9-21-2022

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Short Title: Male and Female Dietary Life Histories from Stable Isotopes

KEY WORDS: STABLE ISOTOPES, SEX-BIASED DIETS, DIETARY LIFE HISTORIES, ISOBIOGRAPHY, CALIFORNIA.

Abstract

Stable carbon and nitrogen isotope analyses of bones and teeth at the ancestral heritage Muwekma Ohlone site of *Yakmuy 'Ooyákma-tka* ("Place of the East Ridge Site"; CA-SCL-215) reveal significant differences in the dietary life history of males and females. Overall, isotope data indicate that site inhabitants were primarily dependent on low trophic-level foods, likely plants, and minor amounts of marine food for their main source of dietary protein. From tooth dentin serial samples, we found that males were elevated by 0.6-1.0‰ in δ^{15}N in early childhood (age 1-9 years) relative to females, while δ^{13}C values were similar by sex, indicating boys were accessing slightly greater amounts of higher trophic-level foods, such as meat from game. The sex-biased difference in δ^{15}N diminishes during the second decade of life, as female δ^{15}N values increase and become equal to males. However, a difference in δ^{13}C emerges during the second decade where female δ^{13}C values are elevated relative to males. This could indicate that teenage females consumed higher amounts of low trophic-level, marine-derived protein, such as shellfish. During later adult years, the difference in δ^{13}C disappears, while males again show an increase in δ^{15}N relative to females. Although these differences are small, they reveal important sex-biased life history patterns during childhood and adulthood in this ancient community.

In many small-scale societies, biological sex and learned gender roles are important factors that affect social organization and influence a range of individual behaviors. For example, they often influence where a person lives (e.g., after marriage), who they associate and interact with, the clothes they wear, their influence in community decision-making, and the types of skills they are expected to acquire (Leacock and Lee 1982; Lew-Levy et al. 2018; Marlowe 2007). These differences have meaningful impacts on the lived experiences of people in modern and ancient societies.

In addition, sex and gender often influence diet. A long history of research (Kelly 1995) shows that division of labor within households is often, though not always, sex- and gender-biased (e.g., hunting vs. gathering vs. fishing). These biases can affect access to, or the importance of, particular foods in a person's diet (i.e., never vs. periodic vs. continual). For example, sex and gender may affect eating order within the house (Mead 1928:18), may impose restrictions against consuming certain foods during menstruation or pregnancy (Montgomery 1974), or influence the ability to acquire particular foods through trading or sharing networks. Many of these factors have a temporal aspect to them. Thus, menstruation and pregnancy are clearly tied to biological age for females (pre-menarche vs. post-menarche vs. post-menopause). Likewise, elderly individuals may no longer be able to walk long distances to hunt or gather in particular food patches. In short, the interplay between sex, gender, and age, can create distinctive dietary life histories within societies. Importantly, these dietary life histories may differ from culture to culture, region to region, or over long periods of time as cultures change.

Unfortunately, much of the archaeological record that pertains to diet is not linked directly to the sex or gender of individuals. Insight into ancient diets derived from the analyses of faunal and macrobotanical remains associated with midden constituents, in most contexts, cannot

be associated with particular individuals or to males vs. females. Stable isotope analysis of skeletal remains offers one avenue forward because chemical signatures recorded in bones and teeth reflect dietary patterns of individuals who can be independently evaluated for sex using skeletal markers (Buikstra and Ubelaker 1994; Phenice 1969), genomic signatures (Skoglund et al. 2013), or proteomic markers (Parker et al. 2019; Stewart et al. 2017).

Advances in mass spectrometric techniques facilitate the analysis of ever-smaller samples for isotope analysis, while maintaining measurement precision (Richards 2020). This allows for the recovery of finer-grained life history information from biological tissues, especially those that grow incrementally and do not remodel in life. Fortunately for archaeologists, the most resilient part of the skeleton, the teeth, also happen to grow incrementally and do not remodel. This is unlike most bony elements, which constantly remodel and average isotopic signatures over months to years, or hair, which does not remodel but rarely survives in archaeological contexts. Because skeletal tissues are synthesized from ingested foods and liquids, the chemical and isotopic composition of growth layers can serve as tracers of an individual's environment and diet while those tissues grew. By analyzing successive layers, archaeologists can recover a time-series that corresponds to life history events of an individual. We refer to this as an isotopic biography, or an "isobiography" for a person. Serial-sampling of incrementally growing tissues from individuals with estimated biological sex allows us to compare potential differences in the dietary life histories between males and females.

This study focuses on carbon and nitrogen isotopes in dentin and bone collagen as tracers of diet, which together establish an isobiography for an individual. Our focus is on an ancestral Ohlone heritage site, CA-SCL-215, or *Yakmuy 'Ooyákma-tka* (meaning "Place of the East Ridge Site" in the Muwekma Chochenyo/Thámien Ohlone language, pronounced "Yahk-mooie Oo-

yaahk-mah-t-kah"). The site is located in the southern San Francisco Bay Area. Median calibrated radiocarbon dates on bone collagen from twelve individuals, reported below, indicate that the cemetery component of the site was in use during a 300-year window between approximately 870 and 1170 ACE. This situates it within the terminal half of what is referred to regionally as the M4 phase of the Middle Period and the first half of the Middle to Late Transition (MLT) Period (Groza et al. 2011). In terms of regional chronology, the site is uniquely positioned as it spans a period with marked evidence for cultural change, from the Middle to MLT Periods (Groza et al. 2011; Milliken et al. 2007; Schwitalla et al. 2014). This site also spans part of the Medieval Climatic Anomaly (MCA; 800-1200 ACE), a period of marked global droughts that were especially notable in California's past (Ingram and Malamud-Roam 2013; Lightfoot and Luby 2002).

Yakmuy 'Ooyákma-tka **(CA-SCL-215).** *Yakmuy 'Ooyákma-tka* is in what is now east San Jose, Santa Clara County, California (see Figure 1). The site lies approximately 25km from the southern edge of San Francisco Bay. During construction of a housing community at the location, 22 pre-contact period graves representing 30 individuals (i.e., some graves contain two or three individuals) were discovered and excavated by the cultural resource management arm of the Muwekma Ohlone Tribe. In addition, human remains recovered from non-grave contexts at the site represent at least six additional individuals. In sum, the study includes bone samples from 32 individuals, and 29 tooth samples representing 16 individuals (Table 1).

Most of the graves were disturbed by mechanical, earth-moving equipment prior to archaeological investigation. Therefore, skeletal elements for many of the individuals were highly fragmented. Where possible, we provide information on the burial position (flexed vs.

extended), cardinal orientation (measured along the spinal column), and clearly associated grave goods (Table 1).

Unfortunately, there was very little investigation of non-burial contexts at the site. Such studies might have provided valuable contextual evidence for subsistence practices of inhabitants in the form of paleobotanical and zooarchaeological studies, as well as indirect evidence in the form of food procurement and processing tools (e.g., millingstones, projectile points). As it is, stable isotope studies provide the best path forward for understanding dietary habits at *Yakmuy ʻOoyákma-tka*.

Isotopic Context. Carbon (C) and nitrogen (N) are essential elements for mammalian bone and tooth formation. Carbon is found in both the mineral (bioapatite) and organic (collagen) components of bone and teeth, while nitrogen is only present in the organic fraction, including bone and dentinal collagen protein. Following ingestion and digestion, C and N are routed via the blood system to sites of bone and tooth formation, and in the case of bone, remodeling as well. Because underlying food sources can vary in their C and N composition, measuring C and N isotopes can provide information on the diet of an individual at the time those skeletal tissues were forming.

The ratio of carbon isotopes ($^{13}C/^{12}C$, expressed as $\delta^{13}C$) can vary in different environments and between food sources. $\delta^{13}C$ is often used to provide an estimate of the consumption of C_3 vs. C_4 plants. The majority of plants around the world are C_3 plants that produce a three-carbon molecule during the fixation of atmospheric carbon. This method of photosynthesis discriminates against the heavier ^{13}C, resulting in $\delta^{13}C$ values between −30‰ and −22‰ (Cerling et al. 1998; Ehleringer et al. 1993; Farquhar et al. 1989). By contrast, a small

number of plants utilize a four-carbon molecule (C_4) and produce tissues with $\delta^{13}C$ values typically between −16‰ and −10‰. In Central California, there are few native C_4 plants (Cloern et al. 2002), and none were important dietary staples prior to contact in 1769 ACE (Bartelink 2006, 2009; Leventhal et al. 2011). Water stress can also affect the carbon isotopic signatures in some plants (Flanagan et al. 2005; Gebrekirsto et al.2011). Perennial plants under significant water stress produce tissues that are enriched in ^{13}C, leading to $\delta^{13}C$ values that are typically 1-4‰ higher than unstressed plants (Picon et al. 1996; Van de Water et al. 2002). In Central California, many important plant foods for humans are either annual in nature (e.g., many grass seeds) or grow along waterways where water stress is not an issue (e.g., oak trees and acorns). However, some perennial and economically important plants, such as manzanita and pine, are found away from water courses and undergo periodic water stress. Isotopic analyses of modern acorn and pine in the Sierra Nevada also show this effect (Hopkins and Kurle 2016). Likewise, empirical studies using archaeological remains (i.e., charred plant material) in California show that these foods are consistently higher in $\delta^{13}C$ than other common food resources (Eerkens et al. 2020; Hull et al. 2016). Likewise,

In contrast to terrestrial systems, carbon enters marine environments mainly through exchange with atmospheric CO_2 and through photosynthesizing phytoplankton (Boutton 1991). $\delta^{13}C$ values of biologically available carbon in marine environments typically overlap with those of C_4 plants. Because C_4 plants were generally not consumed, we use $\delta^{13}C$ in Central California as a discriminator of terrestrial- vs. marine-derived carbon, with heavier (less negative) $\delta^{13}C$ values indicating a greater contribution of marine organisms to the diet (Bartelink 2009; Schoeninger et al. 1983; Schwarcz and Schoeninger 1991). In Central California, people moved marine foods, such as shellfish and small fishes, over large distances (Hildebrandt et al., 2009;

Leventhal et al. 2020). As well, many freshwater aquatic environments offered anadromous fish, such as salmon and sturgeon, which can carry marine isotopic signatures to inland locations.

Nitrogen isotopes ($^{15}N/^{14}N$, expressed as $\delta^{15}N$, see below) provide a complementary tracer of paleodiet. Nitrogen enters biological systems either through atmospheric fixation by soil bacteria or through physical processes (e.g., lightning strikes). Nitrates and nitrites are then taken up by plants and converted into various biomolecular compounds, especially proteins. Animals access nitrogen through the consumption of protein-containing tissues, such as plants or animal meat. Following digestion, animals differentially excrete the lighter ^{14}N in the formation of urea and retain the heavier ^{15}N for tissue synthesis. As a result, $\delta^{15}N$ increases by about 3-4‰ with each trophic level. In terrestrial systems in Central California, there are essentially three trophic levels: plants, vegetarians, and carnivores (Ambrose 1986, 1991; DeNiro and Epstein 1981; Minagawa and Wada 1984). In aquatic environments, baseline $\delta^{15}N$ at the bottom of the food chain is typically higher than in terrestrial systems, and there are usually more trophic levels. As a result, aquatic environments generally have greater enrichment of ^{15}N, especially towards the top of the food chain (e.g., large fish, predatory birds, and aquatic mammals; Schoeninger 1995).

In paleodietary studies, collagen is used as a tracer of dietary protein, while bone bioapatite is more reflective of the whole diet, including carbohydrates, fats, and protein (Ambrose and Norr 1993; Kellner and Schoeninger 2007; Tieszen and Fagre 1993). $\delta^{15}N$ is only measured in bone or dentinal collagen, allowing us to evaluate the trophic level mainly of dietary protein. By contrast, $\delta^{13}C$ is measured in both collagen and bioapatite, allowing us to compare sources of dietary protein (collagen) with whole diet (bioapatite). The difference in $\delta^{13}C$ between bioapatite and collagen (bioapatite-collagen spacing) reflects differences between the sources of protein and non-protein (i.e., fats and carbohydrates), with higher values indicating a greater

difference in the source of protein vs. fats and carbohydrates. Together, $\delta^{13}C$ and $\delta^{15}N$ in collagen and bioapatite can inform on the importance of foods from different environments and trophic levels (Froehle et al. 2010, 2012). By linking isotopic composition of tissues growing at different points in the life course to individuals assigned sex based on osteological markers, we can then explore how different types of food from different environmental contexts did (or did not) change in importance over human life history of males and females within the site.

Methods

Prior to the planned reburial, the human remains from *Yakmuy 'Ooyákma-tka* were sampled for stable isotope analyses. The archaeological recovery program was conducted by the project's state-assigned Most Likely Descendants (MLD), the Muwekma Ohlone Tribe of the San Francisco Bay Area. Permission for the stable isotope analysis was granted by the MLD through a partnership with university collaborators. When available, a small piece of bone, a permanent first molar, and a permanent third molar were sampled from each individual. To assure that bone and teeth were drawn from the same individual, small pieces of mandible were selected to represent the bone, when present.

For bone isotope preparation, samples from various elements (as seen in Table 1) were sent to California State University, Chico. Visible dirt and other exogenous material was removed manually using a diamond studded rotary drill. Samples were then cleaned in an ultra-sonication bath twice with deionized (DI) water, then once each in ethanol 95%, and ethanol 100%. Approximately 0.7-1.0g of cleaned bone was weighed out for collagen extraction, and 0.5-0.7g for bioapatite analysis.

Samples slated for collagen preparation were soaked in a solution of 0.25M hydrochloric acid (HCL). This soak was checked and replaced every two to four days, until demineralization was complete. Samples were rinsed in DI water and then placed in a solution of 0.125M sodium hydroxide (NaOH) for 24 hours to remove humic contaminants. Samples were then put through a solubilization process, in which the samples were soaked in a solution of dilute HCl with a pH of 3 in an oven held at 90°C for three, 24-hour cycles. Collagen pour-offs from the solubilization step were added to glass scintillation vials and freeze dried for approximately 24 hours.

Bone samples for bioapatite analysis were crushed using an M400 mixer mill and run through a 200μm screen. Each powdered sample was then weighed using an analytical balance and recorded. Organic materials were removed through two, 24-hour soaks in a 30% hydrogen peroxide solution. The quantity of H_20_2 per sample was determined using the formula: H_20_2= (0.04)*(1000)*(sample powder weight). Samples were then rinsed in DI water, dried in an oven at 21.1°C, re-weighed, and transferred to a 1.0 M acetic acid (CH_3COOH) solution buffered with NaOH. This solution was refreshed at the 12-hour mark. The amount of acetic acid treatment for each sample was determined using the same formula, as with the H_2O_2. Finally, samples were rinsed in DI water and left to dry at 21.1°C.

Collagen carbon and nitrogen isotopic ratios were determined by continuous-flow mass spectrometry at the Stable Isotope Facility at University of California, Davis. Repeated analyses of standards shows that instrument precision is 0.1‰ for $\delta^{13}C$ and 0.2‰ for $\delta^{15}N$. Atomic C/N ratios were used to evaluate collagen sample quality (DeNiro 1985; van Klinken 1999). All samples fell within the range of acceptable C/N ratios (2.9-2.6) and thus were included in the analysis.

For twelve individuals, bone collagen was submitted for a direct radiocarbon age estimate using AMS. Dates were calibrated and corrected for marine carbon using a simple linear mixing model based on isotope food web data from Bartelink (2006) and empirically observed $\delta^{13}C$ in the collagen. We applied a marine reservoir correction factor (Delta-R) of 365 ± 50 years recommended by Ingram and Southon (1996) for Late Holocene San Francisco Bay and calibrated the dates using the online version of the CALIB 7.1 program with the mixed marine Northern Hemisphere radiocarbon curve (Stuiver et al. 1993).

For teeth, we follow the methods outlined in Eerkens et al. (2011). We initially cut the tooth longitudinally to focus on one half crown to root segment. We removed enamel, cementum, and any visible soil or other adhering material using a handheld drill, leaving only dentin. Each tooth half was then sonicated in DI water to remove remaining exogenous materials and placed in 0.5M hydrochloric acid for demineralization. HCL was replaced every few days until the tooth was spongy in texture, typically between 7 and 15 days. Once a tooth was demineralized, it was cut into 1mm horizontal sections perpendicular to the root axis using a scalpel, producing between 8 to 17 slices depending on tooth length. Each layer was then placed in a 0.125M NaOH solution for 24 hours to remove any residual soil humic acids. Upon rinsing with deionized water, each dentin layer was solubilized at 60-70°C in low pH water. After 1-7 days, solubilized collagen in the aqueous layers were separated from any inorganic solids and freeze-dried to remove water and isolate the solid collagen. All serial samples treated this way produced at least 1mg of collagen, which was submitted as above for C and N isotope analyses.

Prior to sectioning, each tooth was measured from the occlusal surface to the dentino-enamel junction (DEJ), cemento-enamel junction (CEJ), and apical root tip (ART). To reconstruct the age at which each layer was formed, we used data on modern teeth from Hillson

(1996), taking the median age for these landmarks. For first molars, the DEJ forms at age 0, CEJ at age 2.75, and ART at age 9.5 years. For third molars, the DEJ forms at a median age of 8.5, the CEJ at 14, and the ART at 22 years. Since dentin grows in parabolic layers from the tooth crown towards the apical root tip (Hillson 1996), our straight slices cut across the parabolic layers and each slice represents a range of time of tooth formation with some temporal overlap. While smoothing out some of the diachronic variation, this method still records the evolution of diet over controlled amounts of time (Eerkens et al., 2011). Occlusal tooth wear, which often extends through the enamel and into the dentin (especially for first molars), can remove some of the earlier-forming dentin. For example, Burials 4 and 16 are lacking isotopic data for serial sections associated with ages 0-2 years due to occlusal wear. Finally, we use simple univariate *t*-tests (2-tailed, unequal variance) to compare δ^{13}C and δ^{15}N, to assess whether the diets of males and females within particular age cohorts could have been drawn from the same underlying isotopic distribution (i.e., had the same diet).

Results

Table 2 provides results from the bone isotope analyses. As shown, all samples have C/N values between 3.2 and 3.4, well within the 2.7-3.6 range recommended by DeNiro (1985). δ^{13}C values indicate only a small contribution of marine carbon to the diet, between 8 and 20% (reported in the sixth column of Table 2). Calibrated AMS dates also fall within a narrow range, with median dates restricted to a 300-year window between 883 and 1171 ACE, indicating the cemetery was formed during a relatively small amount of time. δ^{15}N values are relatively low compared to other sites in Central California (c.f., Bartelink et al. 2020; Barton et al. 2020; Eerkens et al. 2013).

The data appendix presents $\delta^{13}C$ and $\delta^{15}N$ values for 337 age-linked dentinal collagen samples. Together with bone collagen, we can use the serial samples to reconstruct a dietary life history, or isobiography, for each individual. Figure 2 shows such data for two individuals, Burial 1A (top) and Burial 20 (bottom). Age-controlled $\delta^{15}N$ values are plotted in the upper part of the graph (tied to the left *y*-axis), while $\delta^{13}C$ values are plotted in the lower part (tied to the right *y*-axis). Dotted lines attach the terminal M1 values to the first M3 values, and the terminal M3 values to the bone collagen values, and represent "assumed" changes between these values. Both individuals show elevated $\delta^{15}N$ values in the earliest-forming dentin in the first molar, consistent with a breast-feeding signature, where infants should be approximately one trophic-level higher than their mothers (Beaumont et al. 2013, 2015; Craig-Atkins et al. 2018; Eerkens et al. 2011; Eerkens and Bartelink 2013). During the weaning process, $\delta^{15}N$ values drop until reaching a local minimum when the individual was weaned. For both individuals, we estimate this was between 2.5 and 3.5 years of age. After weaning, both individuals stayed at relatively low $\delta^{15}N$ values, below 7.0‰ through age six years, but then $\delta^{15}N$ values increase during late childhood years. During teenage years, the male in particular shows a large increase in $\delta^{15}N$, reaching values even above the pre-weaning levels in late teenage years and early 20s, although this value drops markedly in his bone collagen, which formed at approximately 35 years of age. For both individuals, there is only minor variation in $\delta^{13}C$ (< 1.0‰).

Discussion

Overall, the $\delta^{13}C$ and $\delta^{15}N$ values from teeth and bone reflect a diet that was dominated by C_3 plant vegetal foods. Figure 3 plots the bone collagen values from *Yakmuy 'Ooyákma-tka* against a comparative sample of other roughly contemporaneous (Middle Period) sites in Central

California. Ellipses in Figure 3 are not statistically determined, but serve to highlight boundaries around individuals buried in, and presumably living in, major environmental contexts.

As shown, the *Yakmuy ʻOoyákma-tka* individuals are low for δ^{13}C and especially δ^{15}N. This is consistent with a high input of low trophic-level foods, such as plants, in the diet. As well, the generally low δ^{13}C values indicate a diet low in marine food, including shellfish and anadromous fishes. By contrast, individuals buried at sites along the Middle Sacramento River (CA-COL-3 and CA-SAC-43) are similarly low in δ^{13}C but much higher in δ^{15}N, mostly likely reflecting significantly higher consumption of freshwater fish versus plants (data from Talcott 2019). Middle Period individuals buried within 1km of the bayshore in the north San Francisco Bay at CA-SFR-191, within modern-day San Francisco, show much higher δ^{13}C and δ^{15}N, reflecting consumption of significant amounts of marine foods, including fishes and marine mammals. Finally, individuals buried in the middle of the San Francisco Peninsula (at *Yuki Kutsuimi Šaatoš Inūx*^{w}, CA-SCL-287) are somewhat intermediary between terrestrial and marine food consumers, though more like the former, suggesting a more mixed diet. *Yuki Kutsuimi Šaatoš Inūx*^{w}, like *Yakmuy ʻOoyákma-tka*, is situated inland, approximately 6km from San Francisco Bay. Thus, it not surprising individuals there have more of a terrestrial focus, as they do at *Yakmuy ʻOoyákma-tka*.

Together, the data presented in Figure 3 show significant isotopic differences between major environments in Central California during the Middle Period, highlighting the role that local ecology played in ancient dietary composition. Distance to San Francisco Bay seems to have been a major driver of access to bayshore resources, with sites even just 6km from San Francisco Bay showing significantly lower δ^{13}C than those right on the bay. The low δ^{13}C and δ^{15}N values at *Yakmuy ʻOoyákma-tka* also indicate that water-stressed plants, such as pine and

manzanita, did not have a major role in the diet during the majority of life stages (though see below for some slight variation among teenage females). In this respect, non-water-stressed plants likely contributed a major portion of the diet at *Yakmuy 'Ooyákma-tka*, including small seeds from annual plants such as grasses, acorns, and geophytes.

Isotopic values from the serial dentin samples indicate significant life-history patterning within the population, especially by age and sex. Figure 4 shows average δ^{15}N (upper half) and δ^{13}C (bottom half) values for males and females, with isotopic measures binned into 2-year intervals. This represents, then, something of the typical isotopic life history for males and females buried at the site. *T*-tests comparing male and female mean values within a particular age cohort with p-values less than 0.05 are indicated with a $*$ symbol.

As expected, δ^{15}N values are highest in the earliest forming tissues for both sexes, consistent with individuals gaining most of their protein from breastmilk. Shortly after this peak, δ^{15}N drops by about 1.4‰ and stays low during the remainder of the first decade of life. Throughout this earlier childhood sequence, male δ^{15}N values are significantly elevated relative to females by approximately 0.6-1.0‰. By comparison, with the exception of slightly higher δ^{13}C values for males in the earliest-forming dentin, δ^{13}C values fluctuate only slightly throughout this sequence, and largely overlap for males and females.

This pattern suggests that young boys, on average, consumed greater amounts of higher trophic level resources compared to young girls. This could reflect a greater proportion of meat in the diet of young boys as they were being weaned, while young girls consumed more plant-based foods. A similar pattern has been documented at other sites in the region such as CA-CCO-548 (Eerkens and Bartelink 2013), though still other sites (CA-SJO-112) show overlapping male-female childhood δ^{15}N values (Eerkens et al. 2017). These different patterns between sites

point to the effects of culture in sometimes promoting sex-biased dietary differences, while in other contexts fostering dietary equality (at least isotopically). Again, the lived experiences of people varies markedly by cultural context.

As a testable hypothesis, we suggest the male-female δ^{15}N offset in childhood (based on the M1 serial sequence) reflects enculturation practices within the *Yakmuy 'Ooyákma-tka* community. Boys under age 2-4 years may have been fed or encouraged to eat more meat. This meat may have served as a supplement to breastmilk intake, perhaps as a way to familiarize boys with meat (e.g., perhaps "priming" the gut microbiome; Roswall et al., 2021), or perhaps as symbolic prelude to their later role in life as hunters. After weaning, we suggest young boys were learning to become effective hunters by spending more time with adult male relatives, and young girls were learning to become effective gatherers by spending more time with adult female relatives (c.f., Bird and Bliege-Bird 2000, 2005; Lew-Levy et al. 2018; Leacock and Lee 1982; Marlowe 2007). During these formative years, boys and girls likely to consumed greater proportions of foods acquired during their respective hunting and gathering bouts, leading to different isotopic values in tissues formed at those times. Behaviors, such as in-field food consumption during hunting or gathering bouts, or sex-biased sharing of food, could account for these differences.

During the second decade of life, the opposite trend emerges (based on the M3 serial sequences). δ^{15}N values converge for males and females, indicating similar trophic position. Note that it is primarily females that increase in their δ^{15}N values, rather than males dropping. This indicates that females had greater access to meat during the second decade of life. By contrast, δ^{13}C values start to diverge for male and females between ages 10 and 18 years. Here

again, it is the female diet that is more dynamic, increasing by 0.2-0.5‰, while male δ^{13}C values stay more consistent with earlier childhood years.

The second decade of life is a major stage of transition in most small-scale communities. It is the time when many males and females are married and begin to establish independent households. A cross-cultural summary of hunter-gatherers shows that the mean age of marriage for women is between 12 and 18 years, and the mean age at first birth varies from 15.9 to 22.8 years (Kelly 1995:245-246). We cannot know the exact age that *Yakmuy 'Ooyákma-tka* men and women were marrying, of course, nor their age at first pregnancy. However, a number of cultural processes, well-documented in other small-scale societies could explain the shifting male-female isotopic values at *Yakmuy 'Ooyákma-tka*.

First, rising δ^{15}N among females around age 9 years of age could indicate that women were doing some hunting of game or fishing around this age, and that they were eating more of the spoils from such activities. Such hunting could include capture of game fortuitously encountered during gathering activities. Second, the converging male-female δ^{15}N values could be the result of a formal brideservice system. Partners may have been chosen for people at a young age, but before formal marriage and establishment of independent households men could have been performing brideservice over a number of years for their to-be partner and her family (see Collier 1988). Brideservice may have included providing the spoils of hunting bouts to the families of younger females, much of which could have been consumed by the brides-to-be. This could explain the rise in female δ^{15}N around 9 years of age, which is earlier than marriage in most documented and modern hunting and gathering societies. Third, it is possible that families could have been preparing young females for marriage by feeding them higher amounts of game. Thus, once a girl had been promised in marriage, families may have felt obligated to feed her

more protein. Alternatively, perhaps girls were learning to prepare and cook meat at this time, in preparation for future domestic activities, providing opportunities to ingest a larger portion of the meal (i.e., experimenting with different cooking techniques). Fourth, it is possible that a feeding order existed within *Yakmuy 'Ooyákma-tka* households, as is common in many small-scale Polynesian societies (e.g., Mead 1928). There, young girls are last to eat, leaving less meat and other desirable foods. As girls aged at *Yakmuy 'Ooyákma-tka*, they may have had greater access to meat by eating earlier during communal meals. Fifth, if young females did establish new households around age 10 years, rising δ^{15}N among females may indicate greater intra-household sharing of foods between these newly established couples, equilibrating average trophic position. Thus, newly married males may have been sharing more or all of their hunting take with their young spouses before they had significant numbers of children to also feed (and train). In any case, regardless whether obtained from spouses, families, the community at large, or through their own hunting activities, increasing intake of high-protein foods, such as meat, may have been important for females who were beginning reproduction and breastfeeding. Additional research and hypothesis testing is necessary to rule out or support some of these possible interpretations.

At the same time, the diverging M3 δ^{13}C values suggest the maintenance of distinct, sex-biased diets during teenage years. The higher δ^{13}C values are consistent with incorporation of greater amounts of either marine-derived foods in the diets, or water-stressed plants, of late adolescent and young adult females. If they were marine foods, given the low absolute δ^{15}N values (below 8‰), these must have been the lowest trophic-level marine foods, such as shellfish or small fishes. We consider this interpretation less likely given the 25km walk to the bayshore, a considerable distance for daily foraging bouts or regular trade of food items. Instead, we believe

it more likely that females were consuming higher amounts of particular plants that are elevated in δ^{13}C, such as pine nuts (but not acorns and seeds from annual plants). Plants that are periodically water-stressed show slightly elevated δ^{13}C in their tissues, typically 1-3‰ higher (Eerkens et al. 2020; Picon et al. 1996; Van de Water et al.2002), an amount within the range documented at *Yakmuy 'Ooyákma-tka*. Whether marine or water-stressed plants, the 0.2-0.5‰ elevated M3 values in females indicate greater consumption of foods derived from these sources. Unfortunately, the lack of excavation in midden contexts at the site precludes knowing if shellfish and marine or brackish-water fish, or pine nuts, were common at the site.

Finally, the bone collagen data show that adult diets after the age of 18 years differed from the second-decade of life, especially in their lower δ^{15}N values. This suggests that both males and females dropped back down in trophic position as they aged beyond 22 years. For many older individuals in the *Yakmuy 'Ooyákma-tka* sample (e.g., age 40+), this would have been after they finished raising their own families. It is likely that hunting returns decreased for more elderly males (Gurven et al., 2006), or alternatively, that more mature males were obligated to share more of their catch within their extended families and the community at large, leaving less for themselves and their aging spouse(s). Interestingly, female bone collagen δ^{13}C values also decrease, closer to male bone collagen and female M1 dentinal collagen values, suggesting that whatever high-δ^{13}C foods females were eating in their second decade, this resource was consumed in much smaller amounts later in life.

Conclusions

Compared with previous studies at other contemporaneous sites in the northern San Francisco Bay area, *Yakmuy 'Ooyákma-tka* inhabitants show low δ^{13}C and δ^{15}N values in bone collagen.

This signature is most consistent with a diet heavy in C_3 plant food (e.g., primarily vegetarianism), with only a small contribution of game and marine resources.

Within this plant-heavy diet, we also document significant ontogenetic variation in the diets of individuals buried at *Yakmuy 'Ooyákma-tka*. Much of this variation seems to correlate with biological sex. During early childhood, between ages 1 and 9 years, males are elevated relative to females in $\delta^{15}N$. This indicates that young boys consumed greater amounts of meat than females. We suggest this reflects a pattern of early sex-biased enculturation (Eerkens and Bartelink 2013), wherein younger girls spent more time learning to gather with adult females and boys spent more time learning to hunt with other adult males. Consumption of greater amounts of the spoils of these activities while away from base camps on gathering and hunting bouts could account for these sex-based differences. Alternatively, back at base camps, girls may have been encouraged to prepare and consume more plant foods, perhaps as a way to become familiar with plant food preparation and/or to connect with plants symbolically or spiritually. Likewise, boys may have been encouraged to eat more meat in their younger years, perhaps as a way to become familiar with meat or to connect to animals in a more symbolic or spiritual manner.

During the second decade of life, females show a marked increase in $\delta^{15}N$ that largely overlaps with males. We suggest a number of hypotheses to explain these changes, all documented ethnographically in other small-scale societies. We argue that the most likely explanation is either the performance of brideservice activities on the parts of young males, providing their to-be bride and her family with a new supply of meat, or reflect the formation of new nuclear households, wherein newly married couples were pooling and sharing meat within the household before they themselves had (many) children. Such meat could have been acquired from the community at large, for example as gifts, or could have been acquired by the couple

themselves in foraging activities. A slight difference in $\delta^{13}C$, wherein females are elevated, suggests young women consumed greater amounts of marine-derived protein, likely in the form of shellfish and/or small-bodied fishes, or ^{13}C-enriched plant foods, such as pine nuts and manzanita berries.

During later adulthood, the pattern reverses again, where $\delta^{13}C$ is similar between the sexes, but males are elevated in their $\delta^{15}N$ values. This suggests that adult males, again, consumed greater amounts of meat relative to females, perhaps as they were training younger male children of the next generation in the practice of hunting. Likewise, adult females may have teaching younger girls their gathering skills, and in the process increasing their intake of field-acquired plant foods.

The isobiographies documented at *Yakmuy 'Ooyákma-tka* mirror patterns we have documented at some other sites and time periods in Central California (e.g., Eerkens and Bartelink 2013; Greenwald et al., 2016; Harold et al., 2016). This suggests that some aspects of life history, child rearing, and cultural transmission were widely shared over time and culture(s). In the future, we hope to test some of the explanatory hypotheses proposed here at other sites, in collaboration with our tribal partners. For example, studies using strontium isotopes might highlight individual mobility life histories, which could allow us to test whether males were performing brideservice by staying in new villages. With tribal permissions, these future collaborative efforts will potentially allow their relations with the past to inform us about diverse aspects of their unique life histories. The results will provide descendant Native communities with a more individual-based and humanistic reconstruction of behaviors discerned at their ancestral heritage sites, while concurrently providing the scientific community with a richer picture of ancient lifeways in small-scale societies.

Acknowledgments

We thank the Muwekma Ohlone Tribe of the San Francisco Bay Area for supporting the research, Dave Grant and Diane DiGiuseppe for assistance with some skeletal samples, and Joy Matthews of the UC Davis Stable Isotope Facility for help in running samples. Research was completed, in part, using funding from the National Science Foundation (grant #BCS-2021256 to JWE).

Received 27 January 2022; accepted for publication 16 June 2022.

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Table 1. Demographic Information, Mortuary Data, and Elements Analyzed for Individuals from *Yakmuy 'Ooyákma-tka* Included in This Study

Ind.	Sex	Age	Position	Orient.	Grave Goods	Elements Analyzed
1A	Female	40+ years	Indet.	Indet.		Mandible, LLM1, LLM3
2	Indet.	Indet.	Seated	38		Long bone fragment
3	Indet.	Indet.	Indet.	Indet.		Femur fragment
4	Indet.	40+ years	Flexed	0		Fibula LLM1, LLM2
5	Indet.	6-9 years	Indet.	Indet.		Mandible and Femur
6A	Indet.	3-5 years	Indet.	Indet.		Mandible
6B	Indet.	0-3 years	Indet.	Indet.		Cranium and Rib
6C	Indet.	Juvenile	Indet.	Indet.		Cranium
7	Female	40+ years	Indet.	Indet.		Mandible, ULM1, LLM3
8	Male	30-39 years	Flexed	355		Mandible, LLM1
9	Male	20-29 years	Flexed	180		Mandible LRM1, URM3
10	Female	Adult	Flexed	Indet.		Humerus
11	Male	30-39 years	Flexed	180	2 G2a beads; 18 Abalone	Fibula, ULM1, URM3
12	Male	30-39 years	Flexed	240		Mandible LLM1, LLM3
13	Female	40+ years	Flexed	Indet.		ULM1, Unsided M3
14A	Male	20-30 years	FD Ext.	270	5 G2 beads	Mandible, LLM1, LLM3
14B	Male	25-34 years	FD Ext.	270		Mandible, LLM1, LLM3
15	Female	40+ years	Flexed	355	8 G-series beads	Mandible, LRM1, LRM3
16	Male	55+ years	Flexed	220		Mandible, ULM1
17	Female	30-39 years	Indet.	Indet.	2 Dart points	Maxilla, ULM1, ULM3
18	Male	40+ years	Flexed	225		Mandible, LLM1, ULM3
19A	Indet.	40+ years	Indet.	Indet.		Lower Long Bone
19B	Indet.	Indet.	Indet.	Indet.		Lower Long Bone
20	Male	30-39 years	Flexed	290		Rib, LRM1, LLM3

21	Male	30-39 years	Flexed	270		Rib, URM3
22	Indet.	Newborn	Indet.	Indet.		Rib
ISO10/11	Indet.	Adult	Indet.	Indet.		Humerus
ISO1	Indet.	Adult	Indet.	Indet.		Ulna
ISO2	Indet.	Adult	Indet.	Indet.		Long Bone
ISO3	Indet.	Adult	Indet.	Indet.		Femur
ISO4	Indet.	Adult	Indet.	Indet.		Cranium
ISO8	Indet.	Adult	Indet.	Indet.		Long Bone
ISO9	Indet.	Juvenile	Indet.	Indet.		Humerus

Note: ISO represents the isolated elements; FD Ext. = Face Down Extended; Indet. = Indeterminate

Table 2. Bone Collagen $\delta^{13}C$ and $\delta^{15}N$ Values, and AMS Dates, for Individuals from *Yakmuy 'Ooyákma-tka*

Burial ID	$\delta^{13}C_{col}$	$\delta^{15}N$	C/N	$\delta^{13}C_{ap}$	% Marine	AMS BP	Median calib AMS (95% CI)
1A	-19.3	6.9	3.3	-14.5	14	1243 ± 20	AD 934 (776-1010)
2				-11.7	n/a		
3	-19.5	6.6	3.3	-11.5	13		
4	-20.1	6.9	3.3	-12.9	9	1158 ± 20	AD 971 (894-1022)
5	-18.3	9.1	3.3	-14.1	20		
6A	-19.3	6.3	3.3	-12.3	14	1009 ± 21	AD 1171 (1046-1225)
6B	-19.3	7.6	3.3	-12.7	14		
6C	-19.4	7.0	3.3	-13.2	13		
7	-19.4	6.6	3.3	-14.9	13	1133 ± 20	AD 1019 (977-1150)
8	-19.7	7.1	3.3	-13.8	11		
9	-19.5	7.5	3.3	-14.6	13	1093 ± 29	AD 1087 (995-1158)
10	-19.7	7.2	3.3	-12.6	11		
11	-19.5	7.5	3.3	-14.2	13		
12	-20.0	7.9	3.3	-14.9	9	1185 ± 20	AD 994 (886-1009)
13	-19.2	7.0	3.2	-15.1	14		
14A	-19.2	7.0	3.3	-14.3	14	1210 ± 25	AD 959 (891-1021)
14B	-19.9	6.9	3.3	-14.9	10		
15	-19.9	6.2	3.4	-14.6	10	1130 ± 30	AD 1003 (894-1119)
16	-19.2	7.6	3.3	-13.9	14		
17	-19.3	8.3	3.3	-13.6	14	1260 ± 30	AD 919 (775-993)
18	-19.7	7.4	3.3	-14.4	12	1265 ± 23	AD 883 (775-977)
19A	-19.1	7.6	3.3	-12.5	15		
19B	-19.3	7.7	3.3	-13.3	14		
20	-19.1	7.9	3.2	-14.4	15	1186 ± 20	AD 996 (896-1034)

21	-19.4	8.5	3.3	-14.5	13	1090 ± 19	AD 1089 (1021-1156)
22	-19.0	7.4	3.3	-13.8	16		
ISO10/11	-20.2	6.2	3.2	-14.0	8		
ISO1	-19.6	7.6	3.3	-14.2	12		
ISO2	-19.4	7.9	3.3	-13.7	13		
ISO3	-19.7	7.1	3.3	-13.5	11		
ISO4	-19.4	7.6	3.3	-12.8	13		
ISO8	-19.6	7.3	3.3	-13.2	12		
ISO9	-18.9	7.7	3.3	-14.4	16		

Supplementary Table S1. Dentinal Serial Collagen δ^{13}C and δ^{15}N Values for Individuals from *Yakmuy 'Ooyákma-tka*

Indiv.	Tooth	Med. Age	δ^{13}C	δ^{15}N	C/N
1A	M1	0.8	-19.7	8.9	3.3
1A	M1	1.7	-19.6	8.0	3.3
1A	M1	2.6	-19.4	7.1	3.3
1A	M1	3.5	-19.6	6.7	3.3
1A	M1	4.4	-19.6	6.8	3.3
1A	M1	5.3	-19.4	6.7	3.3
1A	M1	6.2	-19.3	6.7	3.3
1A	M1	7.1	-19.4	6.9	3.3
1A	M1	8.4	-19.6	7.4	3.3
1A	M3	11.2	-20.1	7.5	3.4
1A	M3	12.4	-20.0	7.0	3.3
1A	M3	13.7	-20.0	7.1	3.3
1A	M3	15.0	-19.8	7.4	3.3
1A	M3	16.3	-19.9	7.3	3.3
1A	M3	18.9	-20.1	7.0	3.3
1A	M3	20.2	-19.9	7.1	3.3
1A	M3	21.5	-19.8	6.8	3.2
4	M1	3.6	-20.1	6.2	3.4
4	M1	4.7	-20.1	6.4	3.5
4	M1	5.8	-20.3	6.4	3.5
4	M1	6.9	-19.9	6.7	3.4
4	M1	8	-20.2	7.1	3.4
4	M2	7.9	-20.2	6.4	3.2
4	M2	8.8	-19.9	6.4	3.1
4	M2	9.7	-20.1	6.1	3.1
4	M2	10.6	-21.3	5.9	3.3
4	M2	11.5	-20.2	5.7	3.2
4	M2	12.4	-20.5	6.1	3.2
4	M2	13.3	-20.4	6.5	3.4
4	M2	14.2	-19.8	6.8	3.4
7	M1	1.3	-19.4	6.5	3.3
7	M1	1.9	-19.4	6.4	3.2
7	M1	2.5	-19.6	6.2	3.3
7	M1	3.1	-19.4	6.3	3.3
7	M1	3.7	-19.4	6.0	3.2
7	M1	4.3	-19.5	5.8	3.2
7	M1	4.9	-19.3	6.2	3.3
7	M1	5.5	-19.4	6.1	3.2
7	M1	9.1	-19.5	7.1	3.3
7	M1	8.5	-19.4	6.8	3.3
7	M1	7.9	-19.4	6.5	3.3
7	M1	7.3	-19.5	6.3	3.3
7	M1	6.7	-19.5	5.9	3.3
7	M1	6.1	-19.5	6.1	3.2

8	M1	1.4	-19.5	8.5	3.3
8	M1	2.1	-20.2	6.8	3.2
8	M1	2.8	-20.4	6.6	3.3
8	M1	3.5	-20.4	6.6	3.3
8	M1	4.2	-20.2	6.9	3.3
8	M1	4.9	-19.9	7.4	3.3
8	M1	5.6	-20.1	7.4	3.3
8	M1	6.3	-19.7	8.0	3.3
8	M1	7.0	-19.9	7.9	3.3
8	M1	7.7	-19.8	7.9	3.3
8	M1	8.4	-19.6	8.4	3.3
8	M1	9.1	-19.6	8.7	3.3
9	M1	0.6	-18.9	9.8	3.2
9	M1	1.4	-18.8	9.7	3.3
9	M1	2.2	-18.7	9.4	3.3
9	M1	3	-19.2	9.2	3.3
9	M1	3.8	-19.8	8.4	3.3
9	M1	4.6	-19.6	8.4	3.3
9	M1	5.4	-19.7	8.2	3.3
9	M1	6.2	-19.5	8.4	3.3
9	M1	7	-19.2	8.8	3.2
9	M1	7.8	-19.5	8.5	3.3
9	M1	8.6	-19.5	8.5	3.3
9	M3	9.5	-19.7	8.1	3.2
9	M3	10.5	-19.5	8.3	3.2
9	M3	11.5	-19.7	7.9	3.2
9	M3	12.5	-19.6	7.5	3.3
9	M3	13.5	-19.6	7.5	3.2
9	M3	14.5	-19.4	7.7	3.2
9	M3	15.5	-19.4	7.8	3.2
9	M3	16.5	-19.7	7.7	3.2
9	M3	17.5	-20.0	7.5	3.2
9	M3	18.5	-19.7	8.2	3.2
9	M3	19.5	-19.8	8.0	3.3
9	M3	20.5	-19.6	8.5	3.3
9	M3	21.5	-19.4	9.4	3.3
11	M1	1.5	-19.7	8.8	3.4
11	M1	2.5	-19.9	7.8	3.3
11	M1	3.5	-19.7	7.9	3.3
11	M1	4.5	-19.8	7.9	3.3
11	M1	5.5	-19.6	7.9	3.3
11	M1	6.5	-19.8	7.5	3.3
11	M1	7.5	-19.7	7.8	3.3
11	M1	8.5	-19.7	7.7	3.3
11	M3	9.5	-19.4	7.3	3.2
11	M3	11	-19.7	7.4	3.2
11	M3	12.5	-19.6	7.8	3.3
11	M3	14	-19.7	8.0	3.2
11	M3	15.5	-19.4	8.1	3.3

11	M3	17	-19.4	8.2	3.2
11	M3	18.5	-19.5	8.6	3.3
11	M3	20	-19.4	8.7	3.3
11	M3	21.5	-19.1	9.1	3.3
12	M1	1.6	-19.7	7.6	3.3
12	M1	2.2	-19.7	7.7	3.3
12	M1	2.9	-19.9	7.3	3.3
12	M1	3.5	-20.0	7.2	3.3
12	M1	4.2	-20.2	7.1	3.3
12	M1	4.8	-19.9	7.3	3.3
12	M1	5.5	-19.8	7.3	3.3
12	M1	6.1	-19.6	8.1	3.3
12	M1	6.8	-19.5	8.3	3.3
12	M1	7.4	-19.7	8.7	3.3
12	M1	8.1	-20.2	7.8	3.3
12	M1	8.7	-19.9	8.4	3.3
12	M3	9.8	-19.6	8.2	3.2
12	M3	11.1	-19.6	8.1	3.2
12	M3	12.4	-19.1	9.1	3.2
12	M3	13.7	-19.4	8.9	3.3
12	M3	15	-20.2	8.5	3.3
12	M3	16.3	-20.2	8.5	3.3
12	M3	17.6	-20.1	8.5	3.3
12	M3	18.9	-19.7	8.8	3.2
12	M3	20.2	-19.6	9.3	3.2
12	M3	21.5	-19.6	9.3	3.2
13	M1	1.6	-20.2	7.5	3.3
13	M1	2.2	-19.8	7.2	3.3
13	M1	2.8	-20.0	7.2	3.2
13	M1	3.4	-20.1	7.1	3.2
13	M1	4	-20.0	7.2	3.2
13	M1	4.6	-20.1	7.3	3.3
13	M1	5.2	-19.2	8.1	3.3
13	M1	5.8	-19.9	7.7	3.3
13	M1	6.4	-19.9	7.6	3.3
13	M1	7	-19.9	7.5	3.2
13	M1	7.6	-19.5	7.3	3.3
13	M1	8.2	-19.6	7.8	3.3
13	M1	8.8	-19.6	8.0	3.3
13	M3	9.8	-19.7	7.0	3.2
13	M3	11.1	-19.3	7.7	3.2
13	M3	12.4	-19.4	8.1	3.3
13	M3	13.7	-19.4	7.5	3.2
13	M3	15	-19.1	7.8	3.3
13	M3	16.3	-19.3	7.4	3.2
13	M3	17.6	-19.3	7.6	3.2
13	M3	18.9	-19.4	7.1	3.2
13	M3	20.2	-19.3	7.3	3.3
13	M3	21.5	-19.5	7.8	3.3

14A	M1	0.5	-18.0	10.9	3.3
14A	M1	1.3	-18.6	9.9	3.3
14A	M1	2.1	-19.8	9.3	3.3
14A	M1	2.9	-19.6	8.6	3.3
14A	M1	3.7	-19.1	8.6	3.3
14A	M1	4.5	-19.2	8.6	3.3
14A	M1	5.3	-19.1	8.3	3.3
14A	M1	6.1	-19.1	8.3	3.3
14A	M1	6.9	-19.1	8.5	3.3
14A	M1	7.7	-19.4	8.3	3.3
14A	M1	8.5	-19.4	8.2	3.3
14A	M3	9.1	-19.7	7.5	3.2
14A	M3	10.2	-19.7	7.5	3.2
14A	M3	11.2	-19.8	7.8	3.3
14A	M3	12.3	-19.8	7.7	3.3
14A	M3	13.3	-19.7	7.8	3.2
14A	M3	14.4	-19.6	7.7	3.2
14A	M3	15.4	-19.6	7.4	3.2
14A	M3	16.5	-19.2	7.6	3.2
14A	M3	17.5	-18.9	8.1	3.2
14A	M3	18.6	-18.9	8.0	3.2
14A	M3	19.6	-19.0	8.0	3.2
14A	M3	20.7	-19.2	8.0	3.3
14A	M3	21.7	-19.5	8.1	3.2
14B	M1	0.7	-18.2	10.4	3.2
14B	M1	1.2	-18.5	10.0	3.2
14B	M1	1.7	-19.3	9.2	3.2
14B	M1	2.2	-18.8	9.5	3.3
14B	M1	2.7	-18.4	9.0	3.2
14B	M1	3.2	-18.7	9.0	3.2
14B	M1	3.7	-18.6	9.0	3.2
14B	M1	4.2	-18.3	9.2	3.3
14B	M1	4.7	-18.2	9.1	3.3
14B	M1	5.2	-18.2	9.1	3.2
14B	M1	5.7	-18.9	8.5	3.2
14B	M1	6.2	-19.6	8.2	3.3
14B	M1	6.7	-20.0	8.3	3.3
14B	M1	7.2	-20.1	8.4	3.3
14B	M1	7.7	-19.8	8.3	3.3
14B	M1	8.2	-19.6	8.1	3.3
14B	M1	8.7	-19.6	8.0	3.2
14B	M3	8.3	-19.5	8.6	3.3
14B	M3	9.2	-19.8	7.9	3.2
14B	M3	10.1	-19.7	8.2	3.2
14B	M3	11	-19.8	7.8	3.2
14B	M3	11.9	-19.8	7.7	3.2
14B	M3	12.8	-19.7	7.5	3.2
14B	M3	13.7	-19.7	7.3	3.3
14B	M3	14.6	-19.7	7.4	3.2

14B	M3	15.5	-19.9	7.3	3.2
14B	M3	16.4	-20.2	7.3	3.2
14B	M3	17.3	-20.1	7.6	3.2
14B	M3	18.2	-20.1	8.0	3.2
14B	M3	19.1	-19.9	7.8	3.2
14B	M3	20	-19.7	7.8	3.3
14B	M3	20.9	-20.1	7.6	3.4
14B	M3	21.8	-19.4	8.1	3.3
15	M1	0.5	-19.2	9.8	3.3
15	M1	1.1	-19.3	9.2	3.2
15	M1	1.7	-19.0	9.3	3.2
15	M1	2.3	-19.0	9.1	3.2
15	M1	2.9	-19.5	8.4	3.2
15	M1	3.5	-19.9	7.7	3.2
15	M1	4.1	-19.9	7.5	3.2
15	M1	4.7	-19.9	7.5	3.3
15	M1	5.3	-19.8	7.3	3.2
15	M1	5.9	-19.9	7.2	3.2
15	M1	6.5	-20.0	7.1	3.2
15	M1	7.1	-19.8	7.3	3.2
15	M1	7.7	-19.7	7.5	3.3
15	M1	8.3	-19.7	7.6	3.2
15	M1	8.9	-19.7	7.4	3.2
15	M3	9.1	-19.5	6.9	3.3
15	M3	10.2	-19.3	7.1	3.3
15	M3	11.2	-19.4	6.6	3.3
15	M3	12.3	-19.4	6.8	3.3
15	M3	13.3	-19.2	7.3	3.3
15	M3	14.4	-19.4	7.2	3.3
15	M3	15.4	-19.3	7.2	3.3
15	M3	16.5	-19.4	6.8	3.4
15	M3	17.5	-19.6	6.8	3.3
15	M3	18.6	-19.6	6.8	3.3
15	M3	19.6	-19.6	6.8	3.3
15	M3	20.7	-19.3	7.3	3.3
15	M3	21.7	-19.6	7.2	3.4
16	M1	2.5	-19.4	7.5	3.3
16	M1	3.1	-19.4	7.7	3.3
16	M1	3.7	-19.6	8.1	3.3
16	M1	4.3	-19.4	7.9	3.3
16	M1	4.9	-19.3	7.5	3.3
16	M1	5.5	-19.8	7.3	3.3
16	M1	6.1	-19.6	7.2	3.3
16	M1	6.7	-19.5	7.6	3.3
16	M1	7.3	-19.4	7.7	3.3
16	M1	7.7	-19.7	7.9	3.3
16	M1	8.5	-19.6	8.1	3.3
17	M1	2.2	-19.4	7.8	3.3
17	M1	2.9	-19.3	7.7	3.3

17	M1	3.5	-19.3	7.4	3.3
17	M1	4.2	-19.4	7.4	3.3
17	M1	4.8	-19.7	7.4	3.3
17	M1	5.5	-19.3	7.1	3.3
17	M1	6.1	-19.2	7.0	3.3
17	M1	6.8	-19.3	7.0	3.3
17	M1	7.4	-19.4	7.1	3.3
17	M1	8.1	-19.5	7.0	3.3
17	M1	8.7	-19.6	7.0	3.3
17	M3	9.4	-19.6	8.1	3.3
17	M3	10.5	-19.4	8.1	3.3
17	M3	11.6	-19.2	8.5	3.3
17	M3	12.7	-19.2	8.4	3.3
17	M3	13.8	-19.0	8.3	3.3
17	M3	14.9	-18.4	9.2	3.3
17	M3	16	-18.4	9.3	3.3
17	M3	17.1	-18.6	9.4	3.3
17	M3	18.2	-18.7	9.3	3.3
17	M3	19.3	-18.3	9.6	3.3
17	M3	20.4	-19.0	9.3	3.3
17	M3	21.5	-19.5	9.4	3.3
18	M1	1.2	-19.5	8.7	3.3
18	M1	1.8	-19.8	8.1	3.3
18	M1	2.4	-20.2	7.7	3.3
18	M1	3	-20.2	7.1	3.3
18	M1	3.6	-20.3	7.0	3.3
18	M1	4.2	-20.1	7.4	3.3
18	M1	4.8	-20.1	7.2	3.3
18	M1	5.4	-20.2	7.3	3.3
18	M1	6.0	-20.2	7.5	3.3
18	M1	6.6	-19.8	7.4	3.3
18	M1	7.2	-20.1	7.7	3.3
18	M1	7.8	-19.7	7.5	3.2
18	M1	8.4	-19.7	7.5	3.2
18	M1	9.0	-19.6	8.1	3.3
18	M3	9.4	-20.2	7.3	3.3
18	M3	10.6	-20.1	7.1	3.3
18	M3	11.8	-20.2	6.8	3.3
18	M3	13	-20.2	7.3	3.3
18	M3	14.2	-20.0	7.2	3.3
18	M3	15.4	-19.7	7.7	3.3
18	M3	16.6	-19.8	7.3	3.3
18	M3	17.8	-19.9	7.8	3.3
18	M3	19	-19.5	8.2	3.3
18	M3	20.2	-19.4	8.5	3.3
20	M1	0.5	-19.9	8.0	3.3
20	M1	1.1	-20.1	7.2	3.3
20	M1	1.8	-20.0	7.3	3.3
20	M1	2.4	-19.6	7.1	3.3

20	M1	3.1	-19.7	6.8	3.3
20	M1	3.7	-19.8	6.9	3.3
20	M1	4.4	-19.7	6.8	3.3
20	M1	5.0	-19.8	7.0	3.3
20	M1	5.7	-20.0	6.7	3.3
20	M1	6.3	-20.0	6.7	3.3
20	M1	7.0	-20.1	6.8	3.3
20	M1	7.6	-19.8	7.3	3.3
20	M1	8.3	-19.7	7.6	3.3
20	M1	8.9	-20.1	8.0	3.4
20	M3	10.0	-20.0	7.3	3.3
20	M3	10.9	-19.9	7.4	3.2
20	M3	11.8	-19.8	7.3	3.2
20	M3	12.7	-19.9	7.3	3.3
20	M3	13.6	-19.8	8.2	3.3
20	M3	14.5	-19.7	8.1	3.3
20	M3	15.4	-19.8	8.0	3.2
20	M3	16.3	-19.6	8.0	3.2
20	M3	17.2	-19.6	8.2	3.2
20	M3	18.1	-19.5	8.2	3.3
20	M3	19.0	-19.5	7.8	3.3
20	M3	19.9	-19.6	8.8	3.3
20	M3	20.8	-19.8	8.8	3.3
20	M3	21.7	-19.4	8.9	3.3
21	M3	10.0	-19.8	7.3	3.2
21	M3	10.9	-19.6	7.2	3.2
21	M3	11.8	-19.8	7.5	3.2
21	M3	12.7	-19.9	7.6	3.2
21	M3	13.6	-20.0	7.5	3.3
21	M3	14.5	-20.2	7.1	3.3
21	M3	15.4	-19.8	7.6	3.2
21	M3	16.3	-19.7	7.6	3.3
21	M3	17.2	-19.8	8.1	3.3
21	M3	18.1	-19.9	7.8	3.3
21	M3	19.0	-19.5	8.0	3.3
21	M3	19.9	-20.2	8.1	3.3
21	M3	20.8	-20.3	8.2	3.3
21	M3	21.7	-19.5	8.8	3.3

Figure Captions

Figure 1. Location of *Yakmuy ‘Ooyákma-tka* and other sites mentioned in the text.

Figure 2. Dietary life histories for two individuals from *Yakmuy ‘Ooyákma-tka*.

Figure 3. Comparison of C and N stable isotopes from *Yakmuy ‘Ooyákma-tka* vs. a selection of other regional sites.

Figure 4. Reconstructed sex-biased dietary life histories for males vs. females at *Yakmuy ‘Ooyákma-tka*.

Figure 1.

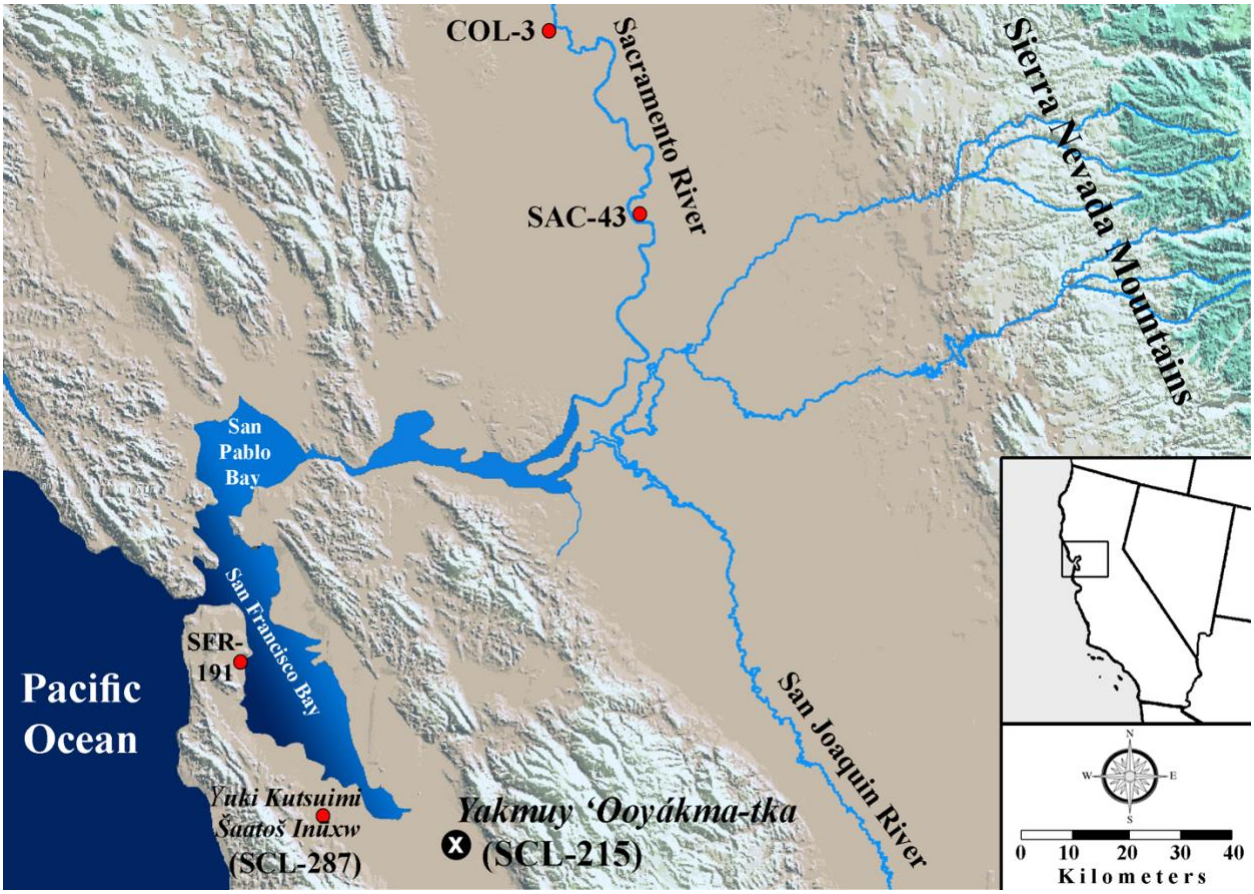


Figure 2.

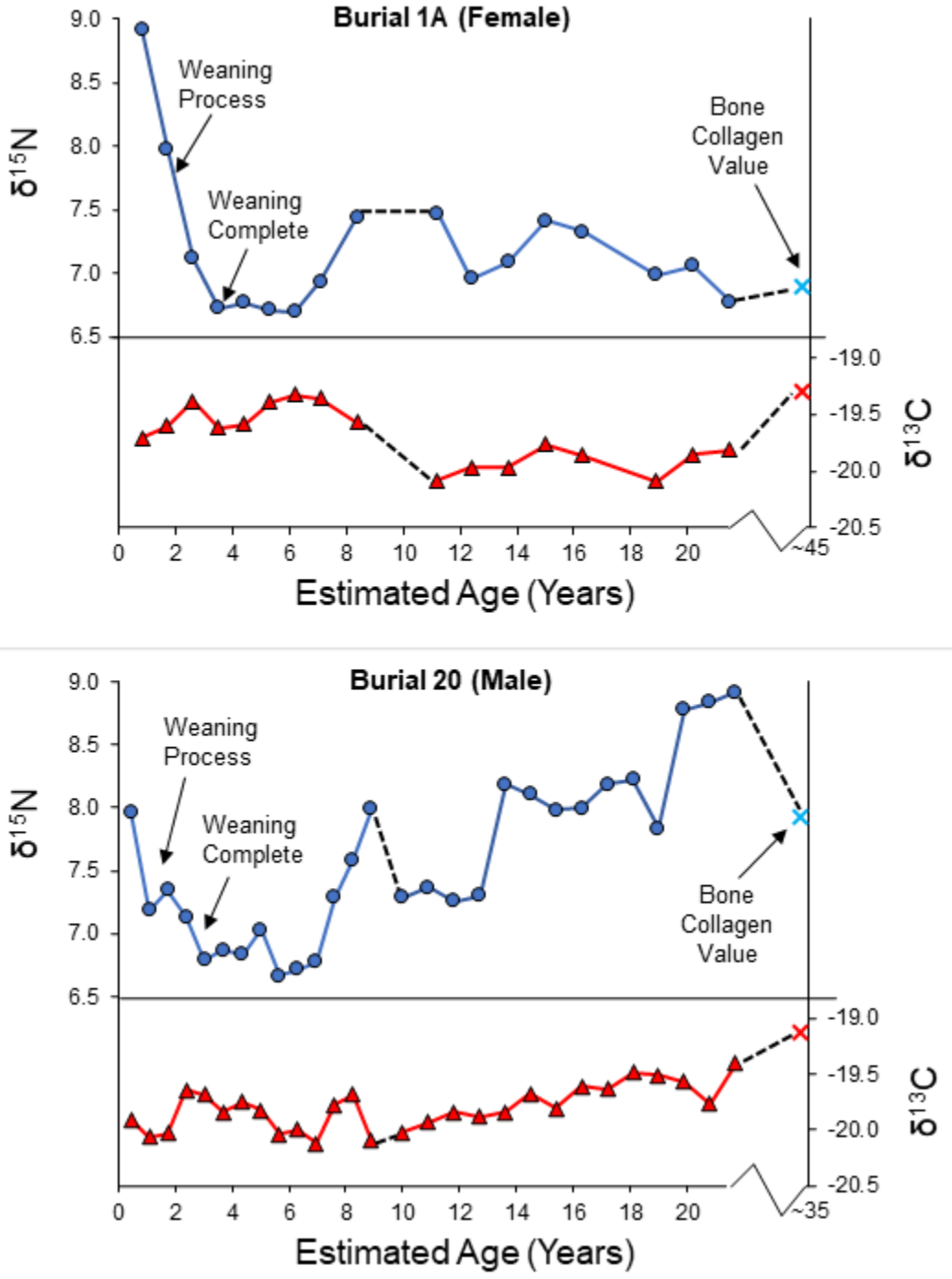

Burial 1A (Female)
Weaning Process
Weaning Complete
Bone Collagen Value
δ15N
δ13C
Estimated Age (Years)
Burial 20 (Male)
Weaning Process
Weaning Complete
Bone Collagen Value
δ15N
δ13C
Estimated Age (Years)

Figure 3.

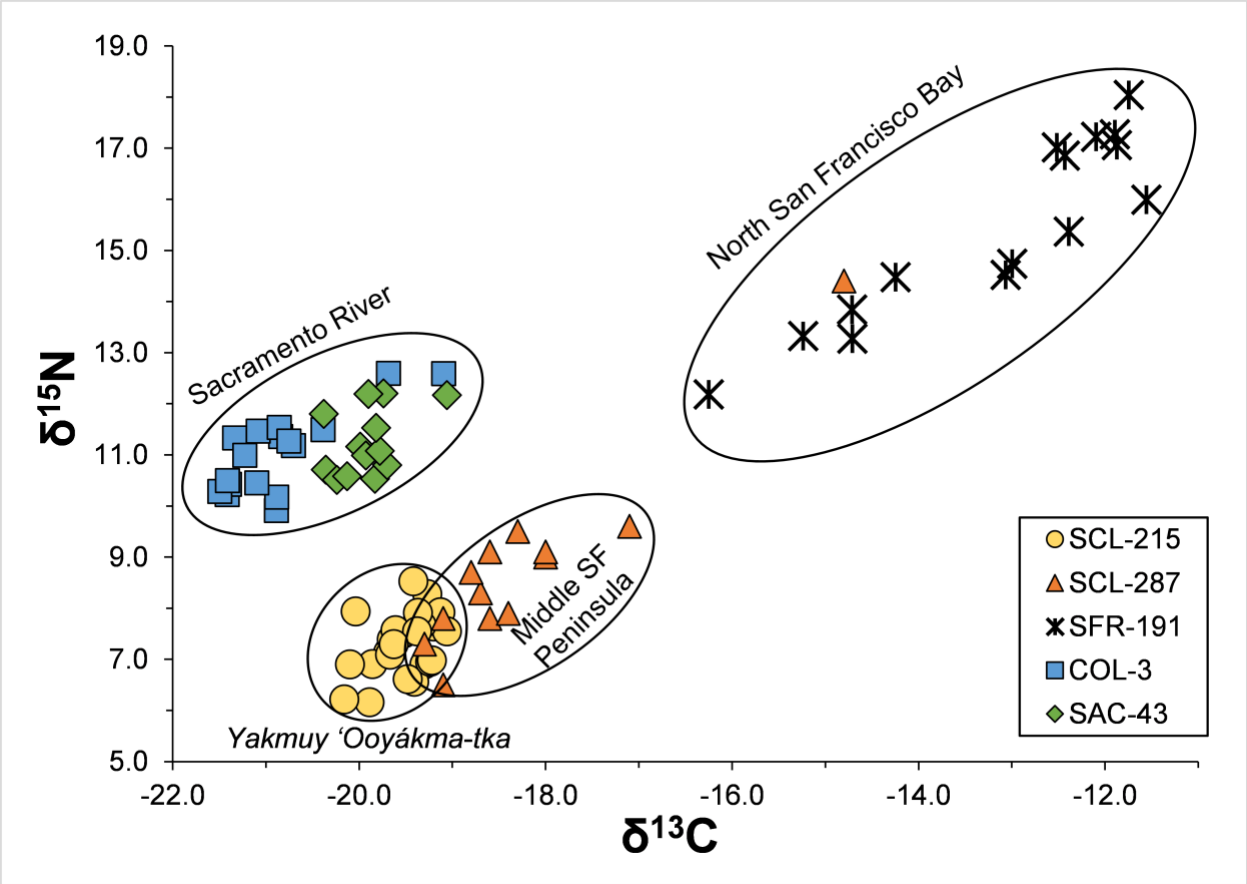
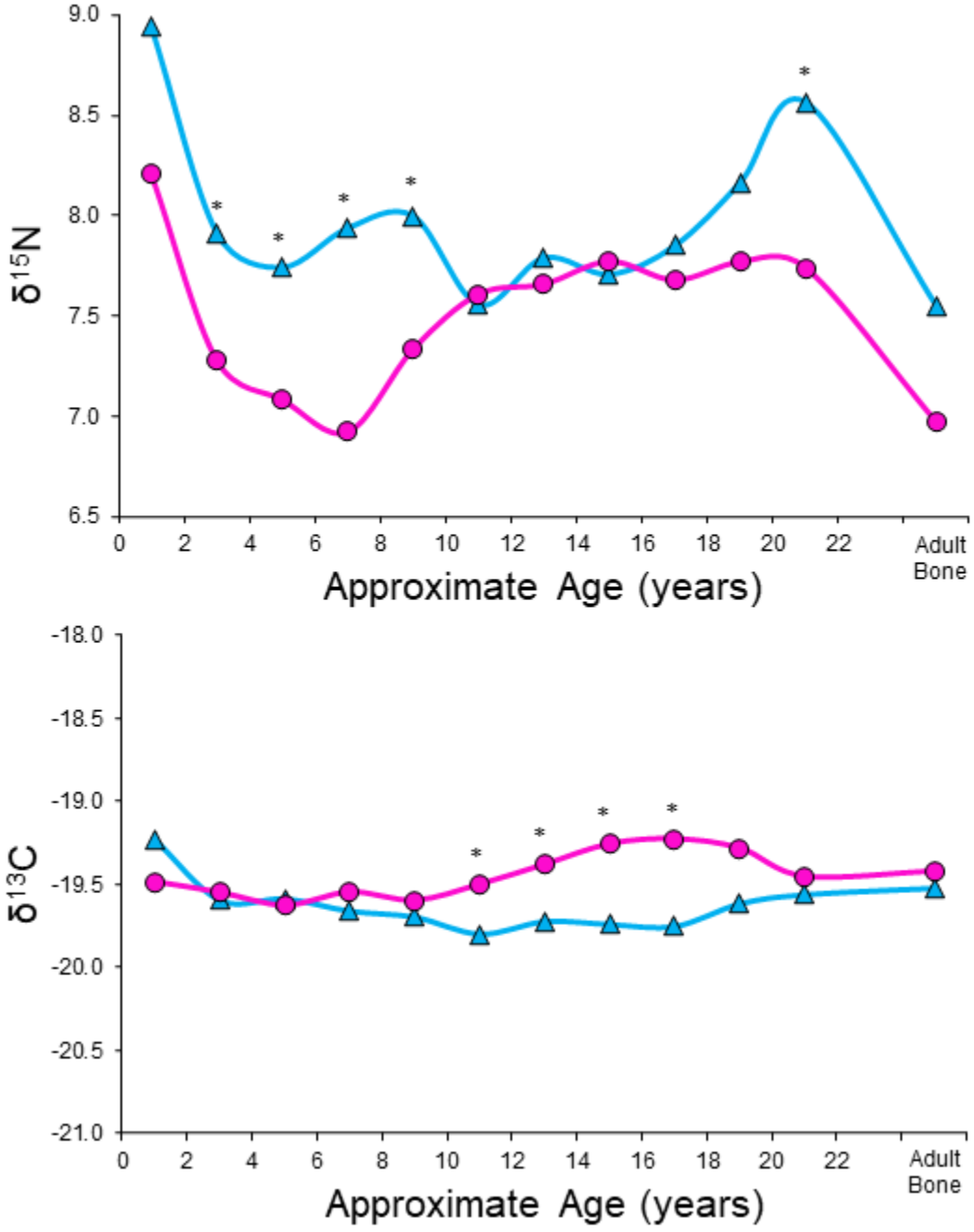


Figure 4.


9.0
8.5
8.0
7.5
7.0
6.5
δ15N
0
2
4
6
8
10
12
14
16
18
20
22
Adult Bone
Approximate Age (years)
-18.0
-18.5
-19.0
-19.5
-20.0
-20.5
-21.0
δ13C
0
2
4
6
8
10
12
14
16
18
20
22
Adult Bone
Approximate Age (years)