.

Age

There are broad similarities in the inclusive demographic age make-up that span Necropolis 1, 2, and 4. Younger adults of 20-40 years of age are disproportionately represented at all mortuary areas, a pattern which also occurs at Valencina de la Concepción (Costa Caramé et al. 2010). The higher number of young adults, lower number of middle adults (40-60 years of age), and the virtual absence of individuals older than sixty years of age is likely an artifact of the limitations of bioarchaeological methods for estimating age, rather than a true absence of older adults. This is particularly true for Necropolis 4, where the use of the Gilmore and Grote first molar wear method to estimate age establishes a definite ceiling, which the authors themselves discuss (Chapter 6). Because wear scores of greater than 10 must be abandoned when using this method, the maximum wear score for a first molar is 9. For the Necropolis 1, 2, and 4 populations, with a predicted annual wear rate of 0.1947, this means the oldest age predicted by the first molar model is 52 years. This limitation is unfortunate, but not unanticipated, and the age estimates predicted by the molar wear model are thus best treated as relative measures of age.

In regards to subadults, all mortuary areas include children, juveniles, and adolescents (Table 9.1). Pre-term infants are missing from all mortuary areas, corresponding to a broader pattern within Late Prehistoric Iberia (Waterman and Thomas 2011). Overall, the three mortuary areas show similar patterning, with between 24% and 29% of the total MNI composed of subadults, and no statistically significant differences between Necropolis 1, Necropolis 2, or Necropolis 4. The proportional representation of subadults (32%) is similar at Necropolis 3 (Cámara Serrano et al. 2012), and one of the five individuals included in the *Fosa Común* 2 deposit is likewise a subadult, between 12 to 16 years of age (Sánchez et al. 2005). As described in Chapter 7, categorical age ranges were explicitly defined to be comparable to Cámara Serrano et al.'s (2012) analysis of Necropolis 3, and individuals were assigned to age categories using the midpoint of their estimated age range. Subadult age categories included preterm infant (prenatal), child (birth–6.9 years), juvenile (7–12.9 years), adolescent (13–20.0 years), and adult (20 +years; Cámara Serrano et al. 2012:54).

The only mortuary area where subadults make up less than 25% of the MNI is *Fosa Común* 2, which shows a different pattern to most other areas in regard to formal composition, location, and material culture, as described in the preceding section.

Table 9.1 Count of subadults by age for all analyzed Marroquíes Bajos mortuary areas

Mortuary Area	Pre-term infant	Child	Juvenile	Adolescent	Total	Subadult MNI /total MNI
Necropolis 1	0	8	1	2	11	0.26
Necropolis 2	0	2	4	2	8	0.25
Necropolis 3	4	34	18	7	63	0.32
Necropolis 4	0	29	22	9	60	0.29
Fosa común 2	0	0	0	1	1	0.20

It is not only the presence of subadults at Marroquíes Bajos that is important. Bioarchaeological analysis has shown that when subadults are buried with adults at N1 and N2, they are treated in a similar fashion to adults. At N1, where adults received either primary or secondary burial, subadults also received both forms of mortuary treatment (Chapter 7). As secondary burials likely represent the conclusion of a multi-stage mortuary program, it appears that subadults also participated in all stages of this program. At Necropolis 2, where adult skeletal completion is low for all mortuary areas, subadult skeletal completion is also low for all mortuary areas (Beck 2015), suggesting that the majority of individuals interred in this mortuary area were given secondary burials. Finally, at Necropolis 4, subadult dental completion scores fall between the subadult dental signatures for primary and secondary burials at Necropolis 1 or Necropolis 2, but future research dedicated to developing expected tooth counts for subadults is needed before further untangling this pattern (Chapter 7). However, the inclusion of subadult interments in the artificial caves suggest that younger individuals had access to most of the forms of mortuary treatment available at Marroquíes Bajos

While children are thus included in mortuary practices, there is still some evidence for age-based distinction at Marroquíes Bajos. Most mortuary areas are dominated by children, which is not surprising given that this would be the age category most susceptible to post-weaning mortality related to increased independence and contributions to agropastoral labor efforts (Beck 2015). However, four of the five mortuary areas show an absence of pre-term infant burials, and relatively young infants with midpoint age estimates under 3 years of age also rare (none at Necropolis 1, 1 at Necropolis 2, and 9 at Necropolis 4). Of this cohort of 10 younger individuals, no subadults had estimates under one year of age, with the possible exception of a deciduous upper lateral incisor from the right (T.2.321.21) from Necropolis 4. This tooth was not counted towards the Necropolis 4 subadult MNI as it was an upper tooth (Chapter 6), but its level of development places it in the 7.5-month age category according to the median age in AlQahtani et al. (2010). Some very young infants may thus have been included in communal burials, as is also demonstrated by the four pre-term infants reported for Necropolis 3 (Cámara Serrano et al. 2012). However, in a pre-industrial population where child mortality would have been extremely high, it is likely that these individuals represent only a fraction of the infants that died.

The dearth of infant remains in communal mortuary areas is not unique to Marroquíes Bajos, but follows the pattern described for the Late Prehistoric Atlantic Coast of Iberia, where infants are likewise underrepresented (Waterman and Thomas 2011). The absence of the remains of the youngest members of society from mortuary contexts is also phenomenon frequently documented in both archaeology and ethnography, and is often related to the unique social status of infants, or the presence of liminal ceremonies designed to confer "personhood" (Beck 2015). The near absence of infants at Marroquíes Bajos, whether due to social norms that associated achievement of "personhood" with older developmental ages or the survival of specific "rites of passage" (Van Gennep 1960), or due to infants' more constrained sphere of social influence (Waterman and Thomas 2011), suggests that the distinct ontological status of infants was have been maintained at Marroquíes Bajos

A second pattern that suggests possible age-based distinctions in mortuary practice is the absence of individual subadult burials. There are few instances of individual burials documented at Marroquíes Bajos to start with (e.g. N1.CE22.01), and none of these burials are subadult. At the Cave of the Child, where a subadult was accorded a degree of spatial differentiation through their placement on a lateral niche carved into the cave wall, the subadult was flanked by an adult burial in a parallel lateral niche on the opposite wall (Espantaleón 1957). Unfortantely, given that these interments were not excavated because they fell outside the spatial boundaries of the excavation, it is impossible to tell if these are derived from the Copper Age or represent an Early Bronze Age reuse of the mortuary caves. The only exception to the absence of individual subadult burials is the possible infant burial documented during the excavation of Necropolis 2. Though no neonatal bones were located in the museum during the process of analysis, the potential infant burial is identified on the map for Structure 44, Planta II as a "concentration of small remains – possible infant burial" (Appendix A), which the site report describes as being placed on a ceramic platter, estimating that the bones were from an individual "0-3 years" of age (Chapter 4). Structure 44 has one radiocarbon date from an adult femur that dates to the Early Bronze Age (MAMS20042, 3621±21, 2σ 2040-1910 cal BC). As a result, the unique mortuary treatment accorded to this younger individual is likely an instance of later mortuary re-use of the site that reflects different social processes than those at play during the height of the Marroquíes Bajos occupation.

In addition to their age, the mortuary treatment of subadults may also be related to the wealth of the social unit responsible for interment, and social norms related to the appropriate burial of younger individuals (Beck 2015). For Necropolis 1 and 2, the analyzed subadult inhumations were concentrated in the structures with the most burials (Structures 13 and 14 at Necropolis 1, and Structures 43, 44, and 45 at Necropolis 2). At Necropolis 1, one of the missing burials from Structure 26 (26.03) is represented as being far smaller than surrounding individuals, and is buried in the same flexed position typical of Necropolis 1 subadult burials. If 26.03 is also a subadult, this represents a third instance of this pattern in this necropolis. Subadults are also never the sole occupants of mortuary structures. The individual burial from Necropolis 1 (N1.CE22.01), the individual cranium from Necropolis 2 (Unit47), and the final potentially articulated interment in the Cave of the Column (MN.2.267.01) are all adults. Research at other Late Prehistoric sites in the Upper Guadalquivir region suggests that this may be a regional pattern. Venta del Rapa, only 20 km away from Marroquíes Bajos, is a Late Copper Age village dated to 2350–2000 cal BC. The necropolis at Venta del Rapa contains three mortuary structures in which 61 individuals are buried. Here too, subadults are interred in the two mortuary structures that house the greatest number of burials (Lechuga Chica et al. 2014). Finally, the two structures that house all of the analyzed subadult burials from Necropolis 1 also house deliberate burials of animals. Though a more detailed analysis of the material culture accompanying the interments is necessary, some of the wealthiest grave goods from Necropolis 2, like the bronze halberd with rivets and at least five bone awls (*punzones*), come from Structure 44 and Structure 45, where most of the subadults are also interred. Of the two interments at Necropolis 2 lacking subadults, Structure 39 had no grave goods, and Unit 47 only produced a small lithic and a fragment of worked bone.

This distinction in the treatment of subadults suggests three broad patterns (Beck 2015). First, while subadult bodies were processed in the same way as adult bodies, the locations where they could be interred were constrained. While time and energy were invested in the mortuary treatment of subadults, their membership in a lineage or social group may have been a more powerful component of their social identity than their individual identity based on their accomplishments and relationship with other members of the settlement. Second, the restriction of subadults to burials in communal mortuary contexts suggests that children and juveniles could not be buried on their own, potentially for religious, ritual, or social reasons. Finally, the correlation between subadult burial and a higher number of grave goods makes it possible that the wealth of the social unit responsible for burial may have affected access to mortuary treatment. If interment was expensive in terms of time, energy, or significant resources, it is possible that not all social units could afford to bury their youngest members.

Pathology

Two main conclusions can be drawn from the pathological analyses for Necropolis 1, 2, and 4. First, incidences of skeletal pathology are generally rare and the most frequently observed pathology (osteoarthritis) is linked to both age and activity levels, rather than disease (Chapter 7). These results may reflect low levels of insults during the Late Prehistoric period. They may also be a result of the relatively poor preservation and representation at mortuary areas like Necropolis 2. It is also possible that the most significant threats to health did not leave skeletal signatures. Finally, it could be that all three of the aforementioned scenarios interacted.

Second, there are some significant differences between the three mortuary areas in regards to dental pathology. Comparisons between Necropolis 1, 2, and 4 suggest significant differences in both the number of teeth showing signs of nutritional stress, and the number of teeth preserving calcified dental plaque (Chapter 7). A significantly higher frequency of enamel hypoplasias is observed for adult teeth from Necropolis 2, where this insult was observed on 15/191 (8%) adult teeth, and 1/12 (8%) subadult teeth. In this mortuary area, all hypoplasias on adult teeth are concentrated in three structures – 41, 44, and 45. Teeth from Structure 39, 43, and Unit 47 did not have hypoplasias. The subadult hypoplasia was also from Structure 45, and occurred on a RlC1 that had achieved stage $A_{1/2}$ (an estimated age range of 12-14 years using AlQahtani (2009) and AlQahtani et al. (2010). It is worth noting that more teeth came from Structures 41, 44, and 45 (186/203, 92%), than came from Structures 39, 43, and Unit 39 (17/203, 8%), so some of this apparent spatial concentration may be related to sampling error.

Hypoplasias do not always occur on overlapping teeth (Table 9.2), so the higher frequency of hypoplasias at Necropolis 2 could reflect either certain individuals having multiple hypoplasias, or differential distribution of hypoplasias across teeth from individuals in each mortuary structure.

Table 9.2 Teeth affected by hypoplasias from Necropolis 2

Structure	No. hypoplasias	No. adult teeth	% teeth affected	Teeth
41	6	47	13	RlM2, Unsided lI1, LlI2,LlC1, RuI2, LuC1
44	6	75	8	LlC1, LuC1, RuC1, RlC1, RuI2,RuC1
45	3	52	6	LlC1, RlP3, RuM1

Importantly, Structures 44 and 45 date to the Early Bronze Age, while Structure 41 dates to the Copper Age use of the center (Chapter 8). The frequency of hypoplasias at Structure 44 and Structure 45 may thus reflect changes in subsistence practices or food availability during the transition to the Early Bronze Age. It is possible that the groups who were burying their dead at Marroquíes Bajos during the beginning of the Bronze

Age were suffering from greater childhood nutritional stress, even though their graves included artifacts like sword blades that were indicative of material wealth.

Even though the majority of hypoplasias from N2 are thus from Bronze Age contexts, it is still possible ot examine the difference in the frequency of hypoplasias between Copper Age contexts that were likely used during the same period (Necropolis 1, Necropolis 4, and Structure 41). Significant differences in contemporaneous Copper Age contexts might reveal differences in synchronous social units (Table 9.3). Indeed, Fisher's exact tests revealed that the significant differences in the frequency of hypoplasias between N1 and N2 (p = 0.029), and N2 and N4 (p = 0.024) were maintained when examining the insult for the combined adult and subadult samples, even when the Necropolis 2 sample was restricted to the teeth from Structure 41. As the samples from Necropolis 1 and Necropolis 4 did not change in this comparison, the lack of significant difference was maintained there as well (p = 0.895).

Table 9.3 Hypoplasia counts for Copper Age contexts, total teeth = teeth with visible enamel

Mortuary Area	Adults			Subadults			Total		
	Hypoplasias	Total teeth	%	Hypoplasias	Total teeth	%	Hypoplasias	Total teeth	%
N1	13	326	4	4	99	4	17	425	4
N2	6	47	13	0	1	0	6	48	13
N3	108	2637	4	34	688	5	142	3325	4

The significant difference between mortuary areas in frequency of hypoplasias is thus maintained even when the Necropolis 2 sample is restricted to teeth from Copper Age contexts. However, this does not necessarily imply that there were persistent differences in access to nutritional resources between different social groups. The MNI for Structure 41 (N = 6) represents only a fraction of the MNI for Necropolis 1 (N = 42) and Necropolis 4 (N = 205), and if these bodies were interred over the course of two to three generations, this statistically significant difference in hypoplastic insults may not have had much significance in life. Additionally, recent research cautions against the simple equation of enamel hypoplasias with ill health, as studies on Black Death populations suggest that individuals with multiple hypoplasias are actually more robust than individuals with fewer hypoplasias (Yaussy et al. 2016).

The only other significant difference in dental pathology was related to the amount of dental calculus preserved on teeth. Calculus in and of itself is not a pathology, but as Ortner notes, “plaque and calculus provide a clear stimulus for inflammation of periodontal tissues” (2003:593), which has the potential to lead to subsequent periodontal disease and antemortem tooth loss. Results of comparisons between the three mortuary areas suggest that Necropolis 4 has a higher proportion of affected teeth preserving a large amount of calculus, and a lower proportion of affected teeth preserving a small amount of calculus, relative to N1 or N2 teeth (Chapter 7). Given the relationship between calculus and periodontal disease, it would seem likely that rates of antemortem tooth loose were higher at N4, where calculus is more severe. These predictions, however, are not borne out by the data. The frequency of resorbed sockets was highest for Necropolis 2, with 12/89 (13%) of sockets resorbed, followed by Necropolis 1, with 23/320 (7%) resorbed, and finally Necropolis 4, with 88/1612 (5%) resorbed. Part of these results are likely related to the problematic nature of fragmentary deposits, where most mandibles and maxillae are partial to begin with. However, the difference in calculus between Necropolis 4 and the other mortuary areas, and the significantly higher frequency of teeth affected by calculus in subadults at Necropolis 1 than Necropolis 4, may be related to dietary differences between the two areas, though immunological and morphological differences have also been suggested to play a role in the etiology of dental calculus (Arensberg 1996).

Domain 2: Material Culture and Mortuary Organization

Material Culture

To date, no rigorous analyses have been conducted of the material culture or faunal assemblages associated with Necropolis 1, Necropolis 2, or Necropolis 4. However, Cámara Serrano et al. (in press) have thoroughly analyzed Necropolis 3. While some unique artifacts, including a zoomorphic figurine and a “copper thread” are documented, there is nothing that compares to the elaborate artifacts interred with particular burials from Valencina de la Concepción and Los Millares (Chapman 1981; García Sanjuán et al. 2011).

The material culture documented during my bioarchaeological analyses of Copper Age (Structure 41) Necropolis 2 includes shell, rim sherds, flint, red ochre, and two worked artifacts made on either antler or ivory, that were mixed in with the human remains, an additional ceramic sherds separated out by the excavators (Chapter 2). The site report documents ceramic sherds for Structure 42, and large ceramic sherds and a shell that may be a scallop for Structure 43. Both of these sites have yet to be radiocarbon dated, and so could date to either the Copper Age or the Bronze Age. The material culture documented for the Bronze Age structures is more impressive, and includes whole ceramics. At Structure 44, the site report describes relatively complete ceramics, including "four hemispherical earthenware bowls, a small flat plate, and three large-sized platters," along with a bone hairpin and a sword blade (*la hoja de una espada con remaches*). Likewise, complete ceramics are also documented for Structure 45. In contrast, there are no grave goods documented for Structure 39. Structures 39, 44, and 45 all had radiocarbon dates that placed them in the early Bronze Age.

The material culture documented for Necropolis 1 is similarly sparse. Archaeologists reported "few or no grave goods," with large ceramic sherds the only material consistently recovered. The archaeologists posited that these may have been related to "libations" or some kind of burning, given that ash deposits were found in the immediate surroundings of individual N1.CE22.01, the central burial at the site. The most noteworthy grave inclusions for the Necropolis 1 structures are in fact the faunal remains (see Appendix A). Complete animal burials that appear to have been used to seal particular burial episodes; they are found between the first and second round of inhumations in Structure 14, and between the second and fourth round of inhumations at Structure 13. These types of animal interments are also documented at Necropolis 3, and appear to be consistent features of Copper Age mortuary practices at the site.

The most impressive material culture recovered from Marroquíes Bajos can arguably be found in Necropolis 4. Espantaleón (1957) documents a wide range of artifacts, including Bell-beaker spherical bowls, pots, flint scrapers and knives, a bronze dagger, and an Early Bronze Age type axe (*con reborde*), most of which are published as photographs or sketches in his 1957 article. The presence of Early Bronze age metal artifacts has led some archaeologists to predict that this mortuary area was used during the later phase of the Marroquíes Bajos occupations. While all of the radiocarbon dates from Necropolis 4 suggest an early use of the caves, sporadic Early Bronze Age re-use cannot be ruled out, particularly since the bronze axe and loose pieces of bronze were associated with the adult interred in the lateral wall niche near the child who was given the same treatment. Because these individuals were not removed from the cave in 2001 (as they were located beyond the official boundaries of the excavations), it is not possible to radiocarbon date them to confirm this suspicion.

Overall, however, there is no evidence for the level of display documented at other macro-villages in the grave goods reported for Marroquíes Bajos. Unlike Valencina (with a Sicilian amber pommel and ivory from both Asia and Africa), there are no raw materials at Necropolis 1 through 4 that imply impressive exchange networks or the ability to attract travelers. Unlike Los Millares, there are no concentrations of spectacular artifacts in particular chambers or surrounding particular individuals. The commingling of human remains that Manzano Castillo and Martínez Ocaña report at Necropolis 4 is similar to the process described for other Late Prehistoric mortuary sites in Iberia, where bodies were moved and mixed together over time in response to the spatial needs produced by repeated depositions (Lillios 2014). It is worth noting that the continual movement of bodies over time would have broken the spatial link between interred individuals and any artifacts that they were interred with, and the living people doing the interring would have been aware of this process. Accordingly, while there is tantalizing archaeological and bioarchaeological evidence of differential treatment of individuals that was related to their age or sex, such distinctions appear to have been subsumed beneath the more encompassing framework of inclusive burial, with the focus on community and social group identity, rather than individual identities.

Mortuary Organization

Almost all mortuary structures from Necropolis 1, 2, and 4 are characterized by communal interments, whether burials are primary (Necropolis 1), secondary (Necropolis 1 and 2) or commingled cave depositions (Necropolis 4). Despite this communal and inclusive approach where individuals of both sexes and almost all ages are accorded the full range of mortuary treatment (Chapter 6 and 7), there are some indications that particular individuals were singled out for differential treatment. For example, burial N1.CE13.02 included a fragmentary upper rib, medial clavicle, and fragment of manual phalanx that all showed signs of burning. Post-mortem manipulation of human remains is also well-documented at Necropolis 3 (Cámara Serrano et al. in press), and the presence of empty structures that are similar in size and scope to the mortuary areas attests to the likely movement of bodies at the site, though it is unclear whether these structures date to the Copper Age or to the Early Bronze Age. As mentioned previously, N1.CE22.01 from Necropolis 1 and MN.2.261.01 from Necropolis 4 are adult males who appear to have acted as foundational or closing deposits for their respective mortuary areas.

What is clear is that multiple methods of interment were practiced simultaneously at Marroquíes Bajos. At N1, the co-existence of both primary and secondary burial may reveal the simultaneous presence of multiple mortuary treatments, or may be a snapshot of a trajectory from primary to secondary burial, with both ends of the spectrum represented. The intermediate dental signature at N4, falling in between the primary and secondary dental signatures from other mortuary areas, suggests that both primary and secondary burials are interred in the artificial caves. Additionally, the chronological overlap of Necropolis 1, Necropolis 3, and Necropolis 4 indicates that there were multiple spaces being used to bury the dead at this site. Because these necropolises were at least partially contemporaneous, and because there appears to be little age- or sex-related mortuary segregation at the site, the existence of multiple burial areas may reflect the existence of larger social units responsible for organizing labor at the site.

Broad similarities in demography and grave goods link these mortuary areas together, suggesting that such rituals acted as a common thread tying the inhabitants of the site together. However, the distinct spatial location of each area (two between the fourth and fifth ditch, and one in the higher artificial caves), along with differences in funerary treatment also underscore the maintenance of mortuary practices specific to particular social units.

Domain 3: Stable Isotope Analysis and Radiocarbon Dating

Necropolis 3 and Fosá Común 2 have been subject to previous bioarchaeological analysis, but the isotopic studies conducted have been of such a small scale (N = 5 at Fosa Común 2) that inter-individual and inter-group differences have been impossible to examine rigorously (Sánchez et al. 2005; Cámara et al. 2012). By sampling 94 individuals for carbon and nitrogen analyses (89 human, 5 faunal), 107 individuals for strontium (103 human, 3 faunal), 117 individuals for oxygen analyses (111 human, 5 faunal), and processing 35 new radiocarbon dates, this dissertation has made significant contributions to unpacking diet, mobility, and chronology at Marroquíes Bajos.

Diet

The results of the carbon and nitrogen isotopic analyses suggest that there were no marked inter-group differences in diet at Marroquíes Bajos. Statistical comparisons of Necropolis 1 and Necropolis 4 showed no significant distinctions between each mortuary area. While the standard deviations in $\delta^{13}C$ values for Necropolis 4 are slightly higher than for Necropolis 1 (Chapter 8, Table 8.8), both of these distributions hint at a relatively homogeneous diet, with a stronger input of C3 plants such as the various species of wheat and barley documented by Montes Moya (2014) (Chapter 3). There are no isotopic indications of a reliance on C4 plants, and millet, the most likely candidate for a terrestrial C4 species in use at this time, is also absent from the paleobotanical analyses of Marroquíes Bajos (Montes Moya 2014). Individuals from Marroquíes Bajos do not show the $\delta^{13}C$ enrichment that has been documented for other Late Prehistoric Iberian sites, a result likely produced by both Jaén's distance from the coast (and consequent low marine input), and the absence of millet or similar domesticates posited to cause that signature in other areas (Waterman et al. 2015).

As with $\delta^{13}C$, there are no significant differences in $\delta^{15}N$ values between Necropolis 1 and Necropolis 4. However, there are marked inter-individual differences in δ15N values at both mortuary areas, on the order of a trophic level or more. At N1, there is a 3.2‰ range for human $\delta^{15}N$ values, and adults alone occupy the lowest and highest tiers of this range, meaning that these inter-individual differences are not solely related to developmental aspects of diet (e.g. nursing enrichment). At N4, there is a 5‰ range in

$\delta^{15}N$ values, and both adults and subadults comprise the lower end of this spectrum. When only adult values are considered, the N4 range is reduced to 3.3‰, still within the order of one trophic level.

These results suggest there was pronounced variability in the amount of protein consumed by individuals buried in each mortuary area. However, protein consumption did not differ significantly between mortuary areas, meaning that these dietary distinctions did not play out along lineage or group lines. The more notable inter-individual differences, however, suggest one avenue for further investigation. Wealth-based differences in material culture are not prominent within the archaeological record of domestic or funerary contexts at Marroquíes Bajos. However, differences in livestock ownership and access to faunal resources may have emerged over the course of the site, allowing some individuals preferential access to resources like meat or dairy products. Hopefully, zooarchaeological analysis of the faunal collections preserved at the settlement will be able to answer questions about livestock management practices.

Mobility

There is some variability in mobility between mortuary areas, but overall there appear to have been few migrants buried in these mortuary areas. At 1σ, only 8/104 (8%) of individuals are non-local. Results of the strontium isotope analyses show that Necropolis 1 contained 4/21 (19%) non-local individuals, Necropolis 2 contained no non-local individuals, and Necropolis 4 contained 4/76 (5%) non-local individuals. The individuals buried in these mortuary areas thus appear to have been locals, with the more radiogenic non-local signatures matching a number of other possible regions in Iberia, including the Central Range or the Estremadura to the northwest. This matches the low level of in-migration described for central Spain, where only 4/80 (5%) of individuals from Late Prehistoric sites near Madrid (Middle Neolithic – Bronze Age) showed non-local strontium isotope ratios, though equifinality of strontium isotope ratios must be taken into consideration (Díaz-del-Río et al. n.d.)

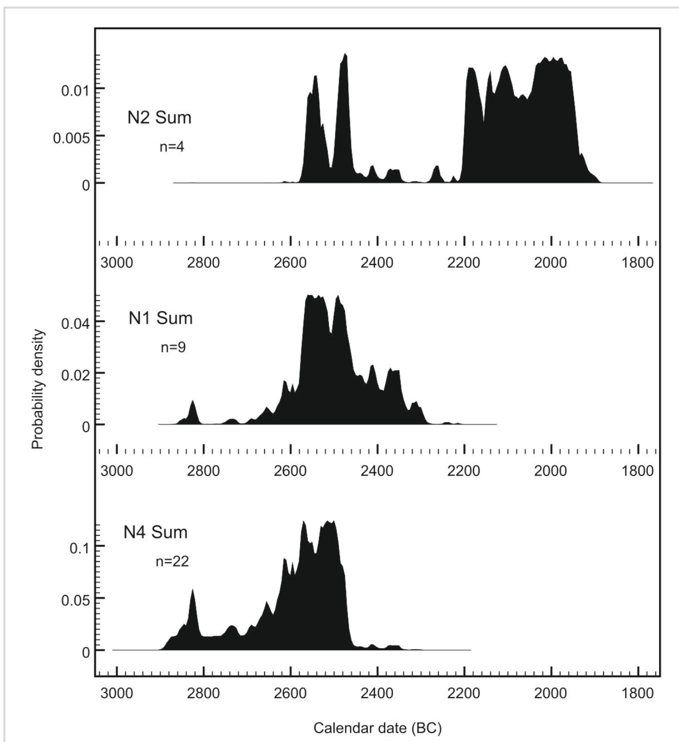
The sample of individuals with non-local strontium isotope ratios contains both subadults and adults, including one child, five young adults, and two middle adults. It was only possible to estimate sex for three of the non-local adults, and all three were female. This sample size is small, but it agrees with current research on sex and mobility in Iberia more broadly, where, women are doing more moving around. The non-local child presents a particularly intriguing case, because at 5.0-7.5 years of age, the child was likely a relatively recent addition to the Marroquíes community. However, this individual (N1.CE13.21) was still accorded the same mortuary treatment as the other individuals in Structure 13, and in fact was buried in close proximity to a number of adult individuals (Appendix A); two of these individuals (N1.CE13.26, N1.CE13.27) were sampled for the isotope analyses, and both have local strontium signatures. The only other non-local burial from Structure 13 (N1.CE13.13) is a middle adult female, buried on the same level as N1.CE13.21. Wherever migrants originated, it appears that these regional distinctions did not matter in death, even if non-local people only lived with their new community for a few years, as could have been the case with the subadult at Necropolis 1.

Time

The new AMS radiocarbon dates from Necropolis 1, 2, and 4 make important contributions to the larger chronology of the site. First, the dates link some burials at Necropolis 4 to foundational activity at the site, contemporaneous with the construction of the first ditch (Enclosure 0). This early use of the site suggests that mortuary practices formed an essential part of the social package that allowed for the emergence of this large scale center, either as a means of emphasizing existing ties to the local area, or establishing new territorial claims through a bounded area for disposal of the dead, (á la Saxe and Goldstein's Hypothesis 8), or creating a new identity that emphasized a larger lineage or community identity. Dates from Necropolis 1 bridge the earlier period of use of Necropolis 4 and the period of posited "peak activity" at the site during ZAMB 3, contemporaneous with large-scale ditch and supporting wall construction. The chronological overlap of these two mortuary areas is important, because it suggests that the choice to bury the dead in different locations at Marroquíes Bajos was not simply a reflection of the use of different spaces over time. Instead, this was a deliberate social choice, and may have acted as one means of consolidating lineage or social group identity.

In contrast, the dates from Necropolis 2 testify to the site's continuing importance as a mortuary locale into the Early Bronze Age, after the radical reorganization of both the settlement itself, and the surrounding regional landscape (Díaz-del-Río 2004). These dates indicate that Marroquíes was used during the late third and early second millennium, echoing the findings of Cámara Serrano et al. (2012). However, the continuing use or re-use of mortuary areas has been previously established, and does not necessarily indicate that the rest of the site was used in the same fashion as it was during the Copper Age. By this point, the enclosure system had been filled in, and occupation at the site was smaller and more dispersed. It is also quite possible that the Bronze Age re-use of this area was not related to Copper Age use, but further dating of the undated structures or burials (specifically Structure 43 and the cranium from Unit47), could help to tease apart the pattern of use at this mortuary area.

Figure 9.4 Dates for Necropolis 1, 2, and 4 (figure courtesy of Pedro Díaz-del-Río)



Conclusions and Avenues for Future Research

The bioarchaeological studies of Necropolis 1, Necropolis 2, and Necropolis 4 at Marroquíes reveal new discoveries about the social organization of this macro-village, allowing us to rank the models outlined in Chapter 2, while also moving beyond them.

First, the results of this dissertation have demonstrated that variability in mortuary practices was not only related to the chronology of the site. Radiocarbon dating shows that Necropolis 1, Necropolis 4, and one structure from Necropolis 2 were used contemporaneously, early in the Copper Age occupations at the site. The use of these mortuary areas also partially overlaps with the use of Necropolis 3 (Cámara Serrano et al. 2012). The remaining structures analyzed for Necropolis 2, however, attest to a subsequent Early Bronze Age re-use of the settlement for mortuary purposes, a phenomenon also documented in some of the late dates from Necropolis 3 (Cámara Serrano et al. 2012). Accordingly, the first model of diachronic change can explain a portion of the mortuary variability at Marroquíes Bajos, but does not provide a sufficient explanation for the synchronic mortuary areas practices represented at the site.

Second, analysis of skeletal and dental completion shows that multiple mortuary practices were in use at the same time. However, the second model, of a multi-stage mortuary program, also does not suffice to explain all of the variability at the site. Necropolis 2 is the only mortuary area that was solely characterized by secondary burial, and hence may represent an end point in a mortuary program. However, the chronology of the remaining undated structures and interments (Structure 42, 43, and the cranium from Unit47) is still unclear. Rather than a necropolis, the Copper Age burials in this area may represent unique, single episode depositions, akin to the interment of human remains in enclosure ditches at other areas of the site. Further analysis of *who* received these particular forms of mortuary treatment, akin to Sánchez et al.'s (2005) study of *Fosa Común* 2, is necessary. Isotopic analyses of diet and paleopathological evaluations and stress and disease, will be particularly informative when examining such depositions.

In contrast to Necropolis 2, evidence suggests that primary and secondary interments co-existed at both Necropolis 1 and Necropolis 4; signatures of skeletal and dental completion show that neither mortuary area acted solely as an area of primary burial, or as an ossuary-type facility to house the final interments secondary remains.

Because multiple mortuary areas coexist, and show different kinds of mortuary treatment being used simultaneously, a portion of the mortuary variability at Marroquíes Bajos is thus related to deliberate choices made by social groups in prehistory. For Necropolis 1 and Necropolis 4, the third model of social differentiation holds the most explanatory power. There are overarching similarities between these necropolises that attest to the organization of the larger community at Marroquíes, which include individuals of both sexes and all ages, and treat local and non-local individuals in a similar fashion. However, there are also hints at the importance of the identities of the social units responsible for burying the dead. The markedly different locations, grave inclusions, and formal characteristics of the burials hint at the maintenance of potential economic or ritual distinctions between these groups. Future research that includes aDNA analysis can help to untangle the nature of these social units by examining any potential genealogical ties among interred individuals, while a rigorous analysis of the material culture from these mortuary areas is an essential step in more fully understanding the mortuary practices at Marroquíes Bajos.

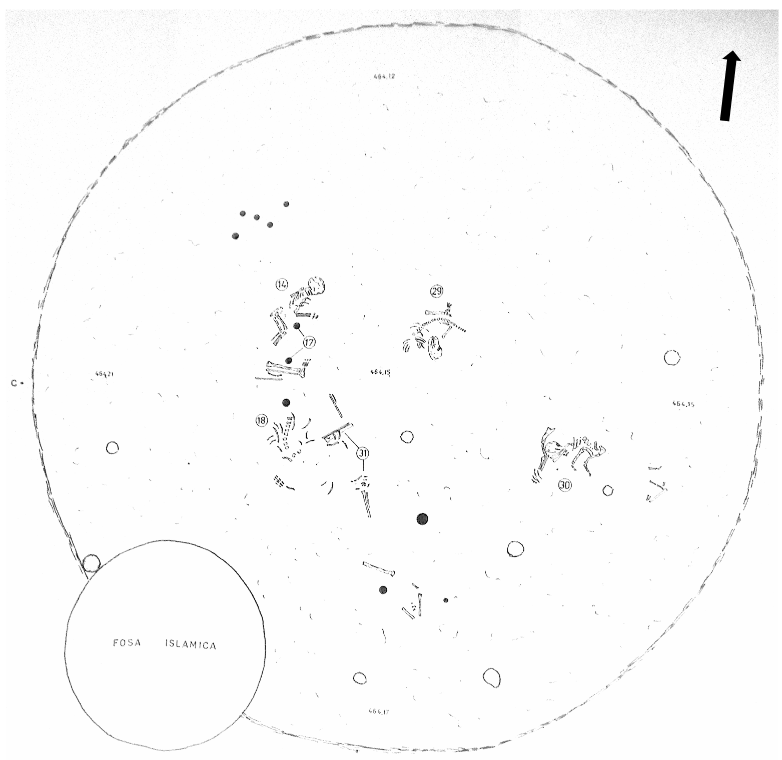
Overall, this dissertation demonstrates that though the prehistory of the city of Jaén is deeply buried, bioarchaeological analysis can still uncover important aspects of what life was like for the third millennium inhabitants of Marroquíes Bajos. The precise documentation of the many archaeological teams who excavated the site, the careful curation by the Museum of Jaén and the use of bioarchaeological techniques designed to collect information from fragmentary and commingled remains have revealed key information. These results give us glimpses into the diet, health, mobility, and individual and community identities of the people who built this macro-village, while radiocarbon dating has contributed to our understanding of the historical trajectory of the site. In this dissertation, and in future research on the human skeletal remains from Marroquíes Bajos, we can continue to fill in the considerable gap that Colin Renfrew noted for Copper Age prehistory.

Appendices

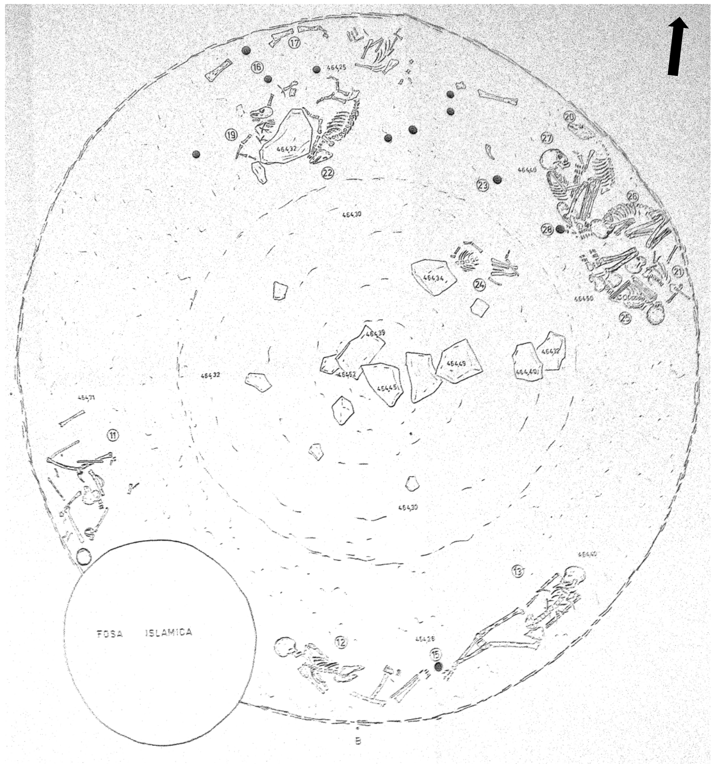
A. Necropolis 1 and Necropolis 2 Structure Maps

Arrows indicate north. Black scale bars are 2 m. Where arrows and scale bars are missing they were not present on the original maps.

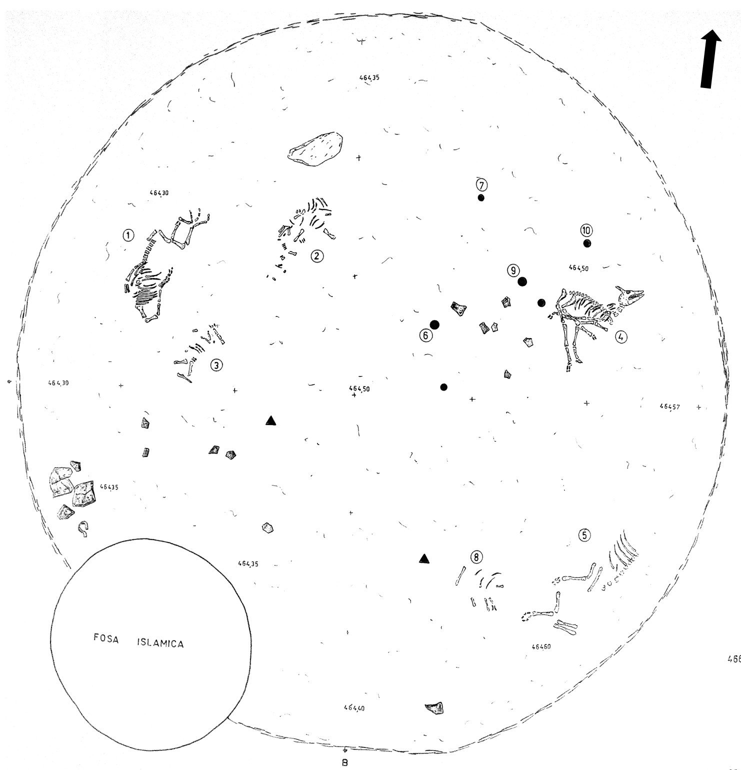
Necropolis 1, Structure 13, Floor I



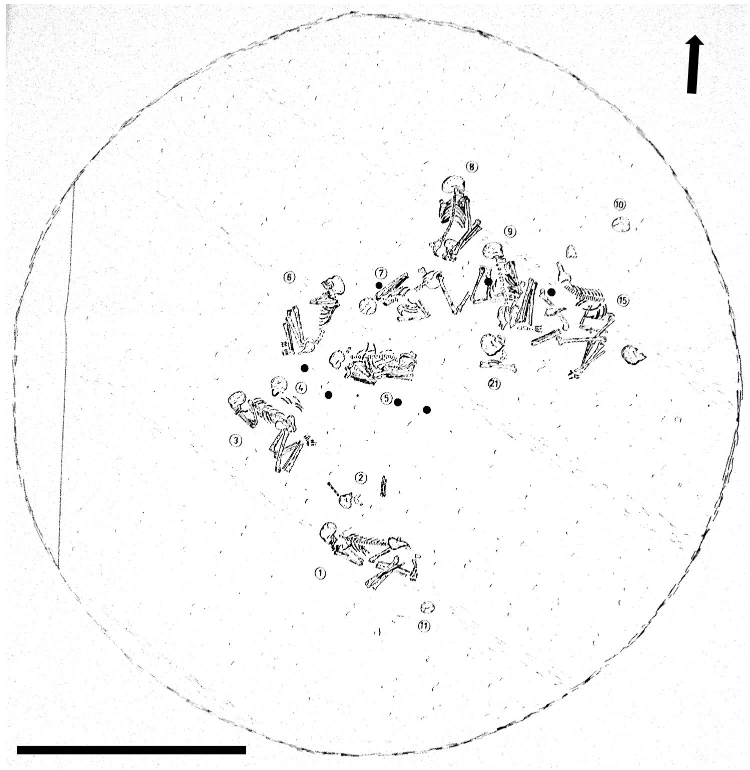
Necropolis 1, Structure 13, Floor II



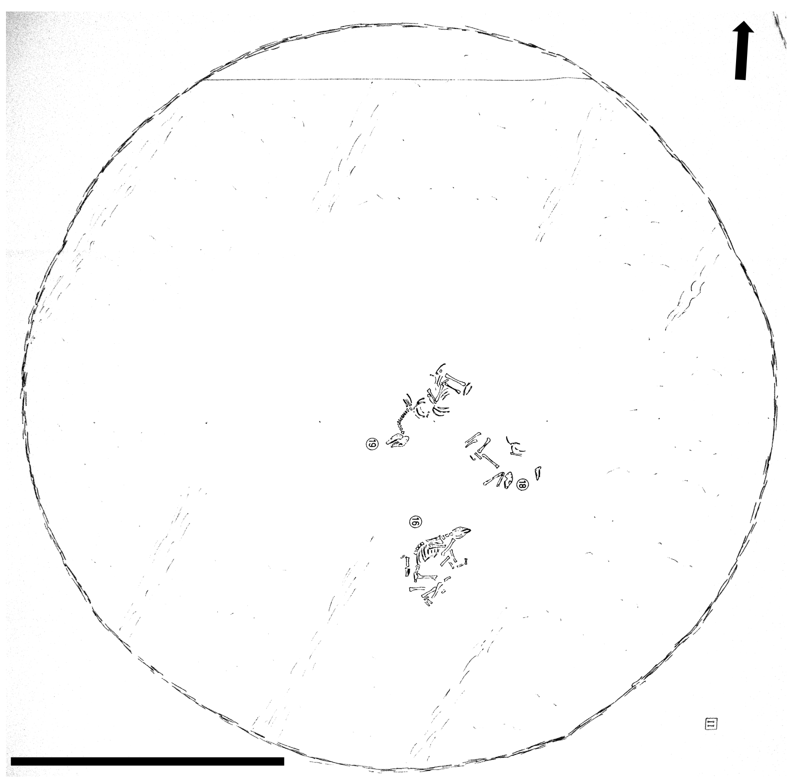
Necropolis 1, Structure 13, Floor III



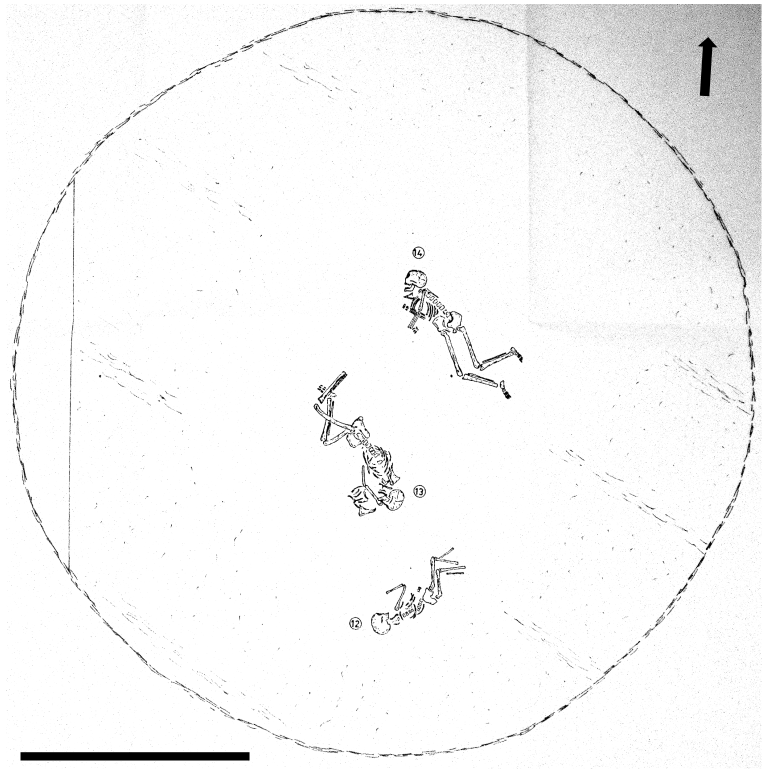
Necropolis 1, Structure 14, Floor I



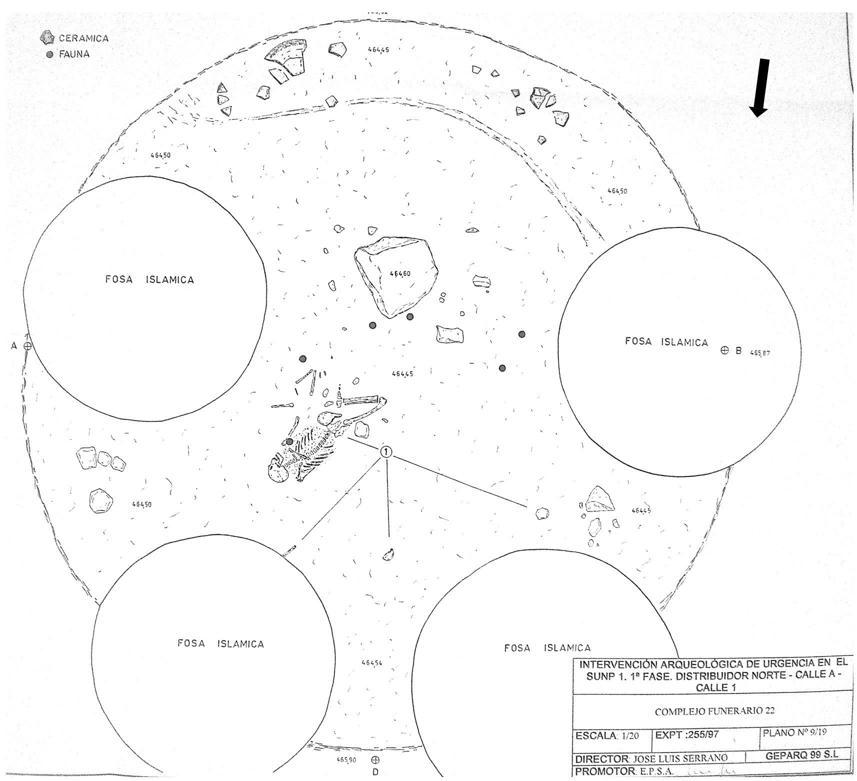
Necropolis 1, Structure 14, Floor II



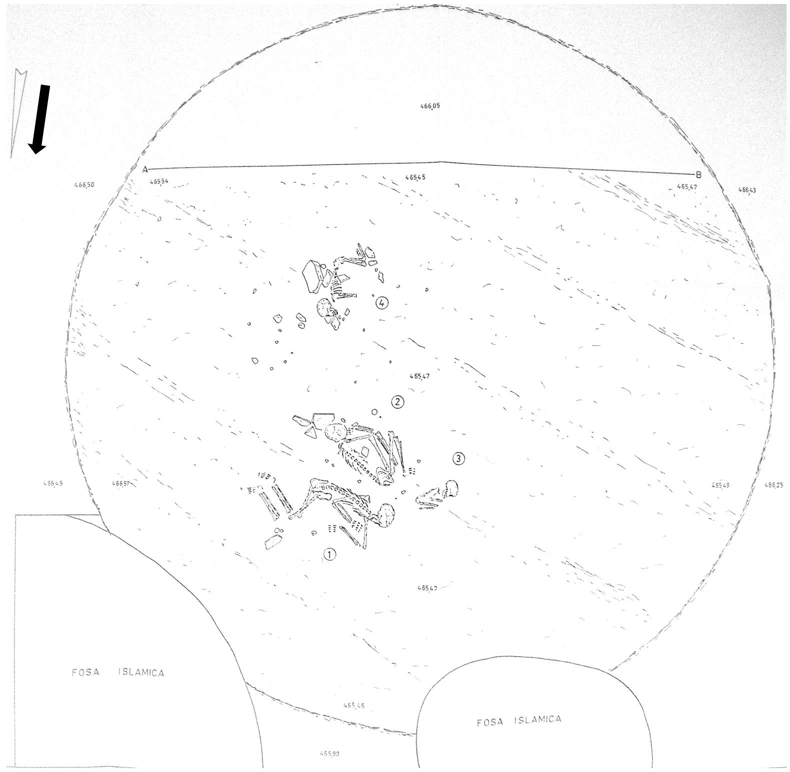
Necropolis 1, Structure 14, Floor III



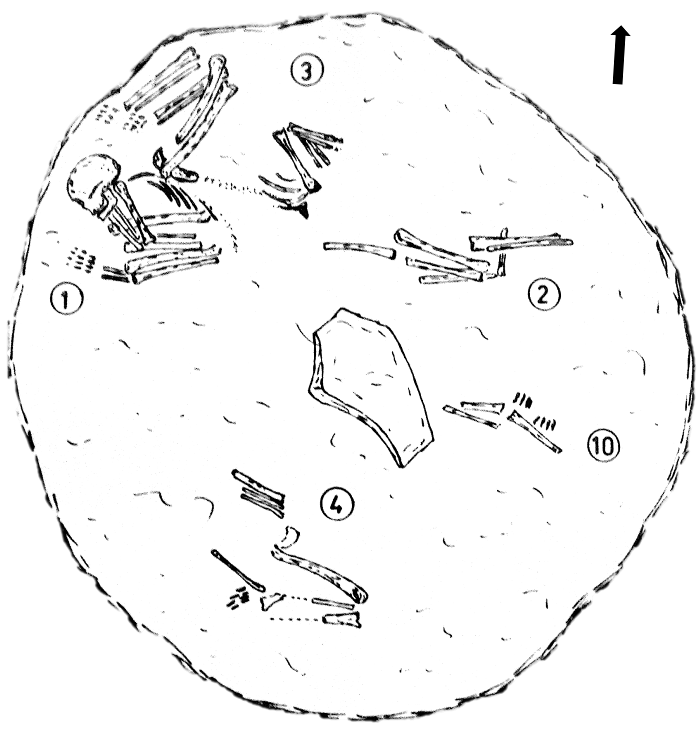
Necropolis 1, Structure 22



Necropolis 1, Structure 26 (individuals not available for study)



Necropolis 1, Structure 27, Floor I



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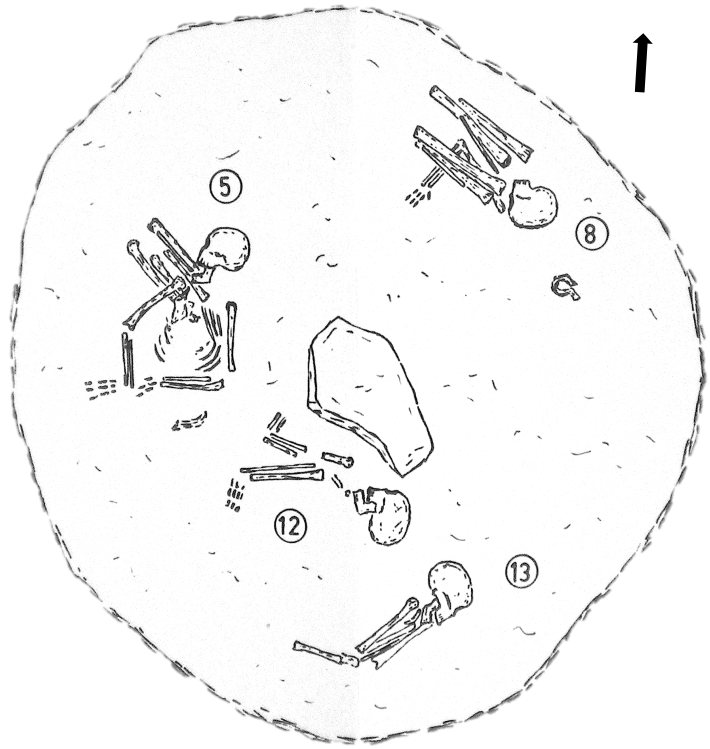

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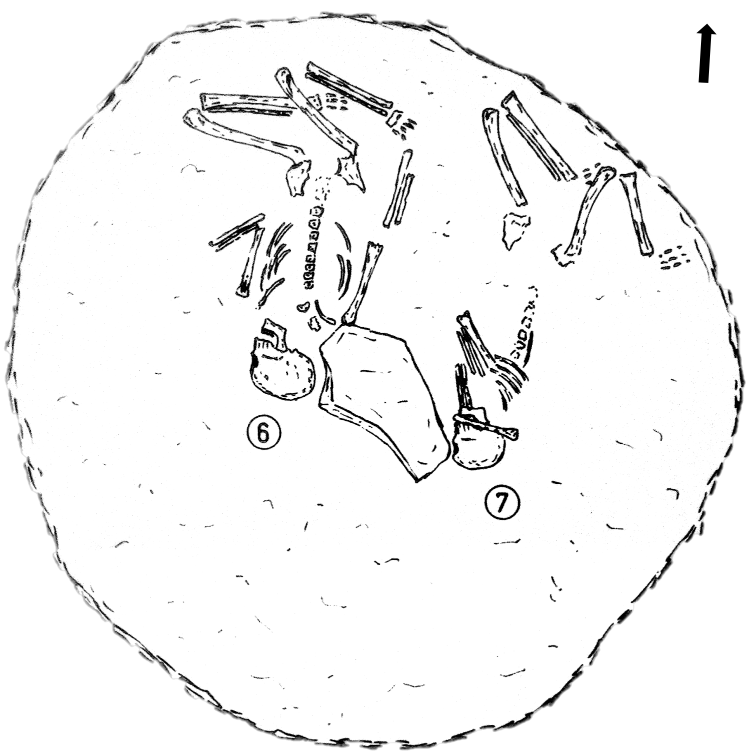
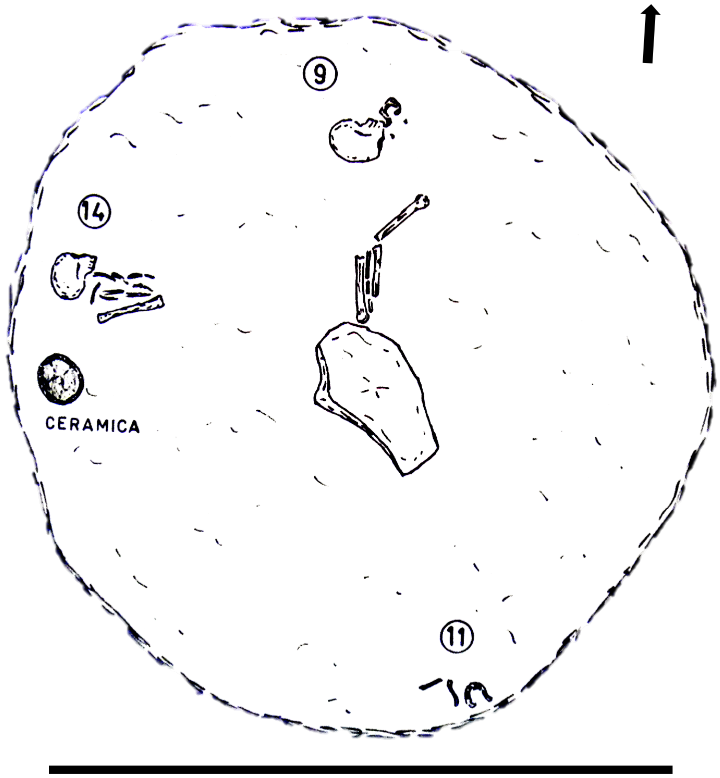
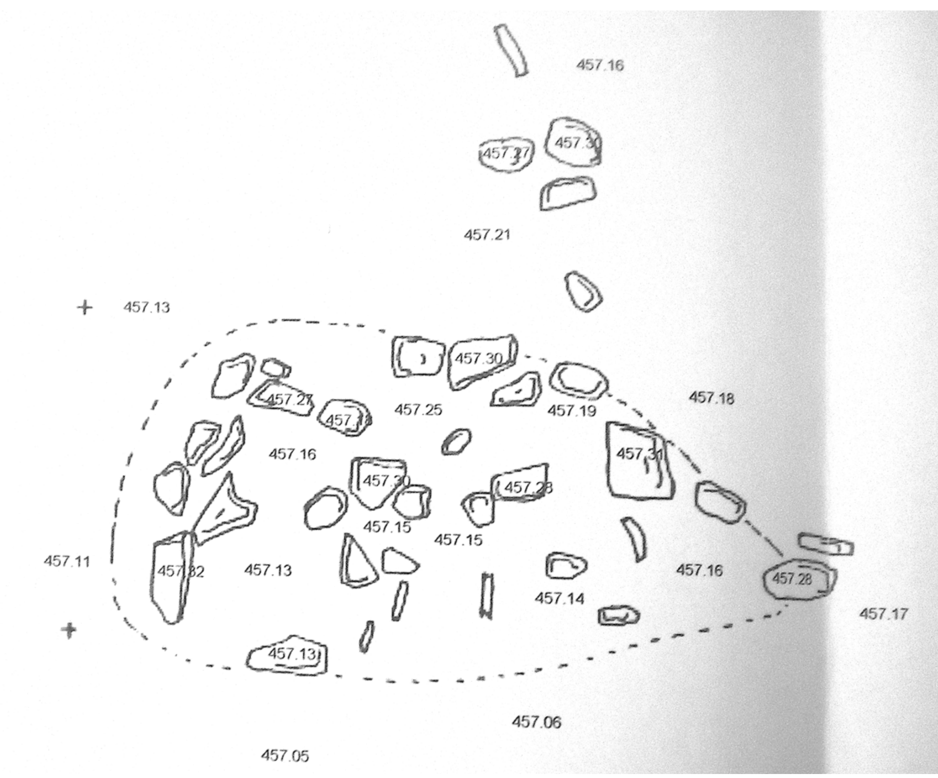


Necropolis 1, Structure 27, Floor IV



Necropolis 2, Structure 39, Floor I



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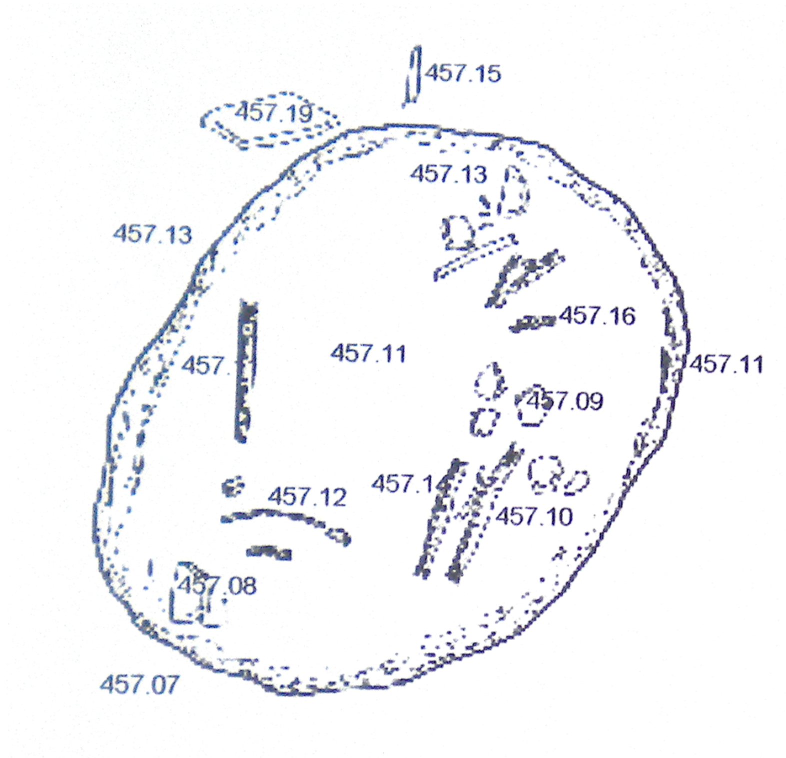
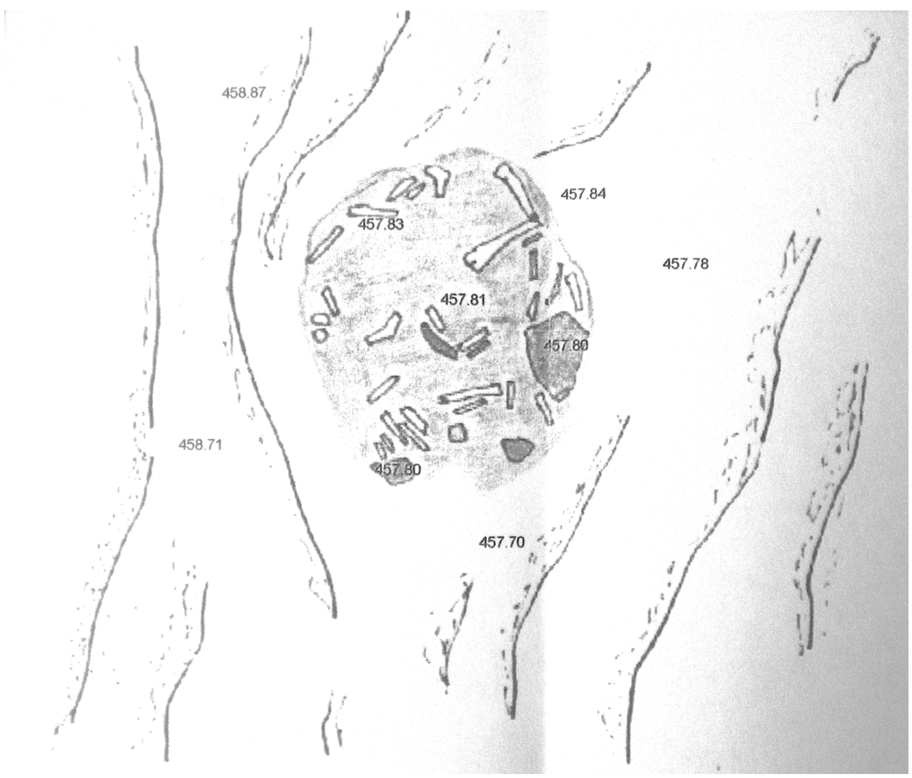
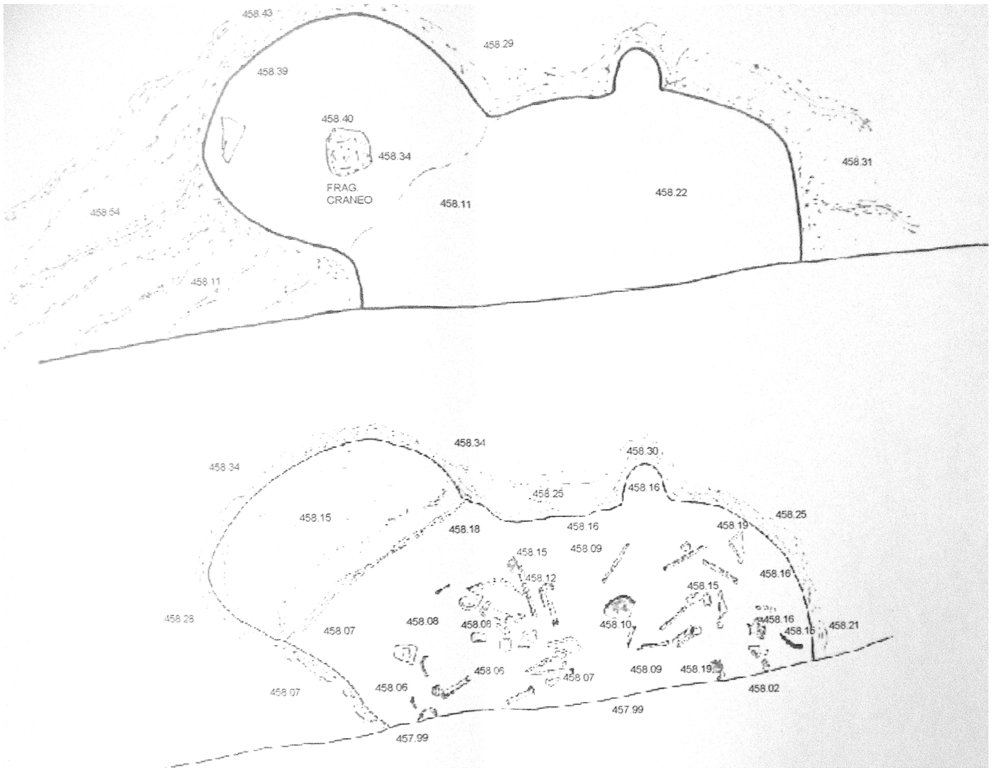


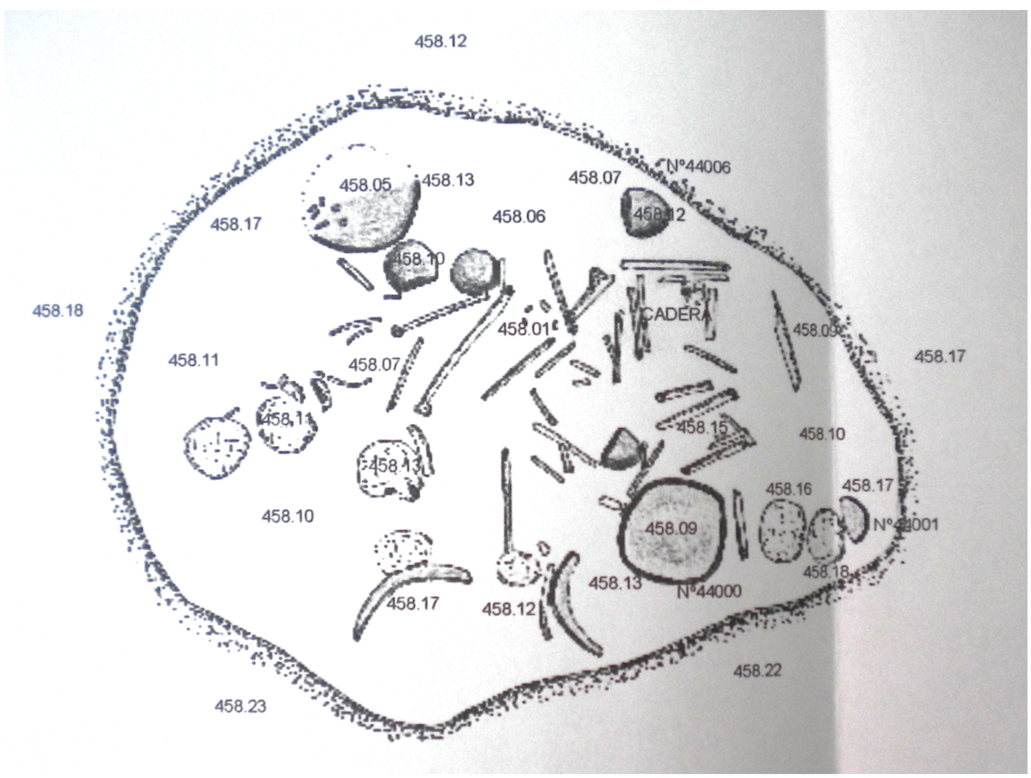
Necropolis 2, Structure 41, Floor I



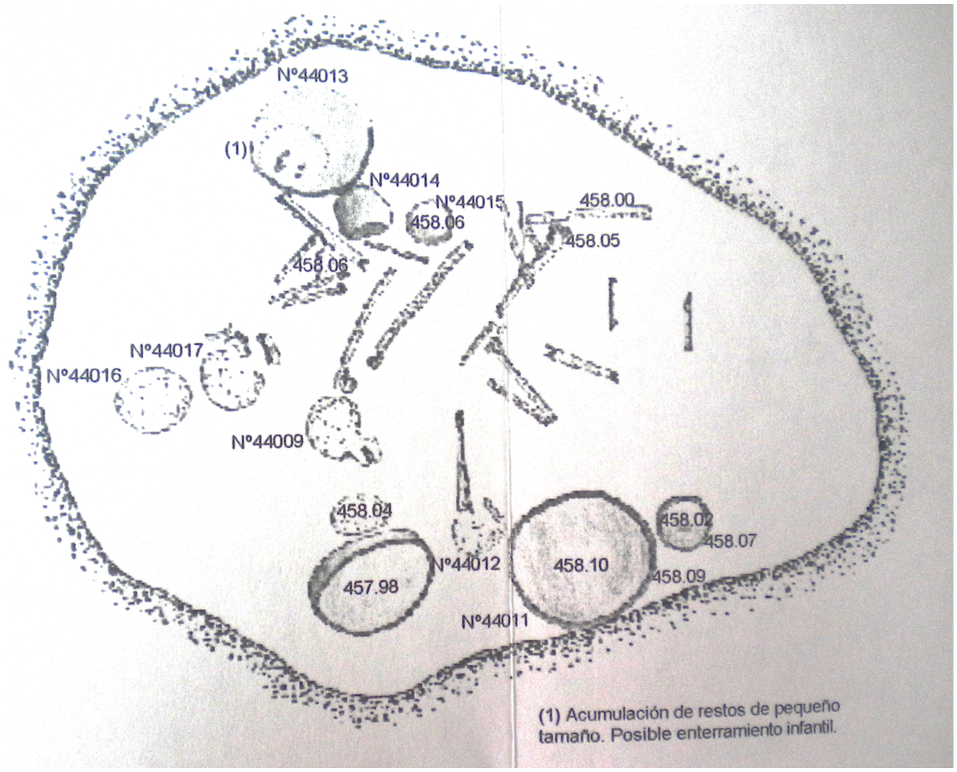
Necropolis 2, Structure 43, Floor I (top) and II (bottom)



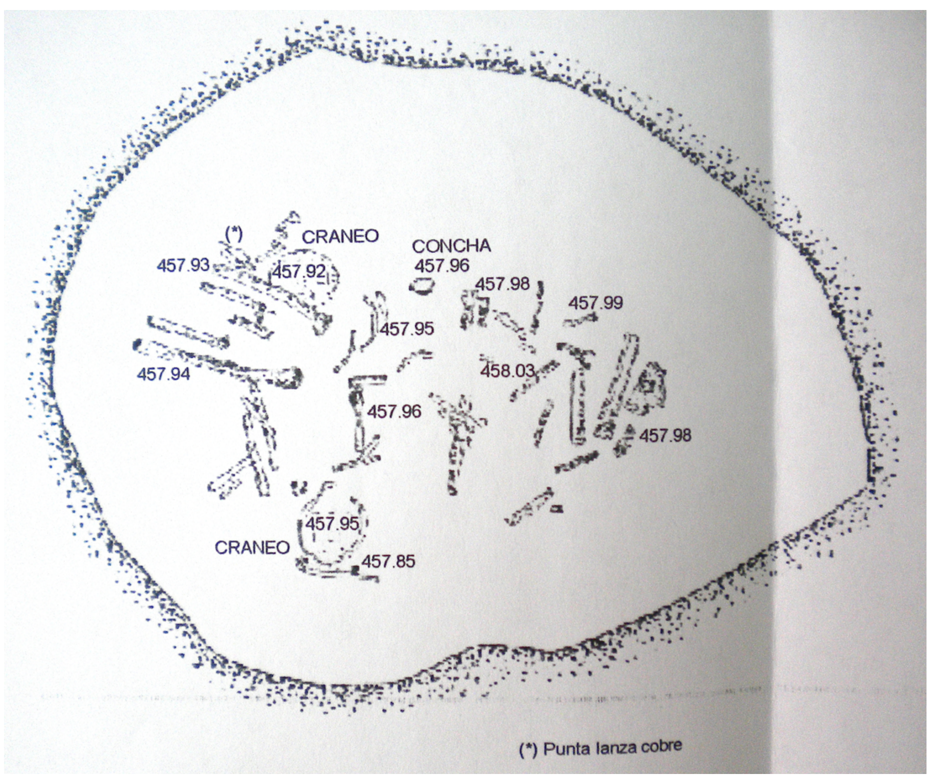
Necropolis 2, Structure 44 Floor I



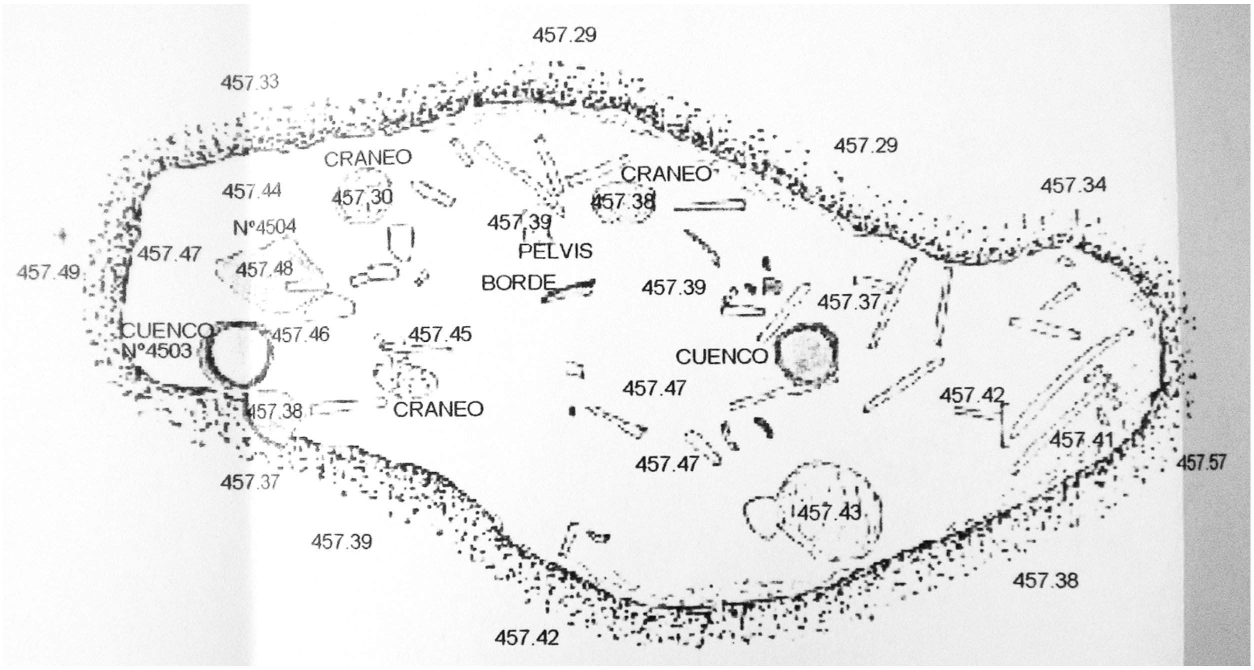
Necropolis 2, Structure 44, Floor II



Necropolis 2, Structure 44, Floor III



Necropolis 2, Structure 45, Floor I



B. Individual Summaries for Necropolis 1

N1.CE13.01: Probable adult

Synopsis: Only cranial bones and a portion right femur are preserved for this individual. The bones that are preserved have quite a bit of taphonomic damage and weathering. Based on the maximum length of the femoral fragment (35.5 cm) and the well-developed linea aspera, this individual was likely an older adolescent or an adult at time-of-death.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
NP	None of pelvis is preserved for this individual	Low	NP	None

N1.CE13.02: Very young adult, 18-25 yr.

Synopsis: There are nine teeth present. The initial age estimate was based on McCall and Schour's chronology of the human dentition, because the one LuM3 present has root formation completed, but apex is not closed or even half closed, which puts this individual in the range of 18-25 (a young adult). This deposit is somewhat unusual; many of the bags contained faunal remains, rather than human remains. The bags for this individual contain cranial fragments and a partial tibia, as well as an upper rib (possible first or second) a medial and middle portion of a clavicle, and a fragment of what appears to be a manual phalanx that all show signs of burning. While these could belong to the same individual as the tibia and cranium, I find it odd that only that specific set of bones are burned. Age cannot be determined, but the size of the clavicle compares favorably with that from N1.CE14.08, so these burned remains are also adult (or older adolescent). None of the faunal remains (which include part of a pelvis, several ribs, and a distal superior portion of occipital bone) are burned.

Sex estimate using	Preservation of feature	Confidence	Description/score	Final estimate
NP	None of pelvis is preserved for this individual	Low	NP	None

N1.CE13.11: Male, 40 – 59 yr.

Synopsis: This individual is shows a medium level of skeletal completion. Most bones of the hands and feet are fragmented and missing, and many of the long bones have suffered taphonomic damage to their cortex. Assessment of age is bolstered by the presence of one medial clavicle, which was fused, confirming that this individual was more than 20-21 yr. old when they died. Confidence in the sex assessment is low because this is an older individual and the estimate is cranial, especially given that females tend to look more masculine as they age. There is not much pathology aside from typical ABF on the articular surface of the right ulna (likely related to OA). Eleven teeth were present, all mandibular. Unusually, no cranial bones were present, though the mandible was relatively complete. In terms of dental health, there were no caries or visible LEH, but this individual evinced a significant amount of calculus. Not many faunal remains were included in the bag with this individual.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. Mental eminence; 2. Age estimate (auricular surface, right).	1. Mandible refits completely. 2. Only partially complete. Entire auricular surface appears to be transitioning from coarse granularity to a dense surface, and the superior demiface is marked by a very irregular topography. The retroauricular area is highly activity, but there is no apparent macroporosity. At the inferiomost part of the inferior demi-face, there is some degree of lipping.	Low	1. 4; 2. Phase 5-7.	Male, 40-59 yr.

N1.CE13.12: Probable female, adult

Synopsis: This individual was moderately complete, with 22 associated teeth, but still quite fragmentary, with almost no proximal or distal ends of long bones preserved. These bones seem to have been covered in a slightly different sediment than some of the other elements, that has a slightly damper feel – more like clay. Right clavicle (13.12.42) has medial end fused, meaning this individual was at least 20 yr. old when they died. The GSN visible on the pelvis seems quite wide. The nuchal crest is more robust, but the mastoid processes are small – I concur with my earlier designation of probable female.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. GSN (right); 2. Cranial.	1. Very incomplete. Fragments of both the right GSN and right ischium are preserved, but they do not refit. However, based on what is preserved (namely from the lowest portion of the auricular surface to just before the acetabulum), this looks very wide. 2. Mastoid process (right) is broken, but can be refit. Cruciform eminence and EOP are preserved on occipital.	Low	1. 2; 2. Mastoid process = 3, nuchal crest = 2/3.	Probable female

N1.13.13: Probable female, adult

Synopsis: Individual has extremely robust long bones, with the largest femoral heads observed for this population. Metrics were possible for the femur, tibia, patella, talus and calcaneus. The teeth are relatively complete.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. GSN (left)	Relatively incomplete. Three fragments (one with auricular surface, one with ilium, one with acetabulum) can be tentatively refit.	Medium	1. 2	Probable female

N1.CE13.14: Subadult, 1.5 – 5 yr.

Synopsis: There were an additional two bones (an intermediate manual phalanx and a proximal pedal phalanx with fused bases) that were too large to be from this subadult. These are recorded in the Structure 13 "Additional Individuals" tab. These bones were in extremely fragmentary condition, and although there is a cranium and mandible pictured on the structure map, no cranium or mandible were present with the postcrania. While there are long bones preserved, the only one that was possible to side was the right ulna, due to the presence of the articular facet for the radius. The age estimate is derived from the (slightly estimated) maximum diaphyseal length of the right ulna, which was the most complete long bone for this individual.

Bone	Observations	Possible age range
Ulna (R) 13.14.10	This is a little bigger than Baker's to-scale figure (2005:110) of a subadult 1.5 year-old humerus, but not big enough to be the 5-year-old. Maximum length is ~92.6 mm using the sliding calipers. While this bone is almost complete, the proximal end is degraded and the distal end is not totally complete, so being conservative it is possible to add about 4 mm to that estimate (92.6 – 96.6mm). In Ubelaker's 1989 chart "Correlations between Chronological Age Estimates and Maximum Diaphyseal Lengths," this places the element between the 0.5-1.5 yr. category and 1.5-2.5 yr. category.	1.5-2.5 yr.
Radius (L?) 13.14.09	This is a little bigger than Baker's to-scale figure (2005:107) of a subadult 1.5 year old radius, but not big enough to be the 5-year-old.	1.5-5 yr.
Femur (R) 13.14.01	This fragment is from where the shaft starts to flare out for the popliteal surface. The width of the diaphysis matches well with Baker's to-scale figure of the 1.5 year-old femur (2005:113), and is much too broad to be from a perinate.	1.5-5 yr.
metacarpal1 (L) 13.14.13	The maximum length for this metacarpal is 15.1 mm, which only produces an upper limit of about 14-16.5 yr.	< 14-16.5 yr.

N1.CE13.18: Female, 35 – 44 yr.

Synopsis: The with of fibular shaft 13.18.01 (17.5 mm) makes this individual clearly adult. A preserved petrous portion of the left temporal and several large pieces of the left os coxa preserving both the GSN and the auricular surface, can be used to estimate the age and sex of this individual. There were also two teeth a RuI2 and RuP4) were included in the bag with the hand bones. While this individual is not particularly complete, this is still an interested pattern of preservation, particularly when considering the amount of fauna (143.2 gr) present (as of June 18 2014 this is my highest faunal weight for N1 so far), which includes a large burned shaft portion of bovid or equid tibia. There were also two metatarsals from a second individual (possibly sub-adult given their small size), bagged with the hand bones for this individual.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. GSN (left); 2.Preauricular Sulcus; 3. Age estimate using auricular surface (left).	1. Relatively complete. It is preserved from the preauricular sulcus all the way down to superior-most portion of the ischial tuberosity, with 2 fragments that refit; 2. Only about half of the preauricular sulcus is preserved for this individual (8.8 mm length); 3. The auricular surface relatively complete, though most inferior portion of inferior demiface and medial-most portion of preauricular sulcus are missing – not all of retroauricular area is present.	High	1. 1 – This is a very wide sciatic notch; 2. 1 –Preserved portion is about 1.7mm deep and 9.7mm wide at its widest point. At least one bony ridge transects the sulcus; 3. There are a range of (sometimes conflicting) features that characterize this auricular surface. The superior demiface is characterized by coarse granularity, with marked transverse organization present just medial to the apex, though in the form of striae rather than billows. There does, however, appear to be a bit of macroporosity on the interior demiface. The preserved portion of the retroauricular area shows no activity. Apex is smooth, but border of the superior demiface show some lipping. The coarse granularity and transverse organization of the visible striae lead this individual to appear slightly younger (the macroporosity in the area of the inferior border is likely a secondary aging characteristic in this case). Score of Phase 4-Phase 5 (35-44).	Female

N1.CE13.21: Subadult, 5.0 – 7.5 yr.

Synopsis: Though the teeth produce an estimate from 4.3-7 yr., the maximum diaphyseal length of the right humerus is 15.6 cm (156mm) using the bone board. Within the Ubelaker (1989) "Correlations between Chronological Age Estimates and Maximum Diaphyseal Lengths" chart, that this individual in between 2.5-3.5 (Range 118.0-157.0, Mean 139.5) and 3.5-4.5 (Range 154.0-159.0, Mean 156mm). The decision to estimate a slightly older age is bolstered by both the teeth, and the fact that the diaphyseal shaft for the right humerus that is relatively complete is larger than Baker's to-scale drawing of the 5-year old humerus (2005:104). Additionally, the more complete left femur is in between the 1.5 year-old and 5 year-old in terms of size, skewing closer to the five-year-old, (2005:113).

No. teeth	Aging techniques	Description	Final estimate
31	1. AlQahtani (2009) and AlQahtani et al. (2010) – The London Atlas of Human Tooth Development and Eruption.	Upper teeth: It is not possible to tell if dm^1 and dm^2 have roots complete (a little bit of breakage on the left), but upper M^1s have erupted (> 5.5 yr.) but their root formation is not complete (< 8.5 yr.). Similarly, enamel is not completed on the M^2s, (< 8.5 yr). Lower M1s have erupted (> 5.5-6.5 yr), though it is not possible to evaluate their degree of root formation because the teeth are articulated. Overall this suggests 6-8 yr. Lower teeth: the main teeth visible (that are not articulated) are the mandibular canines. These are around Stage 6 (Cr_c) or Stage 7 (R_i), closer to Stage 6 (5.5 yr.). However, the central incisors are at the stage $R_{1/2}$, (6.5 yr.) Finally, the lateral lower incisor is at $R_{1/4}$, (5.5-7.5 yr.) Molars: The M1 roots are not complete but fairly far along (~$R_{3/4}$ – 7.5 yr.), but both upper and lower M1s have erupted and are in occlusion. Similarly, the upper M^2s have not yet completed enamel formation, the upper central incisor has started root formation (between R_i and $R_{1/4}$), the upper canines are likely at stage 6 (Cr_c) (5.5 yr.), while the upper P^3 and P^4 are also at stage 6 (Cr_c) (6.5 – 7.5 yr.).	Lower bound based on element size, upper bound based on dental development 5.0-7.5 yr.

N1.CE13.25: Female, 35 – 44 yr.

Synopsis: This is an extremely gracile individual. About one quarter of the surface of the medial right clavicle, (13.25.78), is fused, scoring a "C," "shows completed epiphyseal union with a smooth end and no indications of the epiphysis," meaning this individual was 20 yr. or older at time of death (female) or 21 (male). In addition to the fused medial clavicle, this individual showed obliteration of parts of the sagittal suture, and all preserved sockets on the mandible are resorbed. This individual is relatively complete, and most pathologies are age-related: osteoarthritis and abnormal bone formation or loss, only on articular facets.

Sex estimate basis	Preservation of feature	Confidence	Description/ score	Final estimate
1. GSN (right); 2. Pre-auricular sulcus (R); 3. Pubis (left) using Phenice; 4. Age Estimate (Auricular Surface); 5. Age Estimate (Pubis – Suchey Brooks).	1. The fragment with the auricular surface is very complete. This is a very wide GSN; 2. The sulcus seems about 4.8mm wide using calipers. It runs along the entire visible length of the inferior auricular surface; 3. The pubis has a pronounced central ridge swinging inferio-laterally. There is not enough left of the sub-pubic concavity to tell if it is arching; 4. This most likely falls into Phase IV (35-39) or V (40-44), because there is still some coarse granularity apparent, but no billowing or striae, and no transverse organization. There is no activity at the apex, so an assignation of Phase VI would not be appropriate; 5. There is a relatively clear border around the face that suggests the oval outline is almost complete. The pubic tubercle is not fully separated from the symphyseal face, and is not pronounced. The face itself is slightly depressed relative to that rim, and though there is no lipping dorsally, there are prominent ligamentous outgrowths on the ventral border. This would put this individual in Phase IV (26-70, mean 44) or Phase V (25-83, mean 58), which it most closely resembles.	Medium-high for GSN, high for pubis	1. 1; 2. 2; 3. Ventral arc = 1; Subpubic concavity = 2; Ridge = 2 Average = 1.6 (female, ambiguous) 4. Phase IV or Phase V.	Female; Age from auricular surface (35-44); Age from pubis (26-83) Final Estimate: 35-44 yr.

N1.CE13.26: Probable male, ≥ 20-21 yr.

Synopsis: Both the left medial clavicle (13.26.50) and the right medial clavicle (13.26.54) are fused, meaning > 20-21 yr. yr. The LlM3 is clearly erupted and in occlusion, is slightly worn. Large portions of many cranial bones are preserved, and there is significant dental pathology –calculus, three hypoplasias, two massive caries on the RuM1 and RuM2, and three abscesses associated with the caries. The post-crania are relatively complete, with a little bit of pathology on both tibiae, and ABL on the superior articular facets of four cervical vertebrae.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. GSN (right); 2. Cranium.	1. The GSN is relatively incomplete, but it is possible to see the downward arch towards the ischial spines; 2. This is a better preserved cranium than almost any of the others for this part of the site.	Pelvis: Low Cranium: Medium-High	1. 3/4 – Probable Male 2. Supraorbital ridge (L) = 4 (very thick), mastoid process (L) = 3/4, mastoid process (R) = 3/4, nuchal crest (C) = 2	Probable male

N1.CE13.27.1: Probable male, 30 – 44 yr.

Synopsis: This individual has very gracile long-bones, but there are not that many robust males in this population. Right medial clavicle (13.27.80) is fused, suggesting an individual over 20-21 yr. While this individual has a small pelvis, all visible portions of the iliac crest are totally fused.

Sex estimate basis	Preservation of feature	Confidence	Description/ score	Final estimate
1. Pubis (right); 2. Mental eminence and nuchal crest; 3. Age estimate (auricular surface, left).	1. The superior portion of the pubic symphyseal face and the most medial portion of the iliopubic ramus are missing. The pieces refit perfectly except for that fragment; 2. Mental eminence is completely preserved, even though right portion of mandible is fragmenting. Portion of occiput with nuchal crest can be refit; 3. The inferior portion of the inferior demiface is taphonomically damaged. However, the surface of the auricular area is being covered with coarse granularity, without much dense bone yet. There is no apical activity and no retroauricular activity. The inferior margin of the inferior demiface (the preserved portion of it, at least), is a little lipped, but not too intensely. There does not appear to be any transverse organization, and no billows or striae. Estimated to be within Phase 3-5, leaning towards the latter two phases given the lack of billows or striae, and the uniform coarse granularity. There is no true macroporosity yet, except for perhaps a small amount in the middle of the superior demiface. The rest of it is taphonomic damage.	Medium-low Low for age estimate.	1. Ventral arc = 1, subpubic concavity = not well preserved, ischiopubic ramus ridge =1 2. 3, 3. 3. Phase 3-Phase 5, preferring the latter two phases.	Probable male, 30-44 yr.

N1.CE13.27.2: Subadult, 3 – 6 yr. (second individual)

Synopsis: There are 6 subadult bones also represented in this burial – a lunate, three proximal manual phalanges for Rays 2-5, one distal phalanx for Ray 1, and part of a cervical vertebra.

Bone	Size	Appearance
Lunate	Small.	According to Baker (2005:125), the lunate appears at around age 3 in females and 4 in males.
Manual Phalanges	According to Baker (Table 10.4, p.160), all the manual phalanges appear at around 1-3 yr., and are unfused from 3-6 yr.	The neonate proximal phalanges in Baker measure about 11.26mm long, while the distal Ray 1 phalanx measures about 5.35mm long. This individual's longest proximal phalanx measures 12.5mm long, while its distal manual phalanx measures 10.1mm long. So much younger than 8, but older than a neonate.
Distal Manual Phalanx, Ray 1	See above.	The neonate proximal phalanges in Baker measure about 11.26mm long, while the distal Ray 1 phalanx measures about 5.35mm long. This individual's longest proximal phalanx measures 12.5mm long, while its distal manual phalanx measures 10.1mm long. So much younger than 8, but older than a neonate.
Cervical Vertebrae	Too fragmentary to size/ side.	So small that it must be subadult.

N1.CE13.31.1: Subadult, 14 – 16.5 yr.

Synopsis: Due to the spatial proximity of this individual to N1.CE13.18 on the map, I have associated the extra metatarsals from that bag with N1.CE13.31, and moved them over to this bag. This individual is incomplete, but telling portions of some of the bones (including medial clavicles and phalangeal bases) have preserved, making it possible to estimate age. None of the pelvis has been preserved, so an estimation of sex is not possible. The range of fusion of the left metacarpal1 relative to the phalanges is interesting, but all of these bones have experienced approximately the same taphonomic treatment, which is characteristic of elements associated with a single individual at N1. There is also the possibility that some of the manual phalanges with bases fused should actually be associated with N1.CE13.18. I am not sure whether developmentally all proximal phalanges are likely to be experiencing the same level of fusion at the same time, or if it varies by digit. Either way, some of the long bones are large enough that I am comfortable estimating age in the juvenile range. Medial left clavicle 13.31.04 is not fused, nor is medial right clavicle 13.31.05. See table below for a detailed discussion of the age assessment for this individual.

Bone	Observations	Possible age range
Radius (L) 13.31.02	Distal epiphysis is fused to the shaft. Baker et al., (2005) note that "the distal epiphysis fuses to the shaft between 14 and 17 yr. in females and between ages 16 to 20 in males" (108).	
Clavicle (L) 13.31.04	The medial epiphysis is unfused. This probably sets the highest bound for yr.	< 20-21 yr.
Clavicle (R) 13.31.05	The medial epiphysis is unfused. This probably sets the highest bound for yr.	< 20-21 yr.
Metacarpal1 (L) 13.31.09	The epiphysis for the metacarpal 1 base is unfused. Scheuer and Black (2004) note that this fuses by 14.5 yrs for females and 16.5 yrs for males. However, this is also the period when the bases of the proximal and middle phalangeal epiphyses fuse, and these are fused. Distal portion (head) is broken off, but maximum length is 28.4mm using sliding calipers.	< 16.5 yr.
Proximal manual phalanges (US) 13.31.13	Baker et al., (2005) note that "fusion of the bases to the shaft occurs around 14-15 yr. in females and 16-17 yr. in males, with some sources indicating complete fusion takes place as late as age 21" (137). The largest proximal manual phalanx preserved has a maximum length of 36.9mm using sliding calipers, and its basilar epiphysis is fused. Comparing this to White's to-scale photo, it is likely from Ray 2 (PP2), which puts it in the 12-13 category for males and the 11-12 category for females using Scheuer and Black's *Juvenile Developmental Osteology* (2000) and Table 9.25 on p. 340. The smaller preserved bone has a maximum length of 33.5mm, and its basilar epiphysis is unfused. The length and shape of the smaller proximal manual phalanx with base unfused is mostly similar to that of Ray 5 (PP5) on White's to-scale photo on pp. 234-235 of *HBM.* Using Scheuer and Black's *Juvenile Developmental Osteology* (2000) and Table 9.25 on p. 340, this puts it in the 14-year-old category for males (mean = 33.8) and the 14 (mean = 33.4) to 15 (mean =33.3) year-old category for females. The fusion of the bases for some of these phalanges suggests using 14 as a lower bound.	14-17 yr.

Bone	Observations	Possible age range
Intermediate manual phalanges (US) 13.31.14	Baker et al., (2005) note that "the bases fuse to the shaft at approximately 14 to 15 yr. in females and 16 to 17 yr. in males, ranging up to age 21 for completion" (137). Both basilar epiphyses are fused for the intermediate phalanges: the larger one is 23.77mm in length and the smaller one is 17.7mm in length with reference to the sliding calipers.	14-17 yr.

N1.CE13.31.2: Subadult, 5 – 6 yr.

Synopsis: Importantly, the bag that this individual was found in is from a different stratigraphic unit (XII) than the other bag for N1.CE13.31 (United XIV, C.5414, b.220), and the contents appear to be from a different, younger, individual. None of the long-bone shafts are complete, but the right ilium and right humeral proximal epiphyseal surface/superior shaft are essentially complete, so older age estimates are given priority for this individual, using the to-scale figures and photos from Baker et al. (2005) and White (2005). Doing so produces an age-range of 5-6 yr.

Bone	Observations	Possible age range
Ulna (L) 13.31.2.01	The distal portion of the shaft is fragmented and the olecranon process still has the typical unformed, amorphous look to it characteristic of a younger juvenile. This is *slightly* larger than Baker et al.'s to-scale drawing of a 5-year old (2005:110). Maximum length measurement is 11.4 cm, measured using osteometric board. This could be up to 6 mm longer if complete with epiphysis unfused, which would make for a diaphyseal length of ~12 cm. Using Ubelaker's (1989) chart of diaphyseal lengths, this would this individual. between the 2.5-3.5 (mean 117.9, Range 100.0-129.5 mm) and the 3.5-4.5 range (mean 129.8 mm, range 126.5-133.0)	2.5-5 yr.
Humerus (R) 13.31.2.02	The maximum length is 13.5 cm using an osteometric board. This is slightly larger than Baker et al.'s to-scale drawing of a 5-year old (2005:104). Given the breakage, at most the shaft could continue for another 7 mm or so, making maximum length 14.2 cm, which puts this individual in the same range using Ubelaker (1989): 2.5-3.5 yr. Scheuer and Black's *Juvenile Development Osteology* lists this length as being in the range for a 2.5-3 year old (2000:289). Combining Baker's to-scale figure with the Ubelaker and Scheuer and Black data produces the same range as the ulna.	2.5-5 yr.
Clavicle (L) 13.31.04	Maximum length is 53.9 mm using sliding calipers, but this will definitely extend farther due to breakage. Both ends are fragmented, making it difficult to estimate maximum length.	NP
Ilium (R) 13.31.05	This perfectly matches the size of White's to-scale figure of the six-year old in the HBM (2005:253). Maximum length of crest is 73.6 mm, max height of ilium is 64.9 mm, measured with sliding calipers.	~ 6 yr.

N1.CE13.36: Adult mandible

Synopsis: This likely represents at least two individuals. The more complete individual has a relatively complete mandible that refits, and 15 of the lower teeth (all except the LlM3). No obvious dental pathologies. There is an additional RlM2 (identified based on cusp formation, square outline, root direction, and root spacing).For purposes of parsimonious MNE estimation, we can assume that the extra RlM2 can be associated with another individual from structure 13, as N1.CE13.02 and N1.CE13.25 and N1.CE13.18 are all missing their RlM2s.

N1.CE13.157: Subadult mandible, 3.5 – 7.5 yr. (associated with N1.CE13.14)

Synopsis: This individual consists solely of one subadult mandible with erupted dm1 and dm2 on both sides, as well as several developing permanent teeth.

No. teeth	Aging techniques	Description	Final estimate
9	1. AlQahtani (2009) and AlQahtani et al. (2010) – The London Atlas of Human Tooth Development and Eruption; 2. Size of bones from associated N1.CE13.14.	Molars: The left dm_1 and dm_2 (which can be removed from the mandible) have are fully formed roots, and the M1 has not yet erupted, (< 5.5 yr) .Incisor: The unsided lower lateral incisor is at Stage 9 ($R_{1/4}$) (6.5-7.5 yr.).	3.5-7.5 yr.

N1.CE.13.191: Adult mandible, probable female

Synopsis: A small portion of mandible is preserved, along with 11 teeth, all of which are lower. The mental eminence is present.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. Mental eminence	Mandible is very fragmentary, but mental eminence is fully complete.	Low – because there is only one cranial trait. Mental eminence itself is in good condition.	2/3	Probable female/ambiguous

N1.CE13.211: Subadult, 3.5 – 7.5 yr. (associated with N1.CE13.14)

Synopsis: This individual is represented by 4 deciduous teeth and 7 permanent teeth (11 teeth total), as well as an incomplete cranium. Basi-occiptal synchondrosis present and unfused.

No. teeth	Aging techniques	Description	Final estimate
12	1. AlQahtani (2009) and AlQahtani et al. (2010) – The London Atlas of Human Tooth Development and Eruption; 2. Size of bones from associated N1.CE13.14.	The right upper permanent M^1 has its enamel completed and is between Stage 9 ($R_{1/4}$) and Stage 10 ($R_{1/2}$) (5.5-6.5 yr.). The LuM2 is at stage 5 ($Cr_{3/4}$) (7.5 yr.). The roots are complete on the dm1 and dm2 (there are disarticulated deciduous molars from the left that have visible roots). I1 – P3 have enamel complete, but P4 does not yet have enamel complete (5.5 – 6.5 yr.).	3.5-7.5 yr

N1.CE14.02.1, Subadult, 1.5 – 3.5 yr. (first individual)

Synopsis: This bag contained teeth from two sub-adults of different ages, along with a number of fragmentary bones and faunal remains, as well as a fibular shaft and fragmentary distal tibia from a separate adult individual based on size. There was also an additional adult individual, represented by a fibular shaft and a very fragmentary distal tibia (characteristic angular curvature). Remains were associated with the older or younger subadult based on size and comparisons with tables or drawings from Scheuer and Black and Baker. The bones of the hand were associated with the younger individual by measuring their maximum diaphyseal lengths and comparing them to Table 9.25 in Scheuer and Black (2000:340) "Mean values for maximum metacarpophalangeal lengths (in mm) in Nigerian children."

The maximum length of the first metacarpal with unfused base measured 22.8 mm long using sliding calipers, making this individual < 3 yr. by those standards. Similarly, maximum length for the proximal phalanx (Ray 2-5) is 15.7 mm, which places this individual at < 3 yr. As a result, all hand remains were associated with the younger subadult, N1.CE14.02.1. The metatarsal shaft was of a similar size so it was also associated it N1.CE14.02.1. Finally, the maximum width for the vertebral superior articular facet is 9.6 mm, while in Baker's (2005:79) drawing it is 7.69 mm for the 2-4 year old, leading to association with the younger individual. There are additionally fragments of a mandible, maxilla, a neural arch (category unidentified), and a cervical neural arch present for this individual.

No. teeth	Aging techniques	Description	Final estimate
16	1. AlQahtani (2009) and AlQahtani et al. (2010) – The London Atlas of Human Tooth Development and Eruption.	Both right and left M_1s are between Stage 5 ($Cr_{3/4}$) and Stage 6 (Cr_c) (1.5-2.5 yr.). Upper incisors are at $Cr_{1/2}$, and upper molars are at $Cr_{3/4}$. (1.5-3.5 yr.). The roots are not finished forming on the Ruc^1, Rui^1 or Lui^1, but based on being able to slot the teeth back into their sockets they are in occlusion. Similarly, all upper and lower deciduous molars have erupted and are in occlusion. The eruption of the upper deciduous molars, combined with the incomplete roots on the Lli_2 and the Ruc^1 suggests 1.5 – 2.5 yr.	1.5-3.5 yr.

N1.CE14.02.2: Subadult, 6.5 – 7.5 yr. (second individual)

Synopsis: These teeth were dirty, and some of them appeared to have defects, so they were washed. A complete mandible is present for this individual, as well as rib fragments and cranial fragments that appeared to be too large to be from a 2 to 3 year-old child. However, because they were too small to be from an adult, they were associated with this individual.

No. teeth	Aging techniques	Description	Final estimate
13	1. AlQahtani (2009) and AlQahtani et al. (2010) – The London Atlas of Human Tooth Development and Eruption.	Roots are visible for both Rlm_1 and Llm_2, and they are at Stage 12 (R_c). Lower M1s have erupted (> 5.5 yr.). There is an erupting LlI2, the LlP4 has part of the root formed and is coming in underneath the $Lldm_2$ visible in the crypt, and the one lower permanent canine has not really started root formation, though enamel is complete (5.5-6.5 yr.).	6.5-7.5 yr.

N1.CE14.03: Probable female, adult

Synopsis: The pelvis and cranium were both very fragmentary. None of the long bones were in good condition (particularly the smaller bones of the forearms and legs), and while the site report map shows a relatively complete rib cage and feet, these did not materialize in the osteological analysis. Finally, there was an extra tooth present for this individual, a RuM^1 that is just a crown (Stage 6) – making this from a second individual at 3 – 4 yr. using AlQahtani et al. (2010). This tooth is most likely associated with N1.CE14.04, a subadult who is buried close to N1.CE14.03 and in an appropriate age range.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. GSN (left)	Almost entire GSN is present except for most posterior-medial portion of the auricular surface.	High	1. 2/3	Probable female

N1.CE14.04, Subadult, 1.5 – 3.5 yr.

Synopsis: This is a relatively incomplete subadult individual, represented predominantly by the cranium, mandible, and teeth. There are fragments of a rib body, cervical vertebrae and vertebral fragments, and two phalanges also associated with this individual, all of a size class that is within the range for this age-category. The RuM1 was actually in the bag for adult individual N1.CE14.03 buried nearby. However, this RuM1 mirrors the LuM1 included in the bag with N1.CE14.04 in terms of form, taphonomic treatment, and stage of development, so it was associated with this individual. On the map there appear to be ribs buried with this individual, but none were found with the exception of one small body fragment (and with the exception of 0.5 g of possible faunal ribs).

No. teeth	Aging techniques	Description	Final estimate
8	1. AlQahtani (2009) and AlQahtani et al. (2010) – The London Atlas of Human Tooth Development and Eruption.	The roots are visible for the left and right lower dm_2s. Both are at Stage 10 ($R_{1/2}$) (1.5-2.5 yr.). The right lower M_1 is between Stage 5 ($Cr_{3/4}$) and Stage 6 (Cr_c) (2.5-3.5 yr.). The enamel is complete on all deciduous teeth. The roots for the lower dm_1s and the upper dm^1 and dm^2 look like they may be a little broken. The lower left dm_1 has the least damaged roots, and they are not complete (1.5-2.5 yr.).	1.5 – 3.5 yr.

CE.14.05: Probable male, 30 – 39 yr.

Synopsis: The medial clavicle is clearly fused, so this individual was older than 20- 21 yr.-at-death. Two teeth (LuP3 and LuP4) from the a N1.CE14.06 bag anatomically overlapped with teeth already present for N1.CE14.06. This burial lacked a LuP3 and LuP4, and there were no discrepancies in size or taphonomy with the rest of the teeth. Operating on the principle of parsimony, these two teeth were also associated with N1.CE14.05.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. GSN (left); 2.Cranium; 3. Age estimate (auricular surface, left).	1. Almost the entire GSN is present except for very posterior part of auricular surface. 2. See photos.3. Age estimate: likely Phase 3 or 4. Coarse granularity appears to be taking over the surface - there is some transverse organization/striae on the superior demiface. Little apical or retroauricular activity.	High based on pelvis, lower based on cranium.	1. 4; 2. Supraorbital ridge (R) = 2/3 Mastoid process (R) = 3; Mental eminence (C) = 2/3; 3. Phase 3/Phase 4	Probable male Final Estimate: 30-39.

N1.CE14.06: Probable male, 35 – 44 yr.

Synopsis: The bones for this individual are in poor condition. The long bones and pelvis have what seems like paper adhered to the cortical bone, and the cranial fragments are in poor condition. Some large fragments could not be identified due to poor preservation. An additional bag, labeled "Huesos Humanos Individuo 6" contained the right femoral head, the shafts of some proximal phalanges, the zygomatic arch of the left temporal, one general flat cranial fragment, one metatarsal shaft, two rib fragments, two teeth (LuP3, LuP4), and a number of faunal fragments including long bones, ribs, and what may be carpals/tarsals.

Sex estimate basis	Preservation of feature	Confidence	Description/ score	Final estimate
1. GSN (left); 2. Mastoid process (right); Mental eminence (c); 3. Age estimate (auricular surface, left).	1. GSN refits perfectly, high level of preservation. 2. See photos. 3. Phase 4 - 5. There is not much retroauricular activity, and there are hints of some striations on the inferior demiface. Coarse granularity is being replaced by densification around rim and in islands on surface, as well as some apical changes, and organization on the inferior demiface could be described as "vague and residual."	High	1. 4 2. Mastoid process = 3 Mental eminence = 3 3. Phase 4-5	Probable male Final Estimate: 35-44.

N1.CE14.07: Probable female, 25 – 29 yr.

Synopsis: Because this individual was so complete, 19 measurements could be taken on the femur, tibia, sacrum, patellae, and other bones. Curiously, the right patella is much bigger than that right patella. There were two sets of bones from different individuals included by this bag: ***1. Subadult*:** There is a second subadult individual represented by the left fibula, which is very small (maximum width is 10.6 mmwith sliding calipers, and length of all refit fragments is only 136 mm). The width is too large to be from Baker et al.'s (2005) to-scale figure of a 5-year old, so likely from a subadult that is a little older. This bone was added to the additional individuals spreadsheet. ***2. Adult:*** There are also two overlapping fragments of left ascending ramus for the mandible. These were associated with N1.CE14.07, because all 16 lower teeth are present for this individual, an outcome made much more likely by near-complete preservation of portions of the mandibular body. The other fragment, weighing 7.6 g, was added to the additional individuals spreadsheet.

Sex estimate basis	Preservation of feature	Confidence	Description/ score	Final estimate
1.GSN (left); 2. Mastoid process (right); Nuchal crest; 3. Age estimate (auricular surface, left).	1. The left ilium and top of acetabulum are well-preserved, but not all of the GSN is well preserved; 3. The majority of the surface is marked by fine granularity (though small portions of it are being replaced by coarse granularity). There is no activity at the apex or in the retroauricular area, and the marked transverse organization of the inferior demiface, where billows are slowly turning into striae. As a result, the broadest range for this individual is Phase 1/Phase 2, but because billows cover so little of the surface (unlike in Phase 1, where "billows are well-defined and cover most of the surface" – Standards p.25) this is more likely Phase 2, or even Phase 3, despite the fine-grained nature of the surface.	Low	1. ½; 2. 1, 1; 3. Phase 2 or 3 –widest estimate Phase 2-3 (25-34), narrowest estimate 25-29.	Probable female Final Estimate: 25-29.

N1CE.14.08: Female, 42 – 87 yr.

Synopsis: Portions of most of the long bones are preserved for this individual. Twenty teeth are present, and 12 have calculus (with an average score of 1.25), but there are no other distinct oral pathologies present.

Sex estimate basis	Preservation of feature	Confidence	Description/ score	Final estimate
1. GSN (right); 2. Phenice (right); 3. Age estimate (Suchey Brooks, right); 4. Age estimate, auricular surface.	1. The right os coxa refits perfectly. GSN is quite wide, and relatively complete ones. It is, however, missing the most inferior and medial portion of the auricular surface; 2. The right innominate is well preserved; 3. There is a portion of rim missing dorsally (breakage), the face appears to be slightly depressed relative to the rim, there is activity in the superior ventral area where they there may be rim "break down," there is moderate lipping on the dorsal border and some ligamentous outgrowths on the ventral border; 4. There is some transverse organization apparent on the superior demiface, but there is marked apical activity. There is some irregularity to the organization, despite the transverse striations, moderate to high retroauricular activity. Course granularity is being replaced by dense bone, and there is some macroporosity coming in on the inferior demiface. This is likely at Phase 5 – Phase 7, especially given some of the conflicting signals.	High	1. 2; 2. Ventral arc = 1, subpubic concavity = 1, ischiopubic ramus ridge = 1; 3. Phase 5/6. Phase 5 = 25-83 (mean 58) while Phase 6 = 42-87 (mean 45). 4. Phase 5-7: 40-59	Female **Final Estimate:** 42-87

N1.CE14.09.1: Probable female

Synopsis: The remains in this bag represent at least five individuals, three adults (based on anatomical overlap of foot bones) and two different subadults (based on size of foot bones, and patterns of epiphyseal fusion). There were also a number of medium-sized faunal bones (e.g. small ungulates) included in the bag with the human remains. N1.CE14.09.1 is relatively complete with portions of all long bones represented, as well as a portion of the cranium, with 21 teeth preserved. This individual has one caries and four teeth with calculus. There are also a number of other minor pathologies including signs of osteoarthritis (eburnation, lipping) and abnormal bone formation in the form of both spicules on the humerus and woven bone on both fibulae.

Sex Estimate Using	Preservation of feature	Confidence	Description/Score	Final Estimate
1. Mastoid process (left, right).	1. The mastoid processes both had to be refit, but refit precisely.	Low (only have one cranial trait)	1. 2/2	Probable female

A number of additional bones that anatomically overlap with N1.CE14.09.1 were bagged with this individual. These are detailed below:
Bolsa "*Pie*" – Relabelled "*Pie Individuo 9.2*." A right calcaneus and talus, a left metatarsal5 and lateral cuneiform, and three pedal phalanges (2 proximal, one intermediate). With the exception of the pedal phalanges, these all overlap anatomically with the foot bones already preserved for N1.CE14.09.1. However, since these pedal phalanges were bagged with this foot, rather than the other feet, they are likely associated with this individual. There were also a number of faunal bones bagged with this foot. The bones from the original bags 11 and 20 mirror each other, while the bones from what has been re-labelled "Pie. Indiv. 9.2" do not match. After examining the map, it appears that there are some leg bones buried to the right of Individual 9, so this foot may associate with that. **Bolsa 1 "*Cráneo*":** This bag contained a right lateral cuneiform, two proximal pedal phalanges, an unidentified epiphysis, and a distal right fibula that does not match with either fibula for N1.CE14.09.1. **Bolsa 7 "*Mano D.*":** Importantly, in bag 7 (Mano D.) from Caja 5.417, Bolsa 142, there was an adult right hand, along with more subadult remains – those of a foot this time. These consist of a left metatarsal5 shaft, a subadult left navicular, left talus and right cuboid, three fragments that are not hand bones, and one large fragment (14.09.2.12) that is potentially faunal. **Bolsa 11 "*Pie D.*":** Many of these bones are the remains of a very young sub-adult – a proximal femur with an unfused epiphyseal surface, an unfused vertebral centrum, three pedal phalanges, one partial metatarsal shaft and two metatarsal heads (neither of which fits with the metatarsal shaft). These were all included in the bag along with the right foot from individual N1.CE14.09.1. There were also several faunal remains in this bag. **Bolsa 22 "*Costillas*":** This bag contained a left lateral cuneiform that is subadult due to its size and its slightly amorphous shape. This tarsal likely belongs to the same subadult foot represented in Bolsa 7. **Bolsa 23 "*Vertebras*":** Two relatively well preserved adult left intermediate cuneiforms.

All bones have been re-bagged to reflect these identifications. Bags are clearly labeled as individuals N1.CE14.09.2-5, and are in a larger bag labeled "*otros individuos*."

Individual	Bones	Age	Rationale and comments
A. (N1.CE14.09.2) ***Note:** As of 12 Dec 2014 this has been collapsed with N1.CE14.15.	Large foot bones (calcaneus, metatarsal 5, talus, lateral cuneiform, proximal and intermediate pedal phalanges and proximal manual phalanx) from *Bolsa* "*Pie Individuo 9.2*," plus one of the left intermediate cuneiforms from *Bolsa* 23 (*Vertebras*).	Adult (8 bones)	These bones were all in the same bag, which suggests they were all buried together. The foot bones and manual phalanx all match well in terms of size and taphonomy. The larger intermediate cuneiform was associated with this individual because the bones for Individual A are all larger than those for Individual B.
B. (N1.CE14.09.3) ***Note:** As of 12 Dec 2014 this has been collapsed with N1.CE1421.1.	Distal fibula, 2 proximal pedal phalanges and lateral cuneiform from *Bolsa* 1 (*Cráneo*), Left metatarsal 5 and pedal phalanx from *Bolsa* 7 "*Mano D*.," plus one of the left intermediate cuneiforms from *Bolsa* 23 (*Vertebras*) and the three intermediate pedal phalanges and proximal metacarpal1 fragment from *Bolsa* 11 "*Pie D*.."	Adult (11 bones)	This fifth metatarsal is smaller and more curved than the fifth metatarsal from Individual A. Because it was bagged with the proximal pedal phalanx from Ray 1 in *Bolsa* 7, they were associated. Similarly, the distal fibula and pedal phalanges in *Bolsa* 1 "*Cráneo*" were bagged with a lateral cuneiform that is markedly smaller and narrower than that of Individual A, even though it is from a different side. Finally, I associated the small proximal first metacarpal fragment with Individual B because Scheuer and Black indicate that it cannot be accurately identified until 9-10 yr., and it does not fuse until 14-16 yr. As it is not fused, it is likely from the subadult.
C. (N1.CE14.09.4) ***Note:** As of 12 Dec 2014 this has been collapsed with N1.CE14.09.5 and 21.2.	Navicular, talus and cuboid from *Bolsa* 7 "*Mano D.*" and lateral cuneiform from *Bolsa* 22 "*Costillas*."	Subadult 6-8 yr. (4 bones)	The foot remains from *Bolsa* 7 were all bagged together, and are all of such a size as to be subadult. The first metacarpal is much smaller than the preserved proximal ends of the first metacarpals from N1.CE14.09. These tarsals are all identifiable, and the navicular and cuboid are all slightly smaller than Baker's drawings for an 8 year-old. The talus, however, seems like it might be too small for a 6-8 year old. Either way, Baker notes that the navicular, cuboid and lateral cuneiform do not attain their distinctive shape until the 6-8 year range. These are distinctly identifiable, so this individual is likely older than Individual D., whose bones are too small to be in this range.
D. (N1.CE14.09.5) ***Note:** As of 12 Dec 2014 this has been collapsed with N1.CE14.09.4 and 21.2.	The vertebral centrum, femoral neck + epiphyseal surface for head from *Bolsa* 11 "Pie D," and proximal tibial epiphysis from *Bolsa* 1 "*Cráneo*."	Subadult 1.5-5 yr. old. (3 bones)	The vertebral centrum is likely thoracic (shape most closely aligns with B, upper thoracic in Baker 2005:76; Figure 6.1). However, it is much smaller than the centra drawings she lists. The typical 2-4 year old vertebral centrum she shows is 1.91 cm maximum ML length, and 1.31cm maximum AP length. In contrast, my vertebrae is 1.77 max ML length and 1.15 max AP length, so I think this child may be slightly younger than 2-4 yr.

Individual	Bones	Age	Rationale and comments
			Importantly, the vertebral centrum fuses to the neural arch between 2 and 8 yr. according to *Standards* p.43, so this individual was younger than that at time of death. Size-wise this femur is in between the ranges for a 1.5 year old and a 5 year old (according to Baker's to-scale (113: Figure 8.10) and has a visible proximal epiphyseal surface for the head. The maximum diameter of epiphyseal surface for head is 19.2mm, measured using sliding calipers. The tibia falls in the range between the 1.5 and 5-year old shown in Baker (2005:117; Figure 8.13), much like the femur. This is likely proximal tibia because of two distinctive facets that are likely medial and lateral articular condyle.

N1.CE14.10: Probable adult, ≥ 18 yr.

Synopsis: There are only 5 teeth present for this individual, all upper molars. The cranium was extremely well preserved, and likely interred as a complete cranium given the level of completion and the sheer volume of cranial fragments. The only non-cranial bones included in this bag are three pedal phalanges (one proximal, two intermediate). This individual is supposedly also associated with C.5.400, b.160, "Huesos Suelto. Ind. N˚8 Pie." The metopic suture appears to have remained unfused into adult-hood for this individual. The phalangeal bases for both the proximal and intermediate pedal phalanges present are fused, meaning this individual was > 13-15 yr. (F) or 16-18 yr. (M) at time of death according to Scheuer and Black (2004:408). The upper third molars were erupted and root complete, which puts us in the 18-25 year range according to Thoma and Goldman (1961).

N1.CE14.11: Probable adult

Synopsis: An estimate of sex was not possible, as this individual consisted solely of a fragmentary cranium, one fragmentary metacarpal, and 5 teeth. The size of the cranial fragments and the development of the teeth indicate this individual was an adult.

N1.CE14.12: Subadult, 5.5 – 7.5 yr.

Synopsis: This is a relatively complete subadult cranium embedded in a chunk of sediment. Two additional teeth were located when analyzing the cranial fragments. It was possible to measure maximum diaphyseal lengths for some of the bones. The femur, radius, and humerus are all significantly larger than Baker et al.'s (2005) to-scale figures of those long-bones, meaning that this individual was likely > 5 yr. at time of death. However, all of the long-bone measurements fall right in the middle of age ranges 4.5-6.5 for all Ubelaker's measurements of diaphyseal lengths. In the end, both diaphyseal lengths and dental development/eruption were used to estimate the age of this individual. There are also three circular shaft fragments of faunal long bone included in the bag with this individual. **Additional Individual:** There are bones from at least one other individual also buried with this individual, in the form of a first metacarpal with a fused base. As Scheuer and Black (2004) note that this bone fuses by 14.5 yrs for females and

16.5 yrs for males, this is likely from a second older individual. This bone was entered with the additional individuals for CE14.12.

Element	Maximum diaphyseal length	Comments
Femur (L) 14.12.03	25.00 cm	Measured with osteometric board. This puts this individual between age categories 5.5-6.5 (mean 248.6mm, range 236.0-277.0mm) and 6.5-7.5 (mean 262.0, range 252.0-274.0) for Ubelaker's *Correlations between Chronological Age Estimates and Maximum Diaphyseal lengths* (1989).
Radius (L) 14.12.16	12.80 cm	Measured with osteometric board. This puts this individual in the age category 4.5-5.5 (mean 128.1mm, range 125.0-132.5mm) for Ubelaker (1989).
Humerus (R) 14.12.12	18.05 cm	Measured with osteometric board. This puts this individual in the age category 5.5-6.5 (mean 180.1mm, range 172.5-192.0 mm) for Ubelaker (1989).
metacarpal1 (R) 14.12.23	23.20 mm	Measured with sliding calipers. This puts this individual at < 3 yr. using Scheuer and Black's table in *Juvenile Developmental Osteology* (2009:339); however, because this does not align with any of the other age estimates, the long bone lengths are given priority.

No. teeth	Aging techniques	Description	Final estimate
11	1. AlQahtani (2009) and AlQahtani et al. (2010) – The London Atlas of Human Tooth Development and Eruption.	The root is complete on Ldm1, and the root is complete on Ruc^1. The LuM^1 has erupted and is in occlusion, establishing the highest possible lower bound at 6.5 yr. The permanent central incisor has a portion of its root complete. On the left, the upper canine is erupting but is still higher up (e.g. developmentally behind) the permanent upper P^3, which has part of its root forming. The dm1, dm2 and M1 are all erupted and in occlusion, and M2 is coming in behind M1 (but I cannot see how much of the root is complete. Based on the eruption of both upper M1s and the 3/4 complete development of the RuM1 roots, the most likely age category of 7.5 yr.	Maximum diaphyseal lengths range from 4.5-6.5 yr., while dental development suggests 7.5 yr. The diaphyseal estimates in agreement were used to set the lower bound (5.5 yr.) while the teeth were used to set the upper bound (7.5). Final Estimate: 5.5-7.5

CE14.13: Male, 35 – 44 yr.

Synopsis: Twenty-six teeth are preserved for this individual, and the skeleton is also relatively complete. The majority of the long bones are preserved, with the exception of the left humerus. Measurements could be taken for the humerus, femur, ulna, radius and sacrum. Eight teeth have calculus (average score = 1.63), there is one caries on the RlM3, and the LuM1 socket has begun to resorb.

Sex estimate basis	Preservation of feature	Confidence	Description/ score	Final estimate
1. GSN (right); 2. Mental eminence (c); 3. Age estimate (auricular surface, right).	1.Both right and left GSNs are relatively complete. Right was scored because the auricular surface was slightly more complete. Both os coxae are broken into two but refit; 2. Mandible completely refits; 3. Auricular surface appears to be transitioning from coarse granularity to dense bone (especially at the margins). There is no marked apical activity, there is moderate retroauricular activity, and no evidence of striations. No transverse organization is apparent. Taking into account the amount of coarse granularity remaining places this individual in Phase 4-5.	High.	1. 4; 2. 4; 3. Phase 4 (35-39) or Phase 5 (40-44), with the latter more likely.	Male Final Estimate: 35-44.

N1.CE14.14: Female, 50 – 59 yr.

Synopsis: If this was a female she was *extremely* robust – largest femoral head I have seen for this population! However, this is also one of the larger GSNs I have seen for this population, so this was likely a very robust female. I wound up washing the teeth, because there is so much of it and it is so heavily patinated. This helped somewhat in my ability to score wear and see calculus. Both clavicles had their medial ends fused, which bolsters the "adult" designation. I also found an additional tooth, a LuM2, articulated in a chunk of maxilla, just like its match across the arcade, while going through the cranial fragments bag. The bones for this individual (*particularly* the femora) are in relatively good condition.

Sex estimate basis	Preservation of feature	Confidence	Description/ score	Final estimate
1. Right GSN; 2. Right Preauricular sulcus; 3. Age estimate (auricular surface, left and right).	1. GSN is almost totally complete. The very medial edge of the auricular surface is missing on the right; 2. This appears to be an older individual, based largely on the irregularity of the surface topography and lack of transverse organization. Both left and right auricular surfaces were examined, because of differing degrees of completion on both faces. On the right, , the inferior margin is lipped, and coarse granularity is being replaced by dense bone and macroporosity. This region was thoroughly cleaned to verify that this was actual macroporosity and not taphonomic damage. On the left, the bone is marked by irregular surface tophography with hints of macroporosity, as well as retroauricular activity. There is no real activity at the apex for either element. All of this suggests a categorization in Phase 6-7.	High	1. 1; 2. Either 0 or 3; 3. Phase 6 or Phase 7, 45-59, with a preference for Phase 7.	Female Final Estimate: 50-59.

N1.CE14.15: Subadult, 16 – 19 yr.

Synopsis: When cleaning and disarticulating two thoracic vertebrae that were stuck together with sediment, several annular epiphysis rings *in situ* on the vertebral body were observed. These peeled off as the vertebrae were cleaned. Several more annual rings were found when the rest of the fragments were dry screened – 1.2 g in total. According to Scheuer and Black (2000:212) "Albert and Maples (19950 examined the pattern and charted stages of union of ring epiphyses in thoracic and upper lumbar vertebrae from 55 cadavers. They identified three stages of union and separated each into an early and late phase, thereby effectively using a six-stage process. They found that there was no evidence of epiphyseal union prior to 14 yr. in females and 16 yr. 4 months in males. The youngest female to show complete union in any vertebra was 18 yr. and the youngest male was 18 yr. 9 months." There are still relatively distinct lines around the tibial head, humeral head, and femoral head, though the epiphyses are clearly fully fused. Due to location on site maps and age, the bones from Individual A bagged with N1.CE14.09.1 were associated with this individual.

Bone	**Observations**	**Possible age range**
Femur (L) **14.15.01**	The proximal end of the femur is present and fused. Mackay's *Skeletal Maturation* chart lists this as fusing at 17-18 yr. in males and 15-16 yr. in females. Also, the lesser trochanter is visible and fused. Scheuer and Black (2004) put the distal epiphysis as fusing at 16-17 yr. generally, which produces a lower bound.	≥ 16 -17 yr.
Tibia (L) **14.15.05**	The distal end of the femur is present and fused. Scheuer and Black (2004) list this as fusing at 14-16 yr. in females and 15-18 yr. in males.	≥ 14-18 yr.
Fibula (L) **14.15.10**	The distal fibular epiphysis is present and completely fused. Scheuer and Black (2004) list this as fusing at 12-15 yr. in females and 15-18 yr. in males.	≥ 12-18 yr.
Humerus (L) 14.15.15	The humeral head is present and fused. Humeral distal end (trochlea and capitulum) also present and fused. Scheuer and Black (2004) list humeral head as fusing from 13-17 yr. in females and 16-20 yr. in males. Distal ends fuse between 11-15 yrs in females and 12-17 yr. in males.	≥13-20 yr.
Ulna (R) **14.15.21**	The distal epiphysis of the ulna is present, and unfused. Mackay's *Skeletal Maturation* chart lists this as appearing at 6 yr. in males and 5 yr. in females (range 4-9 yr.), and fusing to shaft at 19 yr. in males and 17 yr. in females.	≥ 5-6, ≤ 17-19
Radius (L) **14.15.22**	The distal epiphyseal surface is visible, epiphysis unfused (though epiphysis not present). Mackay's *Skeletal Maturation* chart lists this as fusing to the shaft at 19 yr. for males and 17 yr. for females.	≤ 17-19.
Metatarsal (US) **14.15.27**	The metatarsal head is present and completely fused. Mackay's *Skeletal Maturation* chart lists these as fusing between 14-21 yr.	≥ 14-21 yr.
Proximal pedal phalanges (US) **14.15.28-9**	The phalangeal bases are fused. Mackay's *Skeletal Maturation* chart lists these as fusing at 18 yr., but the range is 11-22 yr.	≥ 11-21 yr.
Proximal manual phalanx (US) **14.15.30**	The phalangeal base is fused. Mackay's *Skeletal Maturation* chart lists "Phalanges II-V" as fusing between 14-21 yr.	≥ 14-21 yr.

Bone	Observations	Possible age range
Scapula (R) **14.15.32**	The epiphysis for the coracoid process is present and fused. Scheuer and Black (2004) note that the coracoid and subcoracoid commence fusion to body of the scapula from 13-16, while by 15-17 fusion is complete between the coracoid, subcoracoid, and body of the scapula.	≥ 15-17
Patella (R) **14.15.38**	The patella is present and ossification is complete. Mackay's *Skeletal Maturation* chart lists these as appearing by 4-5yr. for males and 3 yr. for females, and achieving complete ossification by puberty.	Puberty
Os Coxae (R +L) **14.15.53** (R) **14.15.54** (L)	Both ossa coxae show epiphyseal surfaces along the superior portion of their iliac crests, indicating their epiphyses are unfused. Two fragments of the epiphysis for the iliac crest itself are present on the right. Scheuer and Black (2000:372) note that "the iliac crest epiphyses commence fusion from 17-20 yr." These epiphyses had not started fusing, so this individual must be younger. The crest itself starts to ossify at 12-14 yr. in females and 14-17 yr. in males, in accordance with the rest of the data for this individual.	≥12-17 yr. ≤17-20
Sacrum (C) **14.15.55**	The sacral body for what is most likely S3 is unfused to the sacral vertebra above it. According to Scheuer and Black (2004) fusion of the posterior sacrum happens during "puberty," and the bodies of S1 and S2 do not fuse until the early twenties.	Puberty

N1.CE14.21.1: Probable adult

Synopsis: This individual is solely represented by the proximal portion of a left femur (head, partial neck, proximal half of shaft) and a relatively complete left navicular. 2.1 is older than individual 2.2, because the femoral head has fused. This individual has been collapsed with N1.CE14.09.3.

N1.CE14.21.2: Subadult, 3 – 5 yr (collapsed with N1.CE14.09.04 and .05)

Synopsis: This individual is represented by a cranium and teeth that were buried in close proximity to the femur of a much older individual. The cranium is associated with Individual 2.2. because (i) all of the cranial bones are very thin, delicate and small (for example, the glenoid fossa on the mandible fits the tip of Ray 5 digit); (ii) there is a left *pars lateralis* of an occipital that has epiphyseal surfaces visible for both the squama and the *pas basilaris*, putting it in the 1-3 range. This individual likely suffered from antemortem physiolgoical stress. Both the upper permanent P3s have strange defects along their interproximal surfaces. These jagged indentations lack enamel below the areas of tooth-tooth contact, but above the bottom of crown formation These do not appear to be taphonomic damage. There is also a pronounced indentation on the mesial side of the Lldm1. Finally, both the RuP3 and RuP4 have defects on their buccal/labial surfaces - these may be hypocalcifications according to *Standards* (1994:57). This individual seems to have been in quite poor health, since three teeth (RuC1, LuC1, RuI2) have horizontal hypoplasias, and 5/6 of the deciduous teeth have calculus. This individual has been collapsed with N1.CE14.09.4 and N1.CE14.09.5.

No. teeth	Aging techniques	Description	Final estimate
14	1. AlQahtani (2009) and AlQahtani et al. (2010) – The London Atlas of Human Tooth Development and Eruption.	1. RuM^1 definitely has enamel completed, and the root is starting to form (3.5-4.5 yr.). The $Rudm^1$ has the root complete. Both lower dm1s and dm2s have erupted. The enamel appears complete on the upper permanent canines, but not on the upper premolars. Similarly, enamel looks like it has just completed on the LlI_2. The RuM^1 is at ~Stage 9 ($R_{1/4}$), the premolars are at Stage 5 ($Cr_{3/4}$), and the LlI_2 is at Stage 5 (R_i) (4.5 yr.), leading to a dental estimate of 4.5-5.5 yr.	3.5-5.5 yr.

N1.CE22.01: Probable male, ≥ 22 yr.

Synopsis: Left clavicle (22.01.40) and right clavicle (22.01.43) have medial ends completely fused with, no fusing flakes. The age range for this individual is derived from Scheuer and Black (2004), who write that "complete epiphyseal fusion is unlikely to be seen before 22 yr. and is always complete by 30 yr. It is worth noting that while the supraorbital ridge is too fragmented to score, it looks pronounced and more robust (more masculine). The RlM3 and LlM3 have erupted and are in occlusion, and the LuM3 also slots back into its socket, suggesting it was in occlusion at time of death. All M3 roots are complete. **Fauna**: The fauna associated with this individual were complex. There were faunal remains in five different bags, three that were labeled as human, and there were also two bags within the larger bags 172 from Caja 5.404 labelled, respectively "*B.179, huesos animales*" and "*B.171 Fauna*"). *11. Pie Derch*: One subadult faunal phalanx with an unfused base weighing 2.8 grams was found in bolsa "11. Pie Derch." *14. Cubito Izq.* (Two bags, same label): Then, there were two faunal tibiae in the bags labeled "*14. Cubito Izq.*" (there were two bags, each with this label, the first bag weighed 13.8 gr, the second bag weighed 25.8 grams). *Bolsa 171* "*Fauna*": This contained several human bones, including the distal portion (trochlea/capitulum) of the left humerus 22.01.01(which refits to the extant portion of that bone), the LlI1 and LlI2, and the base and shaft of a right third metatarsal. The faunal remains from this bag comprise a femur, distal humerus, the metatarsal or metacarpal shaft of an ungulate, herbivore teeth, a vertebra, and a likely mandibular shaft frag. The identifiable bones weighed 82.4 g, while shafts and unidentifiable fragments weighed 26.6 g. *Bolsa 179 "Huesos Animales"*: This bag contained only faunal remains, and included a proximal and distal femur, a nearly complete scapula, two paired ungulate metatarsals with the proximal ends unfused, one unidentifiable long bone, and what I believe is most of a right ungulate scapula, as well as long bone fragments. The identifiable elements weighed 121.6 g, the shafts and unidentifiable fragments weighed 56.6 g.

Sex estimate basis	Preservation of feature	Confidence	Description/ score	Final estimate
1. Left GSN; 2. Right mastoid process; 3. Left mastoid process.	1. This feature is very incomplete as the ischium and the ilium cannot be completely refit; 2 The right side is missing the zygomatic process; 3. The left side is missing part of the mastoid process.	Low	1. 3/4 – probable male though this is very tentative; 2. 3/4 – probable male; 3. 4 – male;	Probable male

N1.CE27.01, Adult

Synopsis: The size of left femur 27.01.01 suggests that this individual is an adult, an assessment bolstered by the presence and wear on the RlM2. This individual is not in optimal condition. While many of the long bones are present, some, like the right humerus, are only present as fragments, and all long bones are missing proximal and distal ends, making metrics impossible. The teeth are also not in good condition. There are only 10 teeth and two additional roots associated with this individual, and many of the teeth evince a heavy taphonomic patination that completely obscures the enamel. **Bolsa N˚2:** There is another bag in the larger bag labeled "M.B99.SUNP1 1:FASE CALLE 1. C.E27. UE1. Planta 2. N˚2. Huesos humanos." It was not possible to tell whether this was meant to contain a second distinct individual – it contained rib fragments, vertebral fragments, a proximal manual phalanx shaft, a fragment of right acromion process and part of a mandibular body in the bag. Everything is quite small, but no bones are complete and no epiphyseal surfaces are visible, so it is near impossible to tell whether or not this is from a subadult. Given that there is no anatomical overlap with what is preserved for N1.CE27.01, it is highly possible that these bones were from the same individual. The bag contained a mixture of large long bone shaft fragments (some likely humeral based on curvature) and small long bone shaft fragments, in addition to the circular shaft fragment of femur and three large shaft fragments that refit to it. Given that there is no anatomical overlap between the second bag and the first bag, all of these elements were associated with Individual N1.CE.27.01 for purposes of parsimony. This adds five bones (a proximal manual phalanx, a right scapula, a mandible, and two vertebrae), to the total for N1.CE27.01. Importantly, while 27.01 already has a right mandible, it is a portion that does not overlap anatomically with the portion from *Bolsa* No˚2.

N1.CE27.02: Probable adult, female

Synopsis: This individual was relatively gracile and small, with only long bones, ribs and vertebrae, pelvis, sacrum, clavicle, and scapula present. The right side is more complete than the left, and there were no teeth and no cranium. The gracility of the long bones bolsters the assessment of sex, and measurements were possible on the relatively complete left femur and right tibial shaft. **Second Individual from Bolsa N˚5**: In addition to the larger bag (B˚4) which contained all of the elements, there was a smaller interior bag labeled "M.B.99.SUNP 1., 1:FASE, CALLE 1, C.E.27, N˚5 HUESOS HUMANOS INDIVIDUO N˚2." This bag contained its own small tag. This bag contained a second femur which anatomically overlapped with the preserved femoral shafts of N1.CE27.02. This femur was moved to the "additional individuals" spreadsheet for Structure 27, and information from the the bag tag for for Bolsa N˚5 was used in its provenience fields.

Sex estimate basis	Preservation of feature	Confidence	Description/score	Final estimate
1. GSN (R).	This feature is very partial – only the superior arc of the GSN is preserved, but the portion that is preserved suggests a very broad width.	Low	1. 1	Female
N1.CE27.03: Probable adult				

Synopsis: This individual was extremely poorly preserved. Bones are extremely weathered, and all cortical bone was subject to extreme taphonomic damage or degradation. This individual is likely adult based on the size of these bones, but no epiphyses or teeth or pelvic bones are present, making it impossible to narrow this age range down further. There is one bone from a second individual represented by a fibula – the fibula bagged as "10.Tibia. Derch" did not match the size of the other fibulae (its shaft was much larger) and anatomically overlapped with the portions present for the other two fibulae, which mirrored each other. The remaining fibula, 27.03.17, perfectly mirrors 27.03.09 in size and shape and enough of both shafts are present that it is clear they anatomically overlap and that these represent two different bones. For purposes of parsimony, I associated these two with N1.CE27.03, and the other, larger, single fibula with a second individual.

N1.CE27.04: Probable adult

Synopsis: This individual is poorly represented, with only 11 bones, few of which can be sided. There were only long bones and some foot bones represented, with no teeth or cranium. A poor individual for sampling. The category of "probable adult" was determined due to the size of the femur.

N1.CE27.06: Adult

Synopsis: The condition of these remains make it appear that this individual was buried in much drier sediment than the other from this structure. While this individual was somewhat complete, none of the long bones had proximal or distal ends or articular surfaces, and the cortex of all bones was heavily worn. The teeth were in very good condition. Curiously, despite the tooth wear, it seems like root formation is not complete (pinprick holes) for some of the upper and lower teeth. This is true of RuM2, LuI1 and LuM3, as well as some mandibular teeth. However, the roots on the LuM3 are closed, which would seem to put a ceiling on dental development. There is either a developmental issue at play, or this is related to taphonomy. Finally, there was also a tiny fragment (0.3gr) of what I believe is burned bone, that is bagged with the maxilla.

N1.CE27.11, Probable adult

Synopsis: The mandible associated with this individual is extremely fragmentary, though there are body fragments from the left and right and a fragment of body preserving the mental spines posteriorly. There are 9 teeth and one root associated with this individual, but one RlM2 was distinct in form, size and wear from the LlM2 (which matched well with the LlM1 and LlM3. Since the RlM1 paired with the LlM1, including having a very large caries in the same location, the RlM2 is most likely from a different individual. The closest mapped individuals are N1.CE27.14 (this individual already has a LlM2), and N1.CE27.09 (an individual that could not be located in the museum inventory).Age category distinction of "probable adult" is based on the presence of third molars. Many of the teeth were in poor condition, and caked with sediment that was near impossible to get off with toothpicks and the toothbrush, so they were washed. The teeth were in pretty dreadful condition. Especially given that there is no mandible, this is not a good individual for sampling. No elements were well preserved enough to estimate age or sex, or to take metrics on. Based on the maps, the additional tooth could come from either

27.14 or 27.09. **Bolsa "Individuo 11 Huesos Sueltos":** These were all very fragmentary and not identifiably human with the exception of a fragment of right clavicle and left scapula (acromion process).

N1.CE27.12: Probable adult

Synopsis: This individual was very fragmentary and extremely poorly represented. The designation of "probable adult" is based on the size of the femoral shaft. The anterioposterior diameter at highest available portion of linea aspera is 24.8 mm, and the mediolateral diameter at the highest available portion of linea aspera is 23.5 mm, with a circumference of 8.15 cm at that point. The designation is additionally based on the presence of a worn RlM2. There are faunal bones mixed in with some of the human bones, and only 12 teeth (7 lower, 5 upper) are present. The teeth are *heavily* worn. The cranium is present, but very fragmentary. The parietal fragments were extremely large, and so were sided based on curvature and the shape of the sutural borders. The bones were caked in sediment that was so dry and firmly adhered that they required soaking. Most of the sediment could not be removed. One fragment of black pottery (that has broken in half) was bagged with the cranium.

N1.CE27.14: Probable adult, ≥ 13.5-13.9 yr.

Synopsis: Based on the size and shape of the small long bone shaft fragments (some of which look like fragments of the interosseous crest on a radius or ulna) and the fact that the clavicle, humerus and manual phalanges are the only identifiable bones for this individual besides the cranium and teeth, it is likely that there is an upper limb present for this individual, though everything is quite fragmentary. The RlM2 root is complete, which puts us at ≥ 13.5-13.9 yr.-at-death using Smith (1991).

N1.CE52.01

Synopsis: This individual is only represented by the distal half of a left fibular shaft.

C. Estimates of Age for Necropolis 2 Subadults

All measurements were taken with a Mitutoyo digital sliding caliper.

Structure 41: 1 SUBADULT (A)

Radius 41.14 and tooth 41.43 could be from the same individual, 6.0-12 yr. of age.
Radius 41.14: *Estimation of subadult based on size.* The maximum measurement of length for this element is ~116 mm. When compared to Baker et al.'s to-scale figure of the radius (2005:107), it becomes clear that this individual is much larger than a 5-year-old. Baker et al's figure is 101.8 mm long, and the length of the proximal end, neck and radial tuberosity, which were 19.66 mm long, suggesting that that proximal portion of the radius is about 20% of the total length of the element for subadults. A conservative estimate that the proximal portion is the only portion that is missing, and that most of the distal portion is represented, produces maximum length of 116 + (116*0.2 → 23.2) = 139.2 mm long, which probably still underestimates the length of this element. This conservative estimate suggests an individual between 5.5 and 6 yr., with ~ 15.8 mm of necessary to move this individual into the 7 yr. range. **Conclusion**: > 5.5 – 6.0 yr.
Teeth: 41.43 is a right dm_2 which has a distal IPCF, suggesting the Rlm1 was erupted and in occlusion. The AlQahtani Atlas notes that the lower dm_2 roots are complete at age category 3.5 yr., but that the RlM1 is not erupted or in occlusion until age category 6.5 yr. Additionally, the Rldm2 is still in the socket up until age category 11.5 yr. Assuming that Copper Age peoples would not bury loose deciduous teeth, this information produces an estimate of between age categories 6.5-11.5 yr. Using the dm2 wear model built from N4 articulated teeth (Chapter 6), the average cusp wear of this molar (3.5) produces an age estimate of 8.7 yr. (range 7.8-.9.5 yr.) **Conclusion:** 6.0-12.0 yr.

STRUCTURE 43: 2 SUBADULTS (B, C)

The proximal manual phalanx 43.043, right second metatarsal 43.044, proximal fibula 44.0125 and lumbar vertebra 43.0142 are associated with Subadult B, 8-16.5 yr.
Pelvic remains 43.0074, 43.0075 and 43.0076 are from Subadult C, 6-8 yr., a range that allows these bones to be associated with humeri 43.0082 and 43.0083. The humeri are likely from an individual 5.5-7 yr. old based on size. The broadest estimated age range for Subadult C is thus 5.5-8 yr.
The scapular fragment of glenoid fossa and coracoid base with an unfused coracoid process (43.0063), could be from either Subadult B or C.

Subadult B

43.043 Proximal manual phalanx, base unfused: This proximal manual phalanx bone is complete with the exception of the distal epiphysis. Using the to-scale photo in White (2005), it is most likely the proximal phalanx for Ray 5. Maximum length is 37.3 mm, and minimum shaft width (measured with calipers in a medial to lateral direction) is 10 mm. The maximum suggests > 16 yr. for males and females, while if this is a second proximal phalanx this individual would be between 12-13 yr. old for males and 11-12 yr. old for females. **Conclusion:** The broadest, most conservative estimate is 11-16.5 yr.

43.044 Second metatarsal (R), head unfused: This is an unidentified metatarsal (2-5) with head unfused. Shaft is too robust and rectangular to be a metacarpal, and the shaft is too round and too narrow in a superior-inferior dimension to be a proximal manual phalanx. Additionally, this refit with one of the existing metatarsal fragments from the foot bag for this individual. The maximum length of the refit fragment is 62.5 mm. Scheuer and Black (2004:408) indicate that epiphyseal fusion occurs in MT heads 2-4 from 11-13 yr. (females) to 14-16 yr. (males), giving us a similar range to element 43.043. These two elements are accordingly considered associated. **Conclusion**: < 11-16 yr.
43.0125 Left proximal fibular epiphyseal surface: This shaft is significantly wider than the to-scale figure of the five-year-old in Baker et al., 2005 (120). Maximum length is 77.1 mm, maximum width of shaft is 14.2 mm. Using the comparative specimen, it appears to have a little more than one quarter the length of the diaphysis represented. Multiplying the length of the preserved portion between three to four times produces a maximum length of between 231.3 and 308.4 mm. This sets the lower bound at 7.5-9.5 yr. (Ubelaker 1989) and the upper bound at between 14.5-16.5 yr. Scheuer and Black (2004:376) indicate that the proximal epiphysis of the fibula fuses at 12-15 yr. in females and 15-20 yr. in males. The proximal fibular epiphysis appears at age 3-4 for females and 4-5 for males. So this individual could have been 7.5-16.5 yr. old in terms of the upper and lower bounds. But this element is still in the possible age-range to match with 43.044 and 43.043. **Conclusion:** < 12 yr.
Lumbar vertebra 43.0142: Weighs 2.5 gr, and measures 25.44 mm from the top of the inferior articular facet to the center of the area the spinous process should be, which is broken off due to taphonomic damage. This is the left half (in posterior view) of a lumbar vertebra, with part of the inferior articular facet visible, and an area directly above it unfused: this is most likely a secondary epiphysis for the mammillary or transverse process region. Baker et al. (2005) note that "The lumbar vertebrae also have seven secondary epiphyses that appear and fuse during adolescence. Two of these epiphyses occur on the mammillary processes, two on the transverses, annular rings for the superior and inferior surfaces of the centrum, and one for the tip of the spinous process" (81). This means that one of these secondary epiphyses is unfused. The most precise estimate from Scheuer and Black (2004:214) is that these appear and fuse during puberty, meaning this vertebra could be associated with the first subadult. **Conclusion:** Puberty
Left scapula 43.0063: This is a fragmentary left glenoid fossa with its coracoid process partially unfused. Because the neck of the coracoid is pronounced and clearly visible, but the coracoid still exhibits epiphyseal surfaces, it is more likely that the epiphyses for the apex and angle of the coracoid process are unfused, rather than the coracoid process itself. Scheuer and Black (2004) indicate that the coracoid process fuses between 13-16 yr., but the fusion of all the coracoid epiphyses is not complete until 20 yr. This makes this scapular fragment more likely associated with Subadult B, the older individual. **Conclusion:** 13-20.

Subadult C

Of the subadult pelvic remains, two are from the right (the ischium 43.0074 and pubis 43.0075) and one is an unsided fragment of ilium (43.0076). Subadult pelves from N1.CE13.31.2 (5-6 yr.), and N1.CE14.12 (subadult 5.5-7.5 yr.) were used to comprare size and age.

Right ischium 43.0074: Maximum height 52.4 mm, though potentially could be as tall as 52.6 mm, measured with sliding calipers. Size was compared to the left ischium from N1.CE14.12 (a subadult aged 5.5-7.5 yr. with a maximum ischial height of 51.5 mm), and this element is significantly larger and more developed. Scheuer and Black (2004:338) indicate that the acetabulum fuses at 11-15 yr. for females and 14-17 yr. for males, so the age for this element must be below that bound. In Scheuer and Black's figures of subadult ischia (2004:324), the scale for this element suggests that it is a little bigger than the 6-year old, which has a max height of 49.6mm, and is quite a bit smaller than the 8-year old, which has a maximum height of 66.7mm. This accords with the earlier estimation of 6-8 yr. based on the height of the ischium. **Conclusion:** 6-8 yr.
Right pubis 43.0075: Maximum length 50.5mm, measured with sliding calipers. **Conclusion:** Associated with other pelvis fragments.
Unsided ilium 43.0076: This element is too poorly preserved for a rigorous estimate, but it appears to be a bit larger than the preserved auricular surface/epiphyseal border of the iliac crest for the ilium from comparative specimen N1.CE13.31.2, meaning likely >5-6 yr. age-at-death. **Conclusion:** >5-6 yr.
Humeri 43.0082 – 43.0083: A maximum diaphyseal length of > 94.1 mm for left humerus 43.0082 means that the child was > 6 months age at death (Ubelaker 1989). Based on the preserved portion of the humerus, a generous estimate for the maximum length of the diaphysis is twice this length, which is 188.2 mm, indicating an individual between 5.5 and 7.5 yr. of age. Similarly, the preserved portion of this humerus is larger than Baker et al.'s to-scale five-year-old humerus (2005:104), which agrees with the estimate based on maximum diaphyseal length. **Conclusions**: 5.5-7.5 age-at-death.

Specimen	Max. length	Max. width	ML diam.	AP diam.	Measurements
43.0082 (Humerus, left)	93.4	37.7	11	12.55	MW at inferior end (olecranon area), ML/AP at around 10 cm above the inferior-most point on the break on the superior shaft fragment.
43.0083 (Humerus, right)	27.7	21	16.6	13.4	ML from approximate center of fragment.

STRUCTURE 44: THREE SUBADULTS (D1, D2 E)

Distal ulna 44.0222, and radial shafts 44.0227 and 44.0228 are likely from an individual 7-17 yr., and distal femoral condyle 44.0191 is likely from an individual 5-20 yr., which falls within this range.
Humeri 44.0157 and 44.0159 are from an individual 1.5-3.5 yr.

Subadult D1 and D2

D1: 8-14 yr., includes radial shafts 44.0227 + 44.0228, distal femoral condyle 44.0191, distal ulna 44.0222, and teeth 44.01, 44.02 and 44.35.
D2: 15-18 yr., includes teeth 44.21 and 44.44.

Distal ulna 44.0222: Styloid processes is unfused, weight 1.1 g. "Fusion of the distal ulnar epiphysis…[begins] at 14-15 yr. in females and 17-20 yr. in males…The Greulich and Pyle (1959) radiographic standards show complete fusion, with epiphyseal line obliteration soon afterwards, at 16-17 yr. in females and 17-18 yr. in males" (Scheuer and Black 2004:286). This indicates an upper bound of less than 18 yr. However, this bone is much larger than the Baker et al., to-scale figure of a five-year old (2005:110). Scheuer and Black (2004:286), show a 7-year old ulna that measures about 9.6 mm diameter in medial-lateral dimension at the very distal base, and an "adolescent" that measures 16.7 mm. This element measures ~ 12.6 mm in that dimension, so likely > 7 yr. age-at-death. **Conclusion**: 7-17 yr.

Teeth 44.01, 44.02, 44.21, 44.35 and 44.44: Five developing permanent teeth were recovered from CE 44. Age was estimated using the AlQahtani Atlas.

- 44.01: RuI1, A1/2 = 10-11 yr. (min 8, max 11)
- 44.02: LuP3, A1/2 = 13-14 yr. (min 11, max 15)
- 44.21: LuM2, A1/2 = 15-16 yr. (min 13, max 17)
- 44.35: LlP3, R3/4 = 11-12 yr. (min 9, max 14)
- 44.44: LlM3 R1/2 = 16-18 yr. (min 15, max 20)

The median age ranges of these teeth (from 10.5 yr. to 17.5 yr.), mean that it is likely that at least two individuals are represented. For purposes of parsimony, these teeth are divided into two groups: younger individual D1, (age 10-14 yr., including teeth 44.01, 44.02 and 44.35, as all of these age ranges overlap) and older individual D2 (age 15-18 yr., including 44.21 and 44.44). Though 44.21 is an upper M2 at $A_{1/2}$ and 44.44 is a lower M2 with $R_{1/2}$, upper and lower jaws are not necessarily symmetrical in terms of the development of the teeth (Zachary Cofran, personal communication).

Radial shafts 44.0227 + 44.0228: Two radial shafts, 44.0227 (L) (weighing 2.9 g) and 44.0228 (R) (weighing 3.4 g) were identified as subadult based on the size of the shaft and the development of the radial tuberosity. These are larger than Baker et al.'s (2004:107) to-scale figure of the 5-year-old radius. Using the comparative radius, the total length was estimated to be 4-4.5 times that of the preserved fragment for 44.0228 (R), which is 44.8 mm long. This produced a range of 179.52 – 201.6 mm. Using Ubelaker (1989) this produces age estimates between 9.5 – 10.5 yr. on the low end, and >12.5 yr. on the high end. Based on their size and level of development, the the lower age estimate was preferred, placing these elements in the 9.5-10.5 year range. **Conclusion:** 9.5 – 10.5 yr.

Distal femoral condyle 44.0191: Fragment weighs 4.5 g. All borders are relatively fragmentary, but maximum dimensions are 25.4 and 21.2 mm. This fragment of distal femoral condyle (44.0191) could not be sided, but it shows that that epiphysis has not yet fused. The distal epiphysis is recognizable at 3-5 yr., and then fuses at 14-18 yr. in females and 16-20 yr. in males, according to Scheuer and Black (2004:356). However, this element is larger than Bakers et al.'s to-scale figure of the 5-year-old (2005:113), producing a broad estimated range of 5-20 yr. Examining Scheuer and Black's figure of the distal femoral epiphysis for various age ranges (2004:348), this appears too large for the two-year old, and seems to fall in between the 8-year old and the 12-year old in terms of size and development. **Conclusions**: 8-12 yr.

Subadult E

Humeral shafts 44.0157-159: These are incomplete humeral shafts. 47.0157 (R) weighs 10.2 gr and measures a maximum of 87.3 mm long. 47.0159 (L) weighs 7.4 gr and measures a maximum of 68.7 mm long. The shaft for 47.0157 falls in between the size categories for the 1.5 year-old and the 5-year-old in Baker et al. (2005:104), with between 3/4 (at the younger end) and 2/3 (at the older end) of the length represented. This produces maximum length estimates of 116.4 mm to 130.95 mm. Using Ubelaker (1989) this produces an estimate between 0.5-2.5 yr. on the low end, and 1.5-3.5 on the high end. Combining the data from Baker and Ubelaker, this produces an estimate of between 1.5-3.5 yr. age-at-death.

Conclusion: 1.5-3.5 yr.

Specimen	Max. length	Max. width	ML diam.	AP diam.	Measurements
44.0157 (Humerus, right)	82.5	NA	12.9	13.04	Flaring at olecranon is 15.8. ML taken at point 55 mm down from superior-most portion of inferior fragment.
44.00159 (Humerus, left)	72	NA	15.1	13	Flaring at the olecranon is 21 mm long. ML/AP diameter taken at point 25 mm from inferior-most edge of shaft available.

STRUCTURE 45: 2 SUBADULTS (G, H)

Subadult G

There are four teeth that hover around the 11-15 mark (older child or early juvenile). The midpoints of their age categories from the AlQahtani Atlas range from 9.75-12 yr. These include:

Chapter 2 45.28: LlP3, R3/4 = 11-12 yr. (min 9, max 14)
Chapter 3 45.31 LlP4, Rc = 12-13 yr. (min 11, max 15)
Chapter 4 45.33: RlC1, A1/2 = 12-14 yr. (min 11, max 15)
Chapter 5 45.45: LlM3, Ri = 13-15 yr. (min 11, max 17)

Subadult H

There is one younger individual in the 4-8 range, represented by paired lower first molars. As their median ages fall outside of the midpoint range for the teeth from Subadult G, the teeth were considered to represent a distinct younger individual.

1. 45.37: LlM1 (A1/2): 9-10 yr. (min 7, max 12)
2. 45.43: RlM1 (A1/2): 9-10 yr. (min 7, max 12)

A Note on MNI and Dentition for Structure 41 and Structure 45

Structure 41

Upper incisors: Even though one of the upper incisors only shows level 2 wear, its root is apex complete. All other upper incisors are at level 4 wear, and the incisor that could not be scored for wear has its roots complete. The subadult from this structure is represented dentally by a Rldm2 showing average cusp wear of 3.5. According to the high leverage model of dm2 wear and age outlined in Chapter 7, this produces a midpoint age estimate of 8.7 yr. (minimum 7.9 yr., maximum 9.5 yr.). The molar wear rate for Marroquíes Bajos, established with reference to Gilmore and Grote (2012), is 0.217. If this wear rate is extended to the upper central incisors, it would take an incisor 4.6 years after erupting to reach level 2 wear. Using the AlQahtani chart, upper incisor eruption occurs at age category 7.5, meaning a wear score of 2 would likely not be achieved until at least 11.6 yr. of age. Since that is at the upper bound of the broad age range for Subadult A, and well outside of the tighter age range estimated based on dm2 wear, the assumption is made that none of the apex complete permanent upper central incisors can be associated with the subadult, producing an adult MNI estimate of 5.

Structure 45

Lower second molars: An argument for an adult MNI of 6 can be made regardless of the number of subadults, using the five LlM2s (45.09, 45.11, 45.38, 45.39,45.41). None of these match the RlM2 45.46, which is extremely heavily worn. This produces an adult MNI of six individuals (or at least, six individuals with erupted lower second molars). This would make the individuals at least 14-16 yr. of age at death. However, most of the second molars show relatively heavy wear, which would suggest that they had been erupted for quite some time, and should be more likely associated with the adults. Only one subadult, N2.G, falls into the 14-16 yr. range, which was taken into account when calculating adult MNI for Structure 45 (adult MNI is only 5).

Lower third molars: There are five lower third molars from Structure 45:

- **Adult 1:** RlM3 45.16 pairs with LlM3 45.44 in terms of size, wear and root development (R_c).
- **Subadult G:** RlM3 45.45 is at R_i, and does not pair with any other molars.
- **Adult 2**: LlM3 45.42 has missing roots, but is extremely heavily worn. Does not pair with any other molars.

D. Isotopic Sample and Results

Field ID	$\delta^{18}O$	$^{87}Sr/^{86}Sr$	$\delta^{13}C$	$\delta^{15}N$	ID	Mortuary Area	Age Category	Sex
1	-9.35				N2.440017.A2 (T.44017.12)	N2	Very Young Adult	Not Possible
2	-9.21	0.70832			N2.44.A6 (T.44.17)	N2	Young Adult	Not Possible
3	-7.35	0.70795	-18.8	9.2	N1.CE13.191	N1	Young Adult	Probable Female
4	-11.05	0.70874	-19.6	7.4	N1.CE14.07	N1	Very Young Adult	Probable Female
5	-10.75	0.70866	-18.9	8.1	N1.CE14.15	N1	Adolescent	Subadult
6	-8.49	0.70815	-19.4	8.5	N1.CE22.01	N1	Young Adult	Probable Male
7	-9.03	0.70873	-19.2	8.9	N1.CE13.12	N1	Middle Adult	Probable Female
8	-7.79	0.70877	-19.1	8.6	N1.CE13.27	N1	Young Adult	Probable Male
9	-8.58	0.70852	-19.9	7.1	N1.CE14.06	N1	Young Adult	Probable Male
10	-8.73	0.70781	-19.0	8.6	N1.CE14.13	N1	Young Adult	Male
11	-9.96	0.71170	-19.8	8.1	N1.CE14.14	N1	Middle Adult	Female
12	-7.54	0.71086	-19.0	9.4	N1.CE13.13	N1	Middle Adult	Probable Female
13	-9.32	0.70882	-19.4	8.6	N1.CE13.11	N1	Young Adult	Male
14	-8.11	0.70862	-19.8	7.0	N1.CE14.05	N1	Young Adult	Probable Male
15	-11.99	0.70810	-19.4	10.2	N1.CE14.09.1	N1	Young Adult	Probable Female
16	-8.72	0.70892	-19.6	7.6	N1.CE27.06	N1	Young Adult	Probable Female
17	-9.57	0.70796	-19.4	9.7	N1.CE13.26	N1	Middle Adult	Probable Male
18	-7.81	0.70857	-19.7	7.1	N1.CE14.08	N1	Young Adult	Female
19	-7.77		-19.5	8.3	N1.CE13.36	N1	Young Adult	Not Possible
20	-10.12	0.71273	-19.5	8.9	N1.CE27.A27.01	N1	Young Adult	Not Possible
21	-8.88	0.70804	-19.4	8.9	MN.1.006.15	N4	Young Adult	Indeterminate
22	-8.48	0.70800	-19.0	9.2	MN.1.006.16	N4	Young Adult	Not Possible
23	-7.17	0.70824	-19.2	8.3	MN.1.006.17	N4	Adolescent	Subadult
24	-8.21	0.70824	-19.5	7.7	MN.1.006.19	N4	Young Adult	Not Possible
25	-8.77	0.70966	-19.2	9.0	MN.1.015.07	N4	Young Adult	Not Possible
26	-9.57	0.70824	-19.4	8.3	MN.1.005.02	N4	NP	Not Possible
27	-8.17	0.70849	-19.2	7.8	MN.3.033.01	N4	Young Adult	Not Possible

Field ID	δ18O	87Sr/86Sr	δ13C	δ15N	ID	Mortuary Area	Age Category	Sex
28	-7.34	0.70831			MN.4.055.10	N4	Young Adult	Not Possible
29	-8.39	0.70875	-20.1	7.3	MN.2.120.05	N4	Young Adult	Probable Female
30	-9.34	0.70814			MN.2.120.08	N4	Young Adult	Not Possible
31	-10.09	0.70894	-19.8	7.9	MN.2.107.02	N4	Young Adult	Probable Female
32	-8.49	0.70837	-19.5	7.9	MN.4.065.02	N4	Young Adult	Not Possible
33	-9.96	0.70982	-19.2	9.2	MN.4.065.03	N4	Young Adult	Not Possible
34	-10.49	0.70810	-20.8		MN.4.065.04	N4	Young Adult	Not Possible
35	-9.77	0.70809			MN.4.065.05	N4	Young Adult	Not Possible
36	-9.26	0.70843	-20.0	8.6	MN.4.081.02	N4	Young Adult	Indeterm inate
37	-8.56	0.70800			MN.4.081.03	N4	Young Adult	Probable Male
38	-8.05	0.70800	-19.2	7.7	MN.2.159.01	N4	Adolescent	Subadult
39	-10.78	0.70884	-19.4	8.5	MN.2.177.05	N4	Young Adult	Probable Female
40	-8.88	0.70854	-19.3	7.7	MN.3.065.01	N4	Young Adult	Probable Male
41	-7.84	0.70875			MN.3.072.01	N4	Young Adult	Male
42	-9.14	0.70889	-19.3	7.9	MN.2.155.11	N4	Young Adult	Not Possible
43	-9.69	0.70801	-20.4	8.6	MN.2.155.12	N4	Young Adult	Not Possible
44	-8.66	0.70806	-19.5	8.6	MN.2.155.13	N4	Young Adult	Not Possible
45	-8.99	0.70868			MN.2.167.01	N4	Young Adult	Male/Pr obable Male
46	-9.76	0.70816	-19.3	8.8	MN.2.170.01	N4	Juvenile	Subadult
47	-9.39	0.70805	-19.4	8.7	MN.2.194.01	N4	Young Adult	Not Possible
48	-9.18	0.70811	-19.4	7.9	MN.2.195.02	N4	Juvenile	Subadult
49	-8.18	0.70911	-19.0	8.1	MN.2.200.01	N4	Young Adult	Probable Female
50	-7.93	0.70995	-18.8	9.8	MN.2.205.03	N4	Young Adult	Not Possible
51	-7.60	0.71311	-20.5	9.0	MN.2.205.06	N4	Young Adult	Female
52	-10.77	0.70837	-19.3	7.8	MN.2.215.01	N4	Young Adult	Indeterm inate
53	-10.00	0.70828	-19.6	7.9	MN.4.091.01	N4	Young Adult	Indeterm inate
54	-9.60	0.70858	-19.3	9.0	MN.4.100.06	N4	Young Adult	Not Possible

Field ID	δ^{18}O	^{87}Sr/^{86}Sr	δ^{13}C	δ^{15}N	ID	Mortuary Area	Age Category	Sex
55	-8.73	0.70817	-19.4	8.1	MN.4.103.05	N4	Young Adult	Probable Female
56	-8.45	0.70763	-18.8	9.1	MN.4.103.07	N4	Young Adult	Not Possible
57	-8.60	0.70855	-20.0	6.5	MN.4.103.08	N4	Young Adult	Probable Female
58	-8.17	0.70886	-19.4	7.5	MN.4.118.01	N4	Young Adult	Not Possible
59	-10.52	0.70803	-19.7	8.6	MN.3.140.01	N4	Not Possible	Not Possible
60	-9.98	0.70831	-19.2	8.5	MN.4.131.05	N4	Young Adult	Not Possible
61	-7.26	0.70819	-19.3	8.1	MN.4.131.06	N4	Young Adult	Not Possible
62	-7.07	0.70864	-19.3	8.5	MN.4.031.01	N4	Young Adult	Not Possible
63	-8.42	0.70882	-19.1	9.1	MN.4.034.02	N4	Young Adult	Probable Female
64	-9.89	0.70813	-19.6	7.5	MN.2.154.04	N4	Very Young Adult	Probable Male
65	-8.57	0.70852	-19.2	8.1	MN.2.141.01	N4	Young Adult	Not Possible
66	-8.49	0.70827	-19.3	8.0	MN.3.078.01	N4	Young Adult	Not Possible
67	-10.20	0.70825	-19.3	7.2	MN.4.095.04	N4	Juvenile	Subadult
68	-10.60	0.70824	-19.7	7.9	MN.2.280.01	N4	Young Adult	Male/ Probable Male
69	-9.81	0.70790	-19.1	9.4	MN.2.286.01	N4	Young Adult	Male
70	-9.11	0.70883	-19.3	8.2	MN.2.274.02	N4	Young Adult	Indeterminate
71	-8.99	0.70920			MN.2.274.03	N4	Young Adult	Probable Female
72	-9.03	0.70815	-19.8	8.2	MN.2.274.05	N4	Young Adult	Probable Female
73	-8.10	0.70797			MN.2.288.04	N4	Young Adult	Not Possible
74	-9.84	0.70804	-19.2	9.5	MN.2.261.01	N4	Young Adult	Probable Male
75	-8.03	0.70824	-19.9	9.1	MN.3.196.03	N4	Young Adult	Probable Male
76	-9.02	0.70854			MN.3.207.02	N4	Young Adult	Probable Male
77	-8.70	0.70820	-19.4	7.8	MN.2.294.01	N4	Young Adult	Female/ Probable Female
78	-7.83	0.71044	-19.4	8.5	N1.CE13.21	N1	Child	Subadult
79	-8.10	0.70838	-19.8	8.8	N1.CE14.04	N1	Child	Subadult
80	-10.95		-19.4	7.5	N1.CE14.2.2	N1	Juvenile	Subadult
81	-7.54	0.70800	-20.0	7.6	N1.CE14.21.2	N1	Child	Subadult

Field ID	$\delta^{18}O$	$^{87}Sr/^{86}Sr$	$\delta^{13}C$	$\delta^{15}N$	ID	Mortuary Area	Age Category	Sex
82	-7.52	0.70819	-19.2	7.9	N1.CE13.157	N1	Child	Subadult
83	-9.36	0.70791	-20.0	6.8	MN.4.055.08	N4	Child	Subadult
84	-9.47	0.70790	-19.0	8.0	MN.2.155.06	N4	Adolescent	Subadult
85	-10.58	0.70854	-19.5	7.6	MN.2.141.02	N4	Juvenile	Subadult
86	-9.38	0.70800			MN.2.197.01	N4	Child	Subadult
87	-7.48	0.70851	-19.1	9.4	MN.1.015.03	N4	Child	Subadult
88	-10.67	0.70798	-19.3	8.1	MN.1.006.10	N4	Juvenile	Subadult
89	-10.14	0.70800			MN.4.030.05	N4	Child	Subadult
90	-8.16	0.70795	-19.1	9.5	MN.2.133.01	N4	Child	Subadult
91	-10.67	0.70815	-19.4	8.3	MN.2.120.03	N4	Very Young Adult	Not possible
92	-10.19	0.70801	-19.3	8.6	MN.4.073.01	N4	Child	Subadult
93	-7.49		-18.6	9.9	MN.4.113.02	N4	Child	Subadult
94	-8.96		-19.4	7.9	MN.2.246.04	N4	Juvenile	Subadult
95	-7.60	0.70798	-19.8	9.0	MN.2.262.01	N4	Child	Subadult
96	-8.77	0.70804	-19.5	8.0	MN.3.203.02	N4	Juvenile	Subadult
97	-8.59	0.70804	-19.2	8.4	MN.2.306.01	N4	Juvenile	Subadult
98					44017.07	N2	Not Possible – mandible	Not Possible
99	-7.59	0.70844			N2.44.A4	N2	Not Possible – mandible	Not Possible
100	-9.57				T.45.10	N2	Young Adult	Not Possible
101	-8.84				T.45.11	N2	Young Adult	Not Possible
102	-9.16	0.70809			T.45.46	N2	Young Adult	Not Possible
103	-7.83	0.70788			T.41.16	N2	Young Adult	Not Possible
104	-9.32	0.70809			T.41.17	N2	Young Adult	Not Possible
105	-8.99	0.70807			T.44.27	N2	Young Adult	Not Possible
106	-8.61				T.44.28	N2	Young Adult	Not Possible
107	-4.53	0.70861	-22.1	7.0	F.3.001.01	N4	Fauna	Fauna
108	-7.55	0.70781			F.2.222.01	N4	Fauna	Fauna
109			-22.6	3.6	F.2.222.02	N4	Fauna	Fauna
110	-6.60	0.70777	-19.6	14.4	F.3.207.01	N4	Fauna	Fauna
111			-18.2	7.7	F.2.012.01	N4	Fauna	Fauna
112					F.2.012.02	N4	Fauna	Fauna
113	-3.81		-19.0	5.9	F.2.012.03	N4	Fauna	Fauna
114	-6.93	0.70806			T.41.43	N2	Juvenile	Subadult

Field ID	$\delta^{18}O$	$^{87}Sr/^{86}Sr$	$\delta^{13}C$	$\delta^{15}N$	ID	Mortuary Area	Age Category	Sex
115	-8.03	0.70828	-17.9	11.5	MN.2.205.05	N4	Child	Subadult
116	-7.38	0.70821	-19.1	7.5	MN.2.274.01	N4	Child	Subadult
117	-8.36	0.70786	-18.9	10.4	MN.2.288.02	N4	Child	Subadult
118	-8.75	0.70775			MN.3.129.03	N4	Child	Subadult
119	-8.48	0.70795	-19.0	8.8	MN.4.080.01	N4	Child	Subadult
120	-8.81	0.70796	-19.3	7.7	MN.2.204.04	N4	Child	Subadult
121			-19.6	7.2	FD.4.1	D4	Fauna	Fauna
122			-20.0	6.3	FD.4.2	D4	Fauna	Fauna
123			-20.3	10.6	FD.4.3	D4	Fauna	Fauna
124			-19.4	7.4	FD.4.4	D4	Fauna	Fauna
125			-20.5	7.0	FD.4.5	D4	Fauna	Fauna
126			-17.9	8.8	FD.4.6	D4	Fauna	Fauna
127			-21.7	7.8	FD.4.7	D4	Fauna	Fauna
128			-19.0	6.9	FD.4.8	D4	Fauna	Fauna
129			-19.3	6.9	FD.4.9	D4	Fauna	Fauna
130					FD.4.10	D4	Fauna	Fauna
131			-20.1	7.0	FD.4.11	D4	Fauna	Fauna
132			-19.1	6.2	FD.4.12	D4	Fauna	Fauna
133			-20.3	5.8	FD.4.13	D4	Fauna	Fauna
134			-20.4	3.4	FD.4.14	D4	Fauna	Fauna
135			-20.1	7.8	FD.4.15	D4	Fauna	Fauna
136			-21.6	5.0	FD.4.16	D4	Fauna	Fauna

E. AMS Radiocarbon Sample and Uncalibrated Dates

Samples beginning with "AA" were processed by the University of Arizona laboratory. Samples beginning with "MAMS" were processed by the University of Heidelberg laboratory.

Field ID	AMS ID	Mortuary area	Individual/ element ID	Age Category	Sex	14C age BP	±
6	AA107181	N1	N1.CE22.01	Young adult	Probable male	4011	33
7	AA107182	N1	N1.CE13.12	Middle adult	Probable female	3902	32
10	AA107183	N1	N1.CE14.13	Young adult	Male	4013	32
11	AA107184	N1	N1.CE14.14	Middle adult	Female	4002	32
12	AA107185	N1	N1.CE13.13	Middle adult	Probable female	3987	34
13	AA107186	N1	N1.CE13.11	Young adult	Male	3934	32
14	AA107187	N1	N1.CE14.05	Young adult	Probable male	4080	33
18	AA107188	N1	N1.CE14.08	Young adult	Female	4027	34
20	AA107189	N1	N1.CE27.A27.01	Young adult	Not possible	3919	32
99	AA107212	N2	N2.44.A4	Not possible – mandible	Not possible	x	x
103	AA107213	N2	T.41.16	Young adult	Not possible	3970	32
2013.1	MAMS20040	N2	45.0015	Adolescent/ adult	Not possible	3675	22
2013.2	MAMS20041	N2	39.02	Adolescent/ adult	Not possible	3745	23
2013.3	MAMS20042	N2	44.0178	Adolescent/ adult	Not possible	3621	21
27	AA107190	N4	MN.3.033.01	Young adult	Not possible	4031	33
32	AA107191	N4	MN.4.065.02	Young adult	Not possible	4013	32
33	AA107192	N4	MN.4.065.03	Young adult	Not possible	4075	34
34	AA107193	N4	MN.4.065.04	Young adult	Not possible	4002	32
35	AA107194	N4	MN.4.065.05	Young adult	Not possible	3997	32
40	AA107195	N4	MN.3.065.01	Young adult	Probable male	4011	32
41	AA107196	N4	MN.3.072.01	Young adult	Male	4102	41
45	AA107197	N4	MN.2.167.01	Young adult	Male/ probable male	x	x
47	AA107198	N4	MN.2.194.01	Young adult	Not possible	4049	33

Field ID	AMS ID	Mortuary area	Individual/ element ID	Age Category	Sex	14C age BP	±
48	AA107199	N4	MN.2.195.02	Juvenile	Subadult	3952	32
50	AA107200	N4	MN.2.205.03	Young adult	Not possible	4084	33
51	AA107201	N4	MN.2.205.06	Young adult	Female	4136	31
53	AA107202	N4	MN.4.091.01	Young adult	Indeterminate	4044	33
59	AA107203	N4	MN.3.140.01	Not possible	Not possible	4119	32
66	AA107204	N4	MN.3.078.01	Young adult	Not possible	4023	32
68	AA107205	N4	MN.2.280.01	Young adult	Male/ probable male	4,049	31
69	AA107206	N4	MN.2.286.01	Young adult	Male	4,064	32
77	AA107207	N4	MN.2.294.01	Young adult	Female/ probable female	4,035	33
85	AA107208	N4	MN.2.141.02	Juvenile	Subadult	4,019	32
86	AA107209	N4	MN.2.197.01	Child	Subadult	4,057	31
92	AA107210	N4	MN.4.073.01	Child	Subadult	4,084	32
96	AA107211	N4	MN.3.203.02	Juvenile	Subadult	4,004	32
118	AA107214	N4	MN.3.129.03	Child	Subadult	4,204	32

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