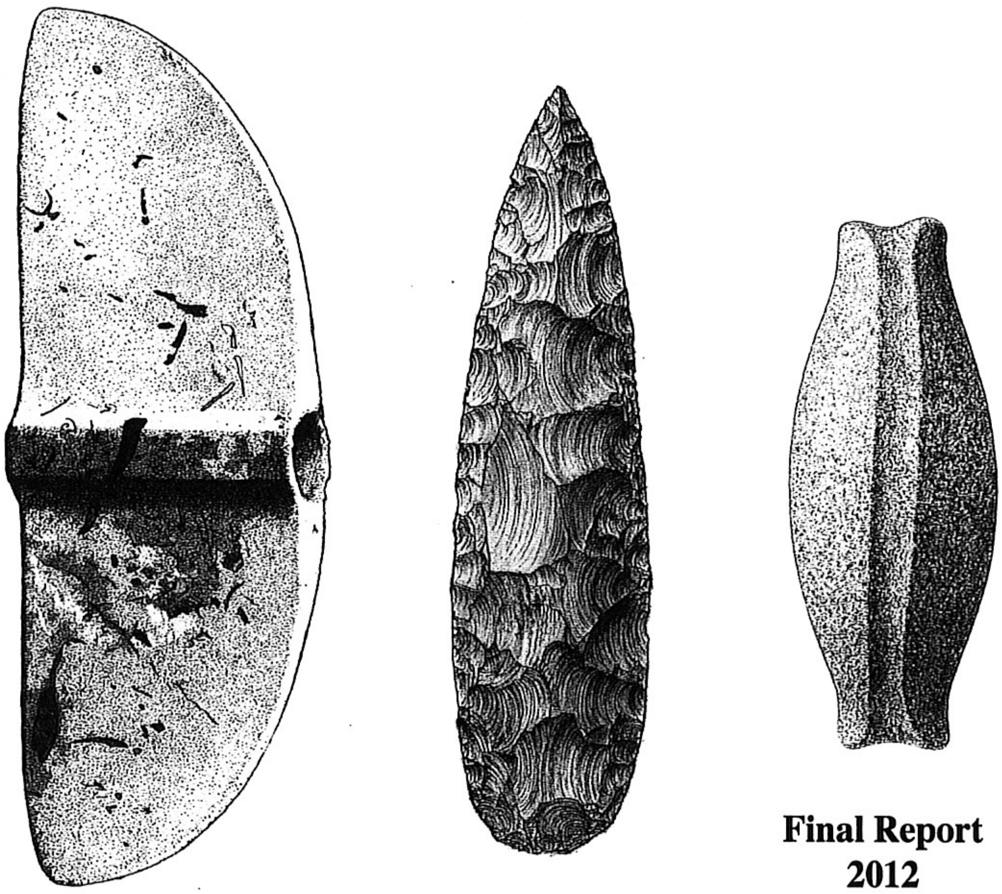
ARCHAEOLOGY AND BIOARCHAEOLOGY OF THE BUCKEYE KNOLL SITE (41VT98), VICTORIA COUNTY, TEXAS



Final Report
2012

Volume 2

Prepared by:

Coastal Environments, Inc.
525 S. Carancahua Street
Corpus Christi, Texas 78401

Contract Nos.

DACW64-97-D-0003,
Delivery Orders 0006 and 0008

GS-10F-0445N, Order No.
DACW64-03-F-0073

Submitted to:

U.S. Army Corps of Engineers
Galveston District

Archaeology and Bioarchaeology of the Buckeye Knoll Site (41VT98), Victoria County, Texas

Edited by:

Robert A. Ricklis
Richard A. Weinstein
Douglas C. Wells

Contributing Authors:

Robert A. Ricklis
Glen H. Doran
Christopher Stojanowski
Susan L. Scott
Robert J. Hard
Noreen Tuross
Bruce M. Albert
Charles D. Frederick
Mark D. Bateman
Jason W. Barrett
Kathryn Puseman
Linda Scott Cummings
Collette Berbesque
Jon C. Lohse
Bruce Rothschild
Christine Rothschild
Tim Riley

Mortuary Artifact Illustrations by:

Alexander N. Cox

Final Report
2012
Volume 2

Robert A. Ricklis
Principal Investigator

Coastal Environments, Inc.
525 S. Carancahua Street
Corpus Christi, Texas 78401

Submitted to:

U.S. Army Corps of Engineers,
Galveston District

Contract Nos.

DACW64-97-D-0003, Delivery Orders 0006 and 0008
GS-10F-0445N, Order No. DACW64-03-F-0073

Chapter 11

STABLE ISOTOPE AND DNA ANALYSES

Robert J. Hard
Noreen Tuross

Analytical Methods and Results (Noreen Tuross)

Stable carbon and nitrogen isotopic measurements were made on collagen purified from the tooth samples of eight individuals. In addition, seven radiocarbon dates were obtained, and five DNA extractions and preliminary PCR reactions were done. The teeth were derived from Burials 5, 6, 8, 23, 27, 55, 71, and 74. All but one of these are ascribed to the Early Archaic cemetery component. The single exception, Burial 23, is a Late Archaic burial. A summary of the work performed is shown in Table 11-1.

Radiocarbon Ages of the Individuals

Collagen was extracted from tooth roots utilizing the decalcifying agent EDTA, washing with sodium hydroxide followed by a gelatinization process and filtering through sintered glass. The collagen had a slight yellow color and was indistinguishable from modern collagen in carbon and nitrogen content (see next section).

With the limited available data, three distinct and noncontemporaneous populations interred human remains at Buckeye Knoll. The large cluster of dates centers around 5600 years B.P. (uncalibrated). One individual is significantly older than the majority grouping, at 7570 ± 55 yrs B.P. (uncalibrated), while another single individual dates to 2120 ± 30 yrs B.P. Correcting these radiocarbon dates to allow for the observed variation in past ^{14}C amounts was done with the OxCal program. The results are shown in Figure 11-1.

Stable Isotope Analyses

Stable isotope analyses $d^{13}C$ and $d^{15}N$ were performed in duplicate on the seven specified individual tooth collagens. The data are shown in Table 11-2. When these data are viewed as a function of the uncorrected age of the sample, interesting patterns are observed (Figures 11-2 and 11-3).

The heavy isotope of nitrogen is enriched in the samples as a function of age. This statement must be accompanied by two caveats. First, the trend in Figure 11-2 is controlled by two samples: the youngest and the oldest. Second, tooth type has been considered. Even with these considerations, the change of almost $3^0/_{00}$ in $d^{15}N$ is substantial and, if confirmed with additional samples, these data would indicate a major shift in human diets or an alteration in the underlying nitrogen isotopic values in plants due to environmental change—or both. These important preliminary conclusions should be further refined with additional analyses.

The carbon isotopic values are quite scattered, but all observed values could be derived from a diet rich in estuarine fauna and/or terrestrial fauna with access to C-4 plants. The range of carbon isotopic values is surprising, as is the depletion of the most recent individual. Again, this preliminary data suggests diet and/or environmental change through the age of the Buckeye Knoll deposit. (Editor's note: These observations are further considered in the discussion by Robert Hard in the next section of this chapter, as well as in a summary discussion in Chapter 15.)

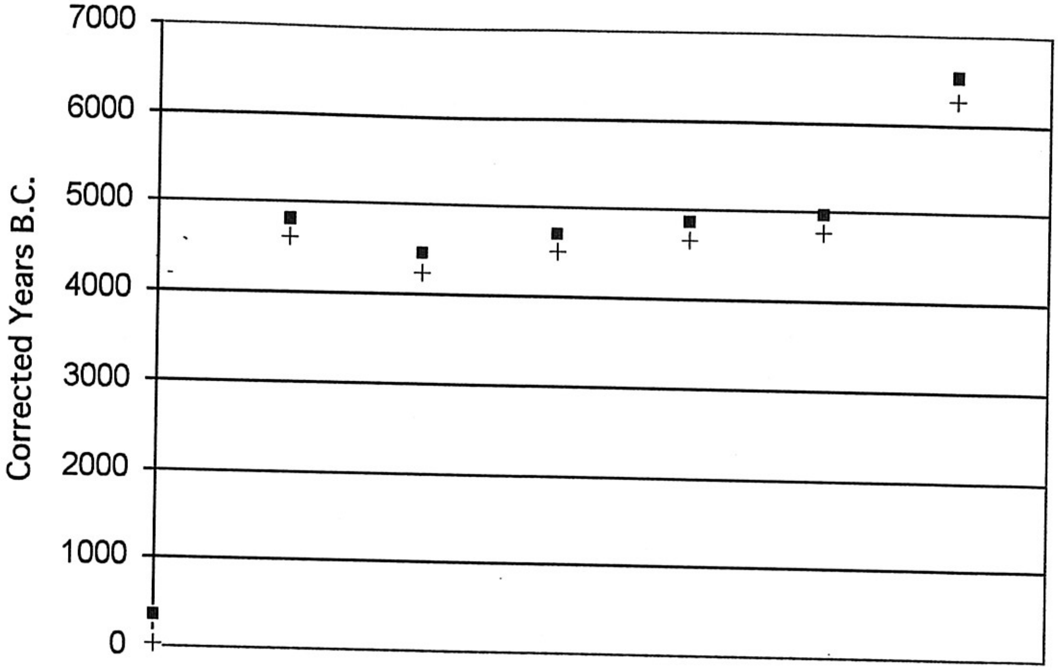


Figure 11-1. The lower (pluses) and upper (squares) limits of the corrected radiocarbon ages in years B.C. at the 95.4 percent confidence level.

DNA Analysis

Preliminary DNA analyses of five tooth extracts yielded no amplification products of the 9bp deletion regions of the mitochondrial genome. The extracts (Kolman and Tuross 2000) were tested for polymerase inhibition, and slight inhibition was observed in all samples. A second extraction based on a recently published technique (Rohland et al. 2004) was processed and amplification showed some promise for analytical success. Given the high input of labor and expense that full analysis would have entailed, however, it was decided by the project sponsor (U.S. Army Corps of Engineers, Galveston District) not to proceed. Janelle S. Stokes, archaeologist with the Galveston District, offered the following explanation for this decision:

> *During sampling for the presence of preserved DNA, initial results on human bone fragments indicated that there was no replicatible DNA in the VT98 materials. Another technique was then applied that indicated additional, intensive analysis might be productive if a full DNA analysis was performed. However, further information provided by the consultant (Noreen Tuross, Harvard University) made it clear that several lengthy and costly steps would be needed to determine if this was actually the case. It was impossible to reliably*

Table 11.1. Summary of Analytical Procedures Performed on Human Tooth Samples from Buckeye Knoll.

Sample ID	Procedures		
	$\delta^{13}C$ and $\delta^{15}N$	AMS Date	DNA Preparation
41VT98S5B74	x	x	x
41VT98S3B27	x	x	x
41VT98S1B6	x	x	x
41VT98S10B71	x	x	x
41VT98S15B23	x	x	x
41VT98S6B5	x	x	—
41VTS7B55	x	x	—
41VT98S2B8	x	—	—

Table 11-2. Stable Carbon and Stable Nitrogen Values for Human Tooth Samples from Buckeye Knoll.

Sample ID	$\delta^{13}C$	$\delta^{15}N$	C/N
41VT98S5B74	-15.8	10.9	2.8
	-15.9	10.9	2.8
41VT98S3B27	-16.2	12.5	2.8
	-16.2	12.6	2.8
41VT98S1B6	-16.3	11.5	2.8
	-16.2	11.5	2.8
41VT98S10B71	-15.6	11.2	2.8
	-15.7	11.1	2.8
41VT98S15B23	-18.1	9.7	2.7
	-18.5	9.7	2.7
41VT98S6B5	-13.6	11.8	2.8
	-13.8	11.8	2.8
41VTS7B55	-17.8	11.2	2.8
	-17.4	11.1	2.7
41VT98S2B8	-13.6	11.5	2.8
	-13.6	11.6	2.8

estimate how long the full DNA analysis would take or how much it would cost, because in most cases, samples such as those from VT98 are contaminated with modern DNA, and thus would require cloning and amplification of thousands of PCA reactions in order to isolate a prehistoric American Indian DNA sequence.

In the end, the Galveston District determined that full DNA analysis would not be performed since: (1) additional funds needed to complete the analysis would be at least several hundred thousand dollars; (2) there was no certainty that funds would be available to complete additional analyses; (3) substantial additional expenditures in this range would not be possible because the overall project cost was nearing the total Congressionally authorized limit, and (4) the treatment plan stipulated that the DNA analysis could be constrained by cost [Janelle Stokes, personal communication 2008].

Data from Buckeye Knoll: Contextual Interpretations
(Robert J. Hard)

Stable ^{13}C and ^{15}N isotopic analyses are particularly well suited to the study of the adaptations at Buckeye Knoll, as this approach can provide data regarding the role of freshwater, marine and terrestrial aspects of the paleodiet that other techniques cannot. Noreen Tuross of Harvard University processed eight human tooth collagen samples from the site (see previous section in this chapter); seven of these dated to the Early Archaic period cemetery component and one dated to the Late Archaic period. This report considers these results within the context of stable isotope ecology of the Texas coastal plain.

Stable carbon and nitrogen isotope studies of ancient skeletal remains have become widely used techniques for the reconstruction of paleodiet (e.g. DeNiro and Epstein 1978, 1981: Katzenberg 2000; Schoeninger and DeNiro 1984; van der Merwe and Vogel 1978; Vogel and van der Merwe 1977). Huebner (1991, 1994) and his colleagues (Huebner and Boutton 1992, 1994; Huebner and Comuzzie 1992; Huebner et al. 1996) were the first to use stable isotope analyses in south Texas. Since then, stable isotopic work has been conducted in a variety of research contexts in the state (Alvarez 2005; Bement 1994; Bousman et al. 1990; Bousman and Quigg 2005; Cargill 1996, Cargill and Hard 1999; Eling et al. 1993; Hard 2002; Hard et al. 1996; Norr 2002; Pertulla 1996, 2001; Skinner et al. 1980; Terneny 2005; Turpin 1988). Recently, Hard and Katzenberg (2007) conducted a stable isotope study of a series of mortuary sites across the Texas coastal plain and this report will include a comparison of the Buckeye Knoll results with that study.

Ideally, such research should include consideration of the stable isotope ecology of the plants and animals in the ancient human food web. If this is not possible, reference to relevant studies can aid in the interpretation of the human data. Biologists have ex-

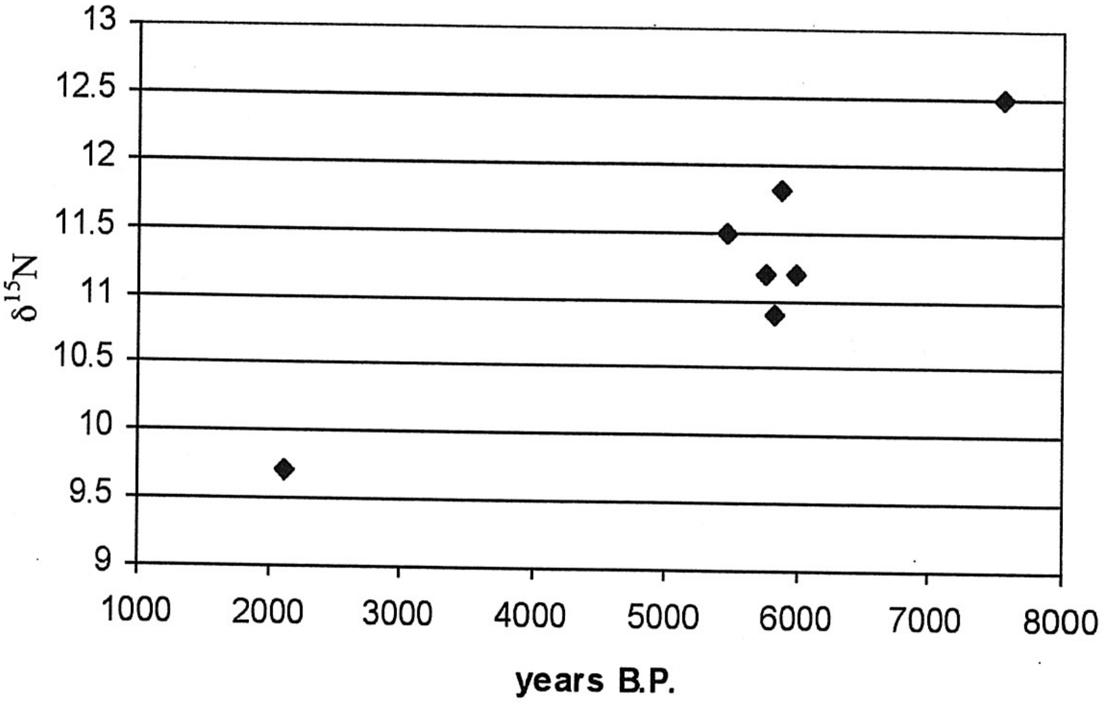


Figure 11-2. Graph showing the relationship between stable nitrogen values and sample ages.

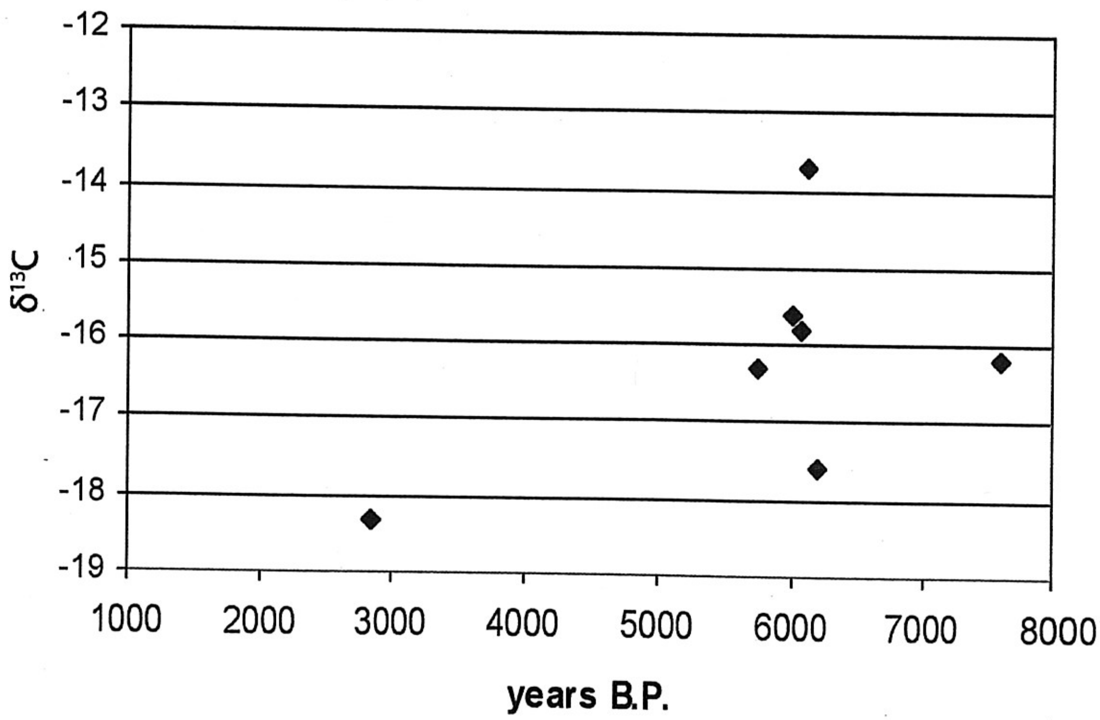


Figure 11-3. Graph showing the relationship between stable carbon values and sample ages.

amined the stable isotope ecology of Texas Gulf Coast marine and freshwater ecosystems (e.g., Fry et al. 1984; Jepsen 1999; Winemiller et al. 2006). Hard and Katzenberg (2007) conducted stable isotope analyses of animal taxa from archaeological sites on the Texas coastal plain.

Since excellent reviews of stable isotope methods and applications are readily accessible, only a synopsis of the principles of human dietary isotope studies is provided here (e.g. Ambrose 1993; Katzenberg and Harrison 1997; Schoeninger and Moore 1992; Schwarcz and Schoeninger 1991). The stable isotopes ^{13}C and ^{15}N have different reaction rates, known as fractionations, than their lighter, more common cousins ^{12}C and ^{14}N. With fractionations, the ratios between the scarce, heavier isotope and the lighter, abundant isotope change (e.g. ^{13}C to ^{12}C) as carbon and nitrogen move from the environment through plants and their consumers. Some groups of plants and animals incorporate heavy isotopes into their tissues at different rates. These ratios are recorded in living tissue, including human and animal bone found on archaeological sites. Laboratory analysis of bone or teeth measures the ratios of ^{13}C to ^{12}C and ^{15}N to ^{14}N and these ratios are compared to the ratios in laboratory standard materials. These ratios of the sample relative to the standard are symbolized with the "6" (delta) sign and are measured in permille (‰) or parts per thousand. The ratios, as they are recorded in human bone and teeth, allow identification of some food groups that tend to have somewhat unique isotopic ratios. As discussed below, some of the identifiable food groups include: terrestrial C_3 plants, terrestrial C_3 animals, terrestrial C_4 plants (including maize), C_4 plant grazers (e.g. bison), freshwater fish and marine (or estuarine) fish.

In bone and teeth, both the collagen and apatite compounds can be analyzed. In this study only tooth collagen was analyzed so apatite will not be discussed further. Ingested protein contains the essential amino acids that build the collagen carbon molecules; therefore collagen $\delta^{13}C$ values usually reflect the protein component of the diet (Schwarcz 2000). Collagen ^{13}C fractionates so that it is estimated to be 5‰ greater than the $\delta^{13}C$ value of the dietary protein source, assuming protein intake is adequate (Katzenberg 2000; Schwarcz 2000; van der Merwe and Vogel 1978). Therefore, if human $\delta^{13}C$ collagen measured -20‰, the ingested dietary protein would be -25‰.

Three groups of plants with different photosynthetic pathways fractionate $\delta^{13}C$ at varying rates. Most trees, shrubs and forbs belong to the C_3 group and have a global mean $\delta^{13}C$ value of about -27‰ (O'Leary 1988:334). Warm-season grasses and some forbs belong to the C_4 group, as does maize, and these plants have a mean $\delta^{13}C$ value of -13.1‰ (O'Leary 1988:334). Maize consumers can be distinguished from non-maize consumers, assuming there are no other significant C_4 or CAM (Crasslucean Acid Metabolism) plants in the diet. Bison that graze on C_4 grasses have more positive values than do deer that feed on C_3 plants. CAM plants, including arid-land succulents such as agave and cacti, can fluctuate between C_3-like and C_4-like values. Prickly pear, the principal CAM plant on the south Texas coastal plain, has C_4-like values (Boutton et al. 1998). Flesh tends to be 2‰ less than collagen, so for example, deer bone collagen with a $\delta^{13}C$ value of -19‰ indicates that deer meat is -21‰.

Nitrogen isotope ratios ($^{15}N/^{14}N$) are potentially more complex, since trophic level, temperature, nitrogen source, and plant and animal physiology can affect collagen nitrogen isotope ratios (e.g. Ambrose 1991; Minagawa and Wada 1984). The $\delta^{15}N$ value of atmospheric nitrogen (N_2), the primary standard, delineates the arbitrary zero point of the nitrogen isotope scale ($\delta^{15}N$=0‰). For each trophic-level increase from plants to herbivores to carnivores in both terrestrial and aquatic environments there is a 3 to 4‰ gain in ^{15}N values (Ambrose 1991; Minagawa and Wada 1984; Schoeninger and DeNiro 1984). Drought-tolerant herbivores can have more elevated ^{15}N values (Ambrose 1993; Sealy et al. 1987). Unlike $\delta^{13}C$ values, the $6^{15}N$ values of flesh and collagen are the same.

The basic principles outlined above apply to aquatic environments, but there are some important differences. Basal carbon sources in aquatic ecosystems may have different $\delta^{13}C$ values than atmospheric carbon; particularly in marine ecosystems where dissolved inorganic carbon is the primary source (Katzenberg 2000; Pate 1994). Freshwater plants obtain carbon, not only from atmospheric CO_2, but from the water and associated sources with more variable $\delta^{13}C$ values than terrestrial C_3 plants (Jepson 1999; Katzenberg 2000). A foodweb study of Brazos River isotope ecology found the $\delta^{13}C$ values of freshwater plants range from -18‰ to -25‰ (Jepsen 1999).

In Texas estuarine settings, seagrass meadows are common in shallow water (<2 m) and have C_4 values, while in offshore environments, algae, with values intermediate between C_3 and C_4 plants, dominate the base of the foodweb (Fry and Parker 1979). Fish from seagrass meadows in some Texas shallow bays yield mean $\delta^{13}C$ flesh values from -8.3 to -15.5‰ (mean -12.1‰) while offshore fish have more negative values, -14.8 to -19.2‰ (mean -17.5‰) (Fry and Parker 1979:502). The role of seagrass versus algae as the basal producer for any particular Texas estuarine environment or fish species can vary. Texas saltmarsh fish (including several species of ancient economic value) yield more negative flesh values, from -13 to -20‰ (Winemiller et al. 2006). The lifecycle of some species involves movement from offshore to nearshore settings, exposing them to both seagrass- and algae-dominated niches. Humans feeding on nearshore fish from seagrass environments may have elevated $\delta^{13}C$ values that overlap with the values resulting from a diet of C_4 plants, while fish from algae-dominated settings should have $\delta^{13}C$ values that are intermediate between that of C_3 and C_4 plants. However, a marine diet should have distinctive elevated $\delta^{15}N$ values.

A Texas saltmarsh yielded ^{15}N values from aquatic plants that ranged from 0.7 to 6.5‰, generally higher than the range of most terrestrial plants (Winemiller et al. 2006). Marine and freshwater fish tend to have elevated $\delta^{15}N$ values reflecting more trophic levels (e.g. aquatic plants, zooplankton and invertebrates, fish, piscivorous fish) than in most terrestrial herbivore species.

Methods

As noted, CEI submitted teeth from eight individuals to Noreen Tuross for $\delta^{13}C$ and $\delta^{15}N$ analyses, ^{14}C dating, and DNA screening. Using a stable mass spectrometer, analyses of $\delta^{13}C$ and $\delta^{15}N$ were performed on pairs of duplicate samples for the eight teeth (see Table 11-2). The difference between the measurements is negligible, indicating high measurement consistency. The ratio of elemental carbon to nitrogen was measured and the values are 2.7 to 2.8 for all samples, thus indicating the carbon and nitrogen in the collagen are well preserved (see Table 11-2). Table 11-3 lists these samples again, along with the results of the associated radiocarbon dates. The "OC" dates are from the tooth collagen Tuross extracted. The "Beta" dates are from bone collagen from that particular burial.

Results

Table 11-3 reports the paired values and the mean of each pair. The mean $\delta^{13}C$ value of the seven Early Archaic period samples is -15.6‰ and the mean $\delta^{15}N$ value is 11.51‰. The $\delta^{13}C$ values are more variable, ranging from -13.7‰ to -17.6‰, while the $\delta^{15}N$ values range from 10.9‰ to 12.55‰. The single Late Archaic period sample (Burial 23) reflects a notable decline in both ^{13}C and ^{15}N values, with values of -18.3‰ and 9.7‰. All values are plotted in Figure 11-4, including the mean and standard deviation of the $\delta^{13}C$ and $\delta^{15}N$ values. The Early Archaic period samples have both elevated ^{13}C and ^{15}N values and the ^{15}N value suggests a substantial reliance on aquatic species. The ^{13}C value suggests freshwater resources dominate over marine species, but marine (or estuarine) resources are isotopically visible (see below). The two individuals with -13‰ to -14‰ $\delta^{13}C$ values (Burials 5 and 8) indicate they had a different diet, one that includes notably more estuarine C_4 resources than the other five Early Archaic period individuals. The single Late Archaic value (Burial 23) suggests a decline in use of aquatic species, particularly in marine resources since there is a decline in both $\delta^{15}N$ and $\delta^{13}C$ values, a trend that can be accounted for if C_3 plant resources were replacing lost estuarine resources.

Discussion and Conclusions

Comparative data allow the stable isotope study for Buckeye Knoll to be placed within the context of human isotopic ecology of the Texas coastal plain. Hard and Katzenberg (2007) measured $\delta^{13}C$ and $\delta^{15}N$ collagen values for 168 faunal samples from 29 taxa from three prehistoric and four historic sites on the Texas coastal plain. Figure 11-5 summarizes the data for 75 of these faunal samples including the four faunal categories (bison, terrestrial mammals, riverine fish, and estuarine fish) that are representative of the most important human dietary items, plus the three plant categories (C_3 plants, C_4 plants and CAM plants) that are isotopically recognizable. The points on Figure 11-5 are the mean collagen values and the error bars represent ± values at a 90-percent confidence interval, with outliers removed. Further details are found in Hard and Katzenberg (2007). The Buckeye Knoll Early Archaic mean value (with its 90-percent confidence level error bars) and the single Buckeye Knoll Late Archaic collagen value (again with 90-percent confidence bars) are also plotted on Figure 11-5.

The C_3 and C_4 plant values were derived from the herbivore collagen values from Hard and Katzenberg (2007). CAM plant values, primarily prickly pear in this region, were derived from Boutton et al. (1998:Table 1) and Boutton (personal communication 2006). C_3 terrestrial mammals represent collagen from white-tail deer, cottontail rabbit, opossum, and raccoon, all of which feed on C_3 plants or their consumers (n=17). This group has negative $\delta^{13}C$ values and intermediate $\delta^{15}N$ collagen values. The riverine fish group repre-

Table 11-3. Stable Isotope and AMS-Derived Chronometric Data Obtained on Samples of Human Tooth Collagen from Buckeye Knoll.

Period	Burial No.	^{13}C pairs	^{13}C	^{15}N pairs	^{15}N	C/N pairs	2-Sigma Cal. (yrs. B.P.)	C14 Lab No.
Early Archaic	74	-15.8/-15.9	-15.85	10.9/10.9	10.90	2.8/2.8	6670-6580	OC-44622
	27	-16.2/-16.2	-16.20	12.5/12.6	12.55	2.8/2.8	6640-6410	Beta- 157424
	6	-16.3/-16.2	-16.25	11.5/11.5	11.50	2.8/2.8	6300-6220	OC-44624
	71	-15.6/-15.7	-15.65	11.2/11.1	11.15	2.8/2.8	6610-6500	OC-44625
	5	-13.6/-13.8	-13.70	11.8/11.8	11.80	2.8/2.8	6730-6650	OC-44627
	55	-17.8/-17.4	-17.60	11.2/11.1	11.15	2.8/2.7	6860-6770	OC-44628
	8	-13.6/-13.6	-13.60	11.5/11.6	11.55	2.8/2.8	6430-6290	Beta-157422
	Mean	—	-15.60	—	11.6	—	—	—
	Std. Dev.	—	1.44	—	0.55	—	—	—
Late Archaic	23	-18.1/-18.5	-18.30	9.7/9.7	9.70	2.7	2130-2050	OC-44626

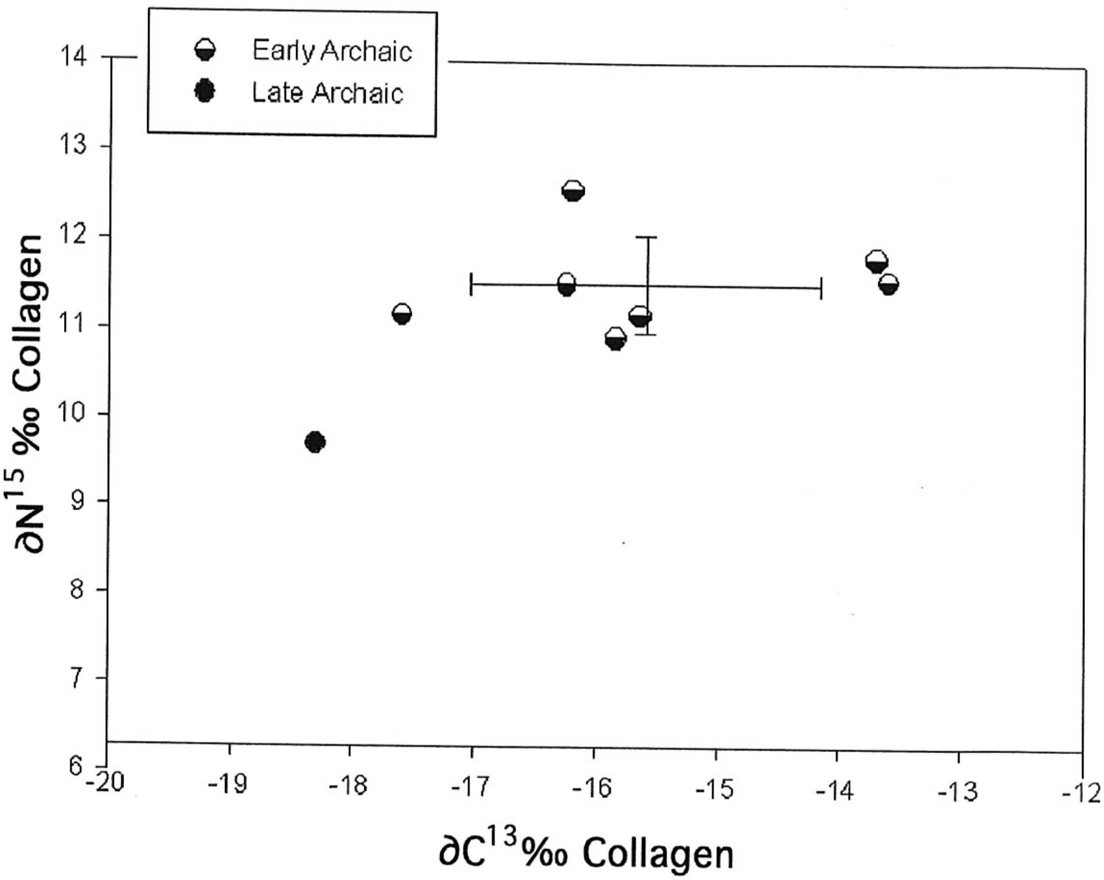


Figure 11-4. Graphic plotting of stable isotope values for the Early Archaic and Late Archaic burials from Buckeye Knoll.

sents freshwater species that include bowfin, catfish, flathead catfish, and gar (*n*=37), all with elevated $\delta^{15}N$ values since fish tend to feed at higher trophic levels and have more diverse $\delta^{15}N$ sources than terrestrial species. Such fish also tend to have depleted $\delta^{13}C$ values that are similar to terrestrial plant C_3 values.

The marine fish category (*n*=16) represents drum, freshwater drum and gar (the latter two live in both freshwater and estuarine environments and can tolerate saline waters); the samples in this study yielded marine values and were so classified (Hard and Katzenberg 2007). This sample yielded mean flesh $\delta^{13}C$ values of -12.01‰ (std dev = 2.7‰) and mean $\delta^{15}N$ flesh values of 9.0‰ (std dev = 2.1‰). Estuarine species linked to C_4 seagrasses tend to have values similar to these. However, fish in estuarine settings can have more negative $\delta^{13}C$ values than this archaeofaunal sample if they are from foodwebs controlled by filamentous algae and C_3 plants rather than seagrass meadows (Fry 2006:120-131; Fry and Parker 1979). For example, Winemiller et al. (2006) found that Matagorda Bay mullet, black drum, red drum, sea trout, gar and sea catfish, all important estuarine resources in ancient times, had mean $\delta^{13}C$ values on the order of 6‰ more negative than the mean values in our study. Once these modern values are corrected for changes due to fossil fuel inputs, the difference remains about 4‰ to 5‰ more negative. The most likely explanation is that the archaeofaunal samples represent foodwebs dominated by C_4 seagrass meadows since the modern samples are from algael foodwebs (Winemiller et al. 2006).

The modern fish samples also yielded mean $\delta^{15}N$ values about 3‰ more positive than archaeological fish samples, even though some species were the same (Winemiller et al. 2006; Hard and Katzenberg 2007). This difference may be due to modern pollution and/or variability in estuarine plant $\delta^{15}N$ values (Fry 2006; Pate 1994). In addition, estuarine gastropods and mollusks can also have widely varying isotopic values (Fry 2006:126; Winemiller et al. 2006). These issues

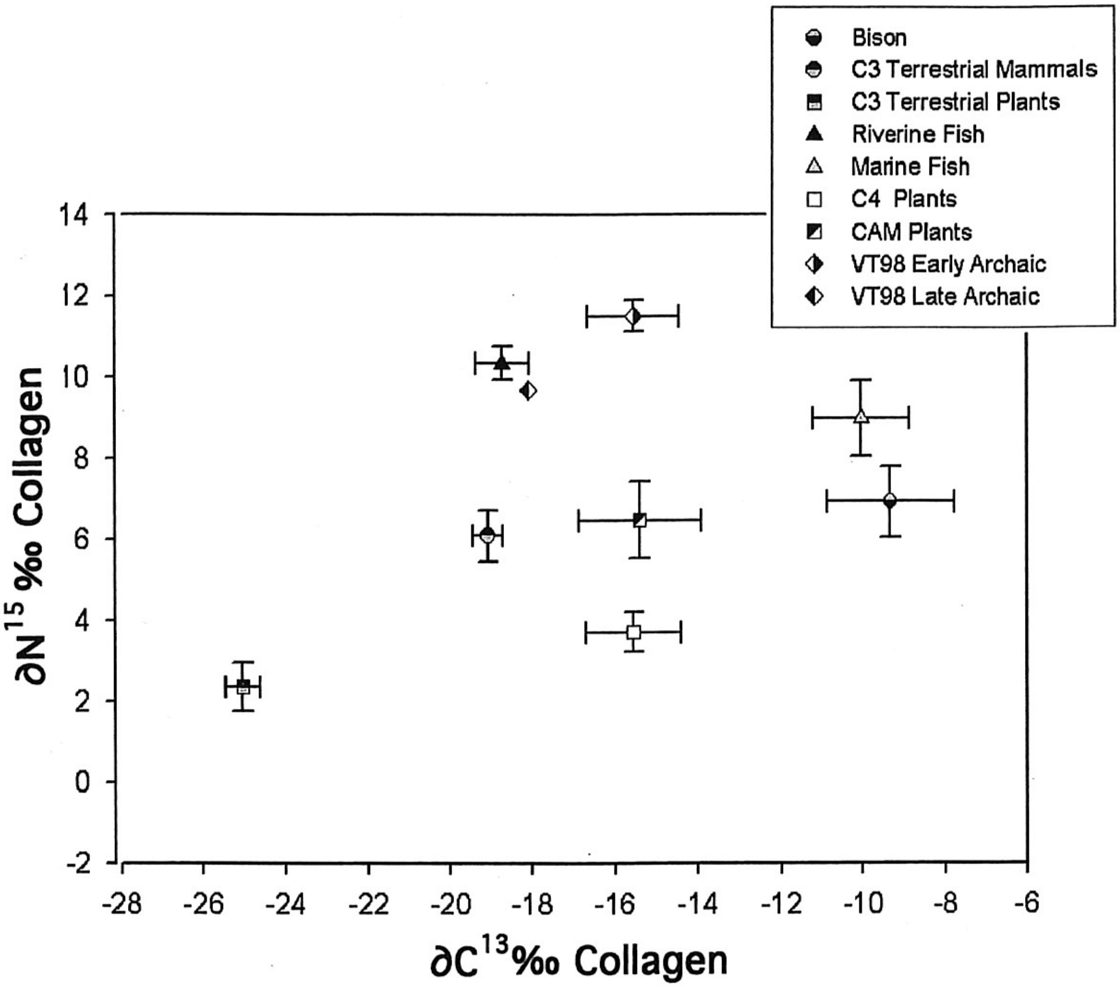


Figure 11-5. Human and animal collagen and plant isotopic values for Buckeye Knoll.

make estimating estuarine dietary inputs difficult and suggest more archaeological fauna samples of estuarine resources need to be examined.

Bison (*n*=5), due to their status as grazers in an environment where C_4 grasses dominate, have elevated $\delta^{13}C$ values and relatively low $\delta^{15}N$values. Figure 11-5 gives a rough idea of the isotopic relationships between potential food sources and collagen values from Buckeye Knoll. It is clear these elevated values suggest substantial inputs of freshwater fish.

The Figure 11-5 collagen values should be corrected for fractionation in order to better estimate diet. Animal $\delta^{13}C$ flesh values are 2‰ more negative than collagen values, but $\delta^{15}N$ flesh values are assumed to be equal to the $\delta^{15}N$ collagen (Ambrose 2000:Table 12.2; Newsome et al. 2004:1106; Schwarcz and Schoeninger 1991:301; Tieszen 1994:273). Figure 11-5 plots these calculated flesh values of the animal groups.

The isotope value of the human diet is estimated to be 3 to 6‰ less than the $\delta^{13}C$ collagen value due to fractionation during collagen production; in this study 5‰ is used (Ambrose 1993; DeNiro and Epstein 1978; Katzenberg et al. 2000; Newsome 2004:1105; Schwarcz 2000; Vogel 1978). The diet is estimated to be 3‰ less than the $\delta^{15}N$ value of collagen due to trophic fractionation effects (e.g. Ambrose 1993, 2000; Newsome 2004:1105). Collagen $\delta^{13}C$ values, under most conditions, tend to be controlled by protein intake rather than whole diet (Ambrose 1993). Therefore, the Early Archaic period component of Buckeye Knoll, with a mean $\delta^{13}C$ collagen value of -15.6‰, indicates these individuals consumed protein with a lifetime average of $\delta^{13}C$ value of -20.6‰ (-15.6‰ –

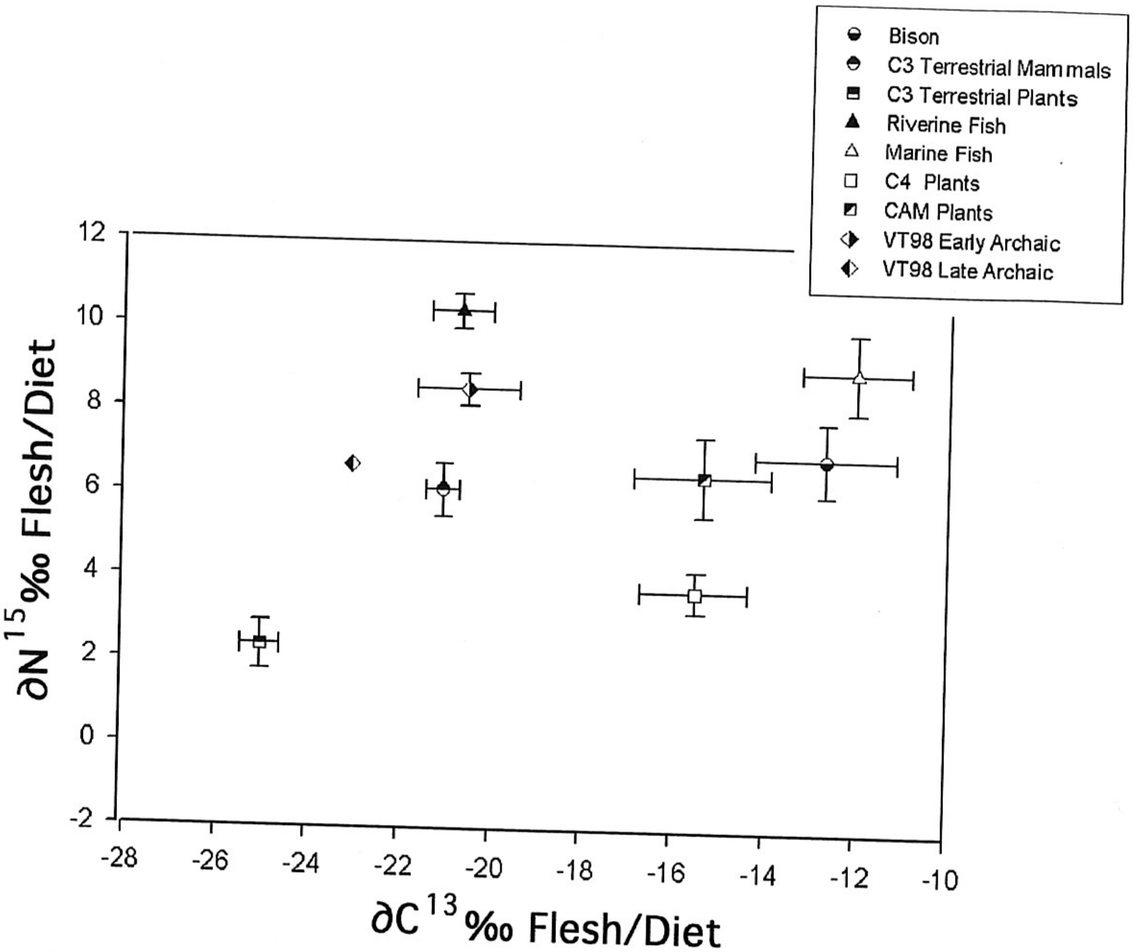


Figure 11-6. Plotting of stable isotope values for major plant and animal resources.

5.0‰). The $\delta^{15}N$ value of 11.6‰ indicates a diet with an average $\delta^{15}N$ value of 8.6‰ (11.6‰ – 3‰). Figure 11-5 displays the resource flesh values and the human dietary values for the Buckeye Knoll individuals.

Figure 11-6 now allows a clearer image of diet at Buckeye Knoll. If the Buckeye Knoll values were centered on any particular resource it would suggest that 100 percent of the diet was from that resource. The Early Archaic component, with a $\delta^{13}C$ dietary protein value of -20.6‰ is consistent with protein sources from both C_3 terrestrial animals and freshwater resources. The $\delta^{15}N$ value falls between that of those two groups suggesting that terrestrial animals and freshwater resources are contributing substantially to the diet. One diet scenario that would account for the Buckeye Knoll values is a diet that is a mix of only freshwater and terrestrial animals. However, this is highly unlikely given the available plant resources and the human need for carbohydrates (e.g. Speth and Spielmann 1983). A more likely scenario is that, along with substantial freshwater resources and some terrestrial animals, the Early Archaic populations were also using C_3 plant resources. However, a diet of freshwater fish, terrestrial animals and C_3 plants would yield $\delta^{13}C$ and $\delta^{15}N$ values lower than the Buckeye Knoll values. However, if marine resources were added then the elevated isotopic values of such resources would offset the negative values of C_3 plants, thus accounting for the measured isotopic values of the Early Archaic component. The most likely diet that accounts for the Early Archaic isotope values is one that is dominated by freshwater resources, but with terrestrial animals, estuarine resources, and C_3 plants each contributing to the diet. It is difficult to make a more explicit estimate of dietary source contributions, particularly with the uncertainty of estuarine source values. None to only slight levels of bison, CAM or C_4 plants were likely being used in the Early Archaic period.

The $\delta^{13}C$ value of the dietary protein from the single Late Archaic individual is -23.1‰ and the dietary $\delta^{15}N$ is 6.7‰, representing a decline in both values compared with that of the Early Archaic period. Notice on Figure 11-5, the Late Archaic data point represents a clear increase in C_3 plant resources and a drop in aquatic resource use. Marine resource use notably declined and freshwater resource use declined somewhat but still remained important. This individual's diet was made up of substantial levels of freshwater resources, C_3 plant resources, and C_3 terrestrial animal resources, with marine resources playing a negligible role or being completely absent. Given that this is only a single individual, it is unknown if this is typical of the Late Archaic period for the area.

Comparisons with Other Sites

Hard and Katzenberg (2007) included analysis of nine prehistoric cemeteries in three ecological zones: the Coastal Zone, the Riverine-Savanna Zone and the Inland Zone (Figure 11-7). The Coastal Zone covers a strip of land about 50 km wide extending from the shoreline inland It includes the coastline, bays, estuaries, and river mouths. Extending westward from the western boundary of the Coastal Zone, to about 200 ft amsl, is the Riverine-Savanna Zone. The land in this zone is flat to gently rolling and the rivers are sinuous, with wide floodplains, swamps, sloughs, and oxbow lakes where freshwater aquatic resources are abundant. The Riverine-Savanna Zone measures about 30-70 km east-west but extends an additional 30-100 km farther inland following the 200-ft contour along the low-lying floodplains. This zone is attractive to spawning fish in the spring and forms resource-rich zones that Hall (1998, 2000) describes as "natural catfish farms." The Inland Zone extends west from the Riverine-Savanna Zone to the edge of Edwards Plateau. This flat to hilly land rises from the 200-ft contour to about 1,000 ft in the vicinity of San Antonio.

Human bone samples from three prehistoric Coastal Zone cemeteries were included in the study: Cayo del Oso (41NU2), Mitchell Ridge (41GV66), and Harris County Boys School Cemetery (41HR80). All are largely Late Archaic to Late Prehistoric in age. The five mortuary sites from the Riverine-Savanna Zone are Morhiss (41VT1), Ernest Witte (41AU36), Bowser (41FB3), Crestmont (41WH39), and Loma Sandia (41LK28). The one site in the Inland Zone was Olmos Dam (41BX1). Bone preservation at Loma Sandia was poor, so valid results were obtained for only one sample from this site, although 37 samples from the locale were processed.

Figure 11-8 shows the dietary values (collagen corrected for fractionation, see above) for the sites in the Texas coastal plain study, as well as the Buckeye Knoll data. Three prehistoric cemeteries in the Riverine-Savanna Zone, Ernest Witte (AU36), Bowser (FB3) and Crestmont (WH39), overlap with mean $\delta^{13}C$ dietary values ranging from -23.9‰ to -24.1‰. The $\delta^{15}N$ dietary values are sharply elevated and range from 7.6‰ to 8.1‰. These values represent substantial dependence on freshwater resources with C_3 plant and animal resources present as well. In contrast to the Early Archaic period diet at Buckeye Knoll, marine resource use does not appear to be isotopically visible in these Riverine-Savanna sites during the Middle and Late Archaic periods.

The Morhiss site (VT1) population represents multiple periods, as existing site data do not allow the burials to be sorted temporally. In Figure 11-8, the Morhiss data plot between the Early Archaic Buckeye Knoll data and the Late Archaic Buckeye Knoll individual. The Morhiss site has a mean $\delta^{13}C$ value that is more positive than the other three Riverine-Savanna sites, suggesting that some of the Morhiss population, like the Early Archaic Buckeye Knoll population, may have been utilizing some of the marine resources that were available 38 km to the south.

Radiocarbon dating at Morhiss has identified three individuals belonging to the Early Archaic period, two to the Middle Archaic period and two to the Late Archaic period, and these are plotted on Figure 11-9 along with those of unknown temporal affiliation (Hard and Katzenberg 2007). The three Early Archaic Morhiss individuals and the one Middle Archaic Morhiss individual are similar to the Buckeye Knoll Early Archaic sample. The other Middle Archaic individual from Morhiss, plus one of the Late Archaic individuals from that site, cluster with the Buckeye Knoll Late Archaic individual. Most of the unknown affiliates from Morhiss fall in or near this late cluster. This cluster of Late Archaic and unknown period individuals indicates a decline in aquatic resource use. The contribution of marine resources declined to lower levels and may have been slight to none. Freshwater resource use declined from Early Archaic levels but remained an important part of the diet. Note that the single Late Archaic individual from Morhiss, on the far right of Figure 11-9, has a sharply elevated $\delta^{13}C$ value. This person likely came from a coastal environment as its $\delta^{13}C$ value is similar to individuals from the Cayo del Oso site (NU2).

On Figure 11-8, the three Coastal Zones sites—Cayo del Oso (NU2), Harris County Boys School

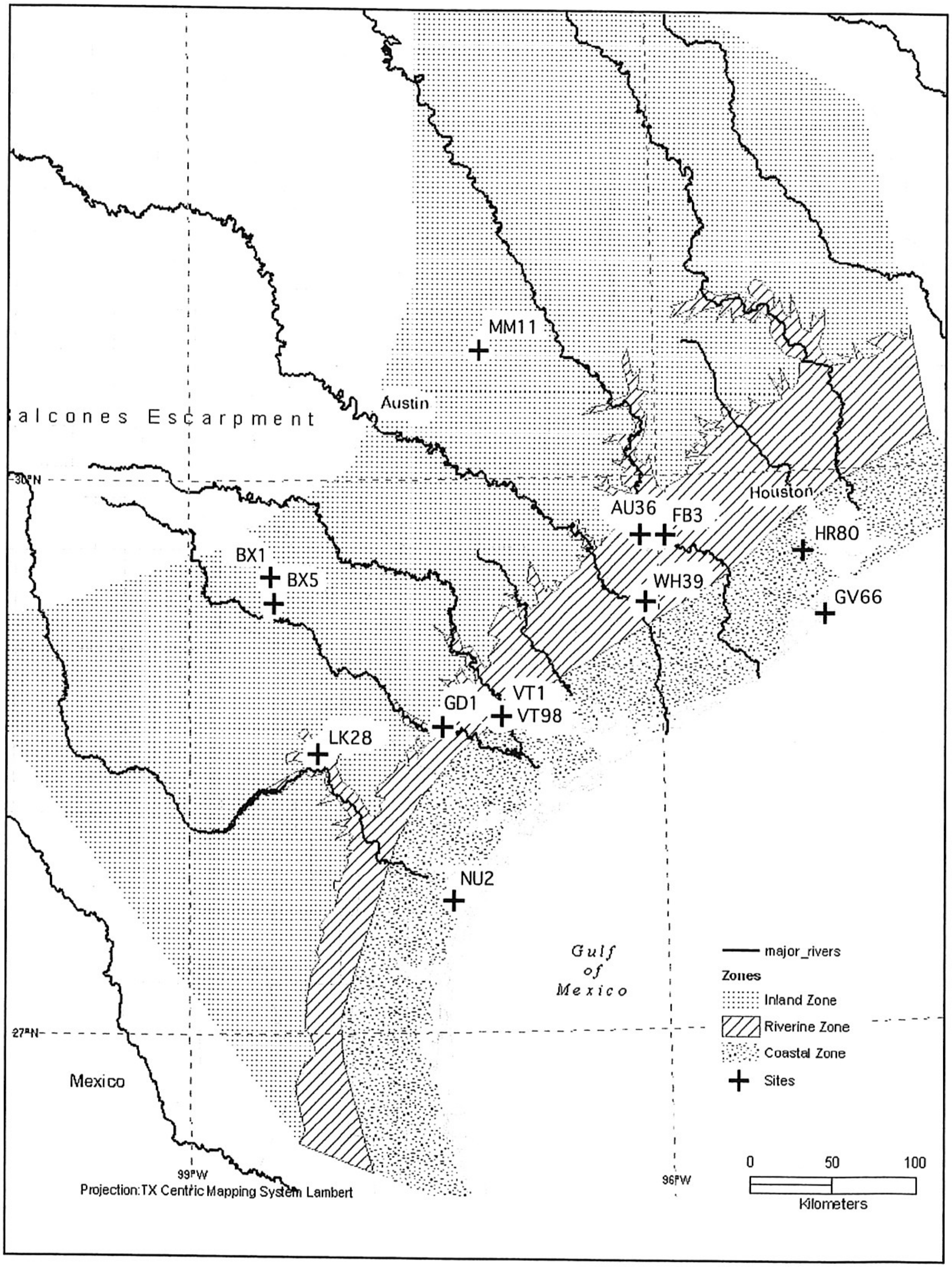


Figure 11-7. Map showing Coastal, Riverine, and Inland Resource Zones on the Texas coastal plain, plus locations of sites referenced in the text.

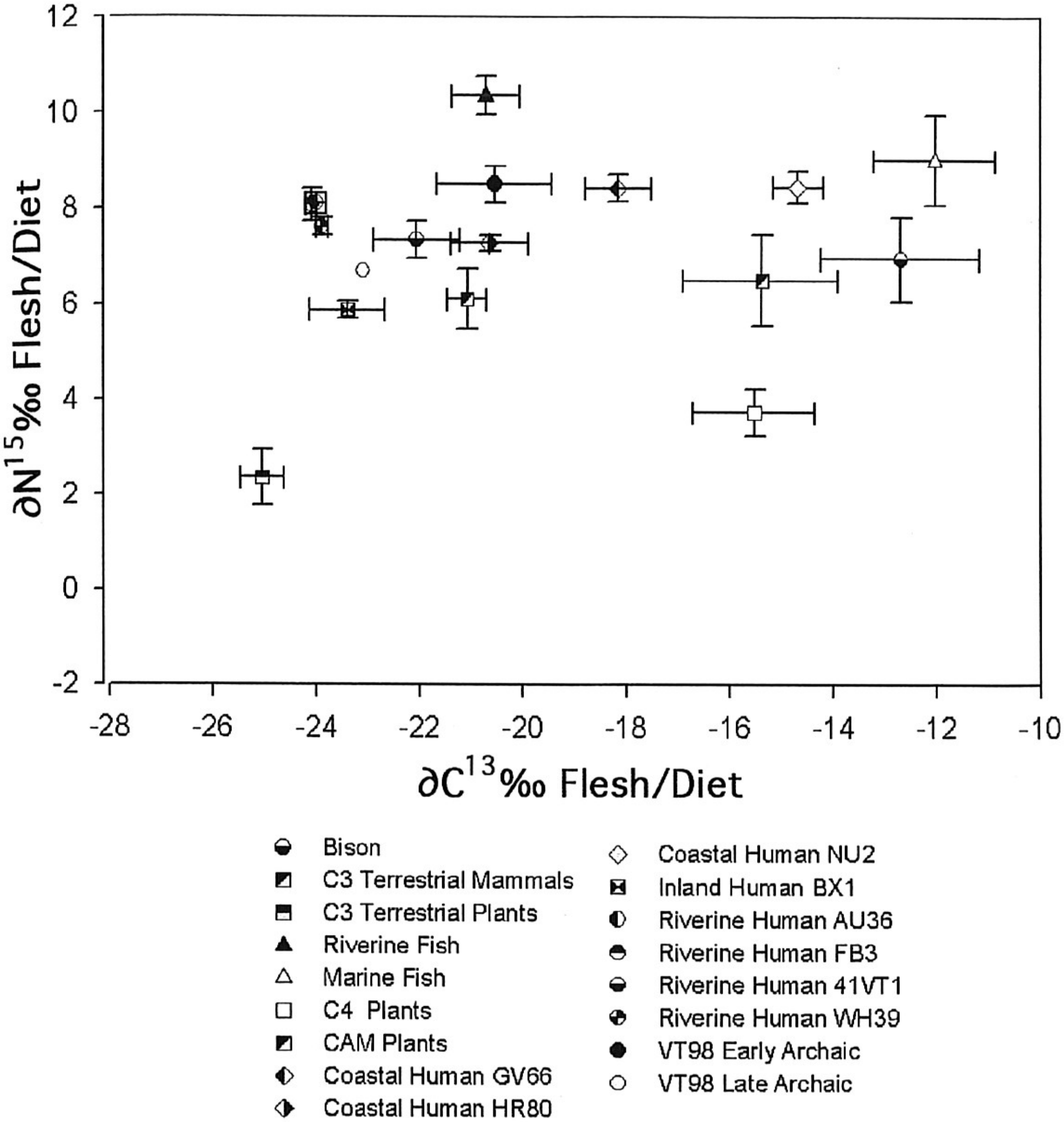


Figure 11-8. Stable isotope values from collagen (corrected for fractionation) from Buckeye Knoll and other sites on the Texas coastal plain.

(HR80), and Mitchell Ridge (GV66)—show elevated $\delta^{15}N$ values, but more variability in the $\delta^{13}C$ dietary values. The Cayo del Oso individuals are the most enriched, with mean $\delta^{13}C$ and $\delta^{15}N$ dietary values of -14.7‰ and 8.5‰, respectively, indicating a diet with a substantial contribution of marine resources and little to no use of freshwater resources. The Harris County Boys School and Mitchell Ridge individuals reflect various mixtures of marine and freshwater resources, combined with terrestrial resources. Improved baseline estuarine source data would allow a better resolution of this issue. The individuals from the single Inland Zone site, Olmos Dam (BX1), have lighter mean isotopic values that reflect a focus on inland, C_3 plant and animal resources, although minor use of freshwater aquatic resources likely occurred (see Figure 11-8).

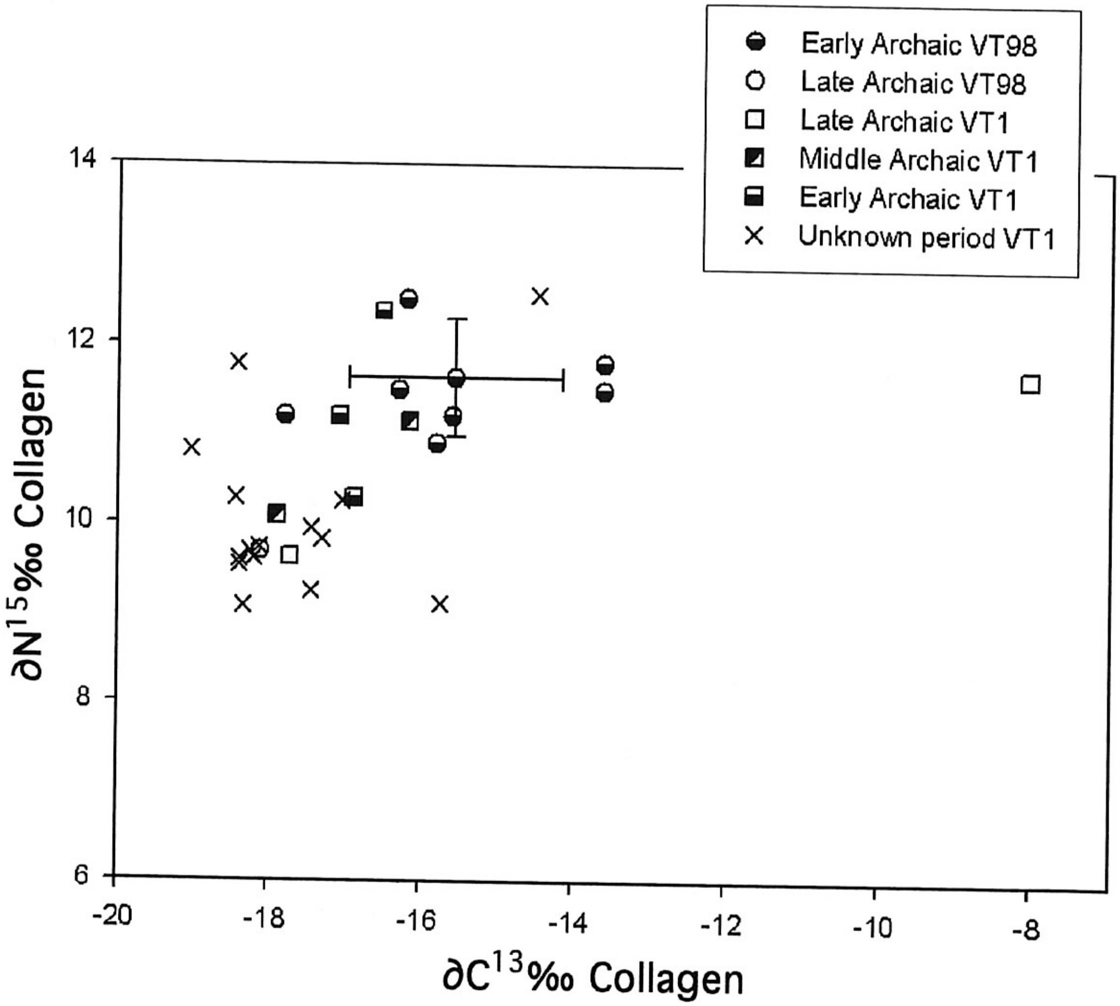


Figure 11-9. Plotting of the stable isotope data from Early, Middle, and Late Archaic burials from the Buckeye Knoll and Morhiss (41VT1) sites.

Conclusions

The Early Archaic individuals from Buckeye Knoll reflect a very early focus on freshwater aquatic resources combined with terrestrial C_3 plants, terrestrial C_3 animals and estuarine resources. This diverse pattern reflects a wider mix of resources and perhaps a greater level of mobility than the pattern that had emerged by the Middle Archaic period and continued into the Late Archaic period, in which hunters and gatherers in Riverine-Savanna settings (Morhiss, Ernest Witte, Crestmont, and Bowser) appear to have made little or no use of coastal resources, despite their proximity. The single Late Archaic individual from Buckeye Knoll is consistent with that pattern. Future work will need to consider the ramifications of these important cultural changes, as well improve baseline estuarine resource data.