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STABLE ISOTOPE ANALYSIS OF HUMAN REMAINS FROM THE EARLY CONTACT PERIOD SITE OF

LA CAPILLA DEL NIÑO SERRANITO AT LA CAPILLA SANTA MARÍA MAGDALENA DE ETEN

by

LESLIE E. BROWN

Under the Direction of Bethany L. Turner-Livermore

ABSTRACT

Oxygen and carbon stable isotope analyses of bone and tooth enamel carbonate were conducted on a subset of the burial population (n = 17) of the La Capilla de El Niño Serranito of the La Capilla Santa María Magdalena de Eten site in the Lambayeque Valley of Peru. The individuals sampled display oxygen stable isotope ($\delta^{18}O_{dw(V\text{-}SMOW)}$) values consistent with higher altitude $\delta^{18}O_{dw(V\text{-}SMOW)}$ levels. Carbon stable isotope ($\delta^{13}C_{(VPDB)}$) values for the individuals sampled are consistent with C_4 and potentially marine-based food sources. The results of the stable isotope analyses, when combined with elements from the site-specific archaeological and bioarchaeological data, provide a more comprehensive view of the lives and identities of the individuals examined.

INDEX WORDS: Muchik, Sicán, Chimú, Inka, Stable Isotope, Carbonate, Carbon, Oxygen, Lambayeque, La Capilla Santa María Magdalena de Eten, La Capilla de El Niño Serranito

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LESLIE E. BROWN

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DEDICATION

The following work is dedicated to my three sons, David, Thomas, and Seth. Without their patience, love, and understanding such a project would not have been possible.

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1   INTRODUCTION

1.1   The Indigenous experience versus the European accounting at the Time of Contact

The personal narratives of individuals living in the pre- and early-contact period populations in Peru are frequently absent from or overwhelmed by the European (predominantly Spanish) chronicles related to the indigenous populations of the region (Livi-Bacci 2006:200; Myers 1974:138).   Despite the historical value of the European chronicles, there is a marked absence of the voice of the indigenous people of Peru contained within these historical records. The establishment of a more thorough understanding of the lives of the indigenous people of Peru, such as the Muchik, prior to and during the initial contact period with the Spanish is essential to gaining a more complete view of the socioeconomic, political, and cultural climate of the region prior to the initial contact of the indigenous populations with the Europeans. In the absence of indigenous ethnohistorical accounts of life before, during and after the Early Contact Period, archaeological and bioarchaeological analyses are the only way to provide these people with a voice.

For burial sites in which the geographic origin of the individual may be obscured due to the style of the mortuary treatment, bioarchaeological analyses permit some estimation of residential origin for the individual—are the individuals indigenous to the region or immigrants from another region, possibly even the Old World? These analyses may provide insight into the identities of the individuals that standard mortuary archaeological studies alone may fail to permit. Clarification of the potential geographic location of origin of an individual interred at an Early Contact Period burial site in Peru provides information about the overall demographics of

the region. Furthermore, bioarchaeological analyses can be employed to determine the potential dietary resources accessed by the individuals during their lifetime. When combined with information related to the possible geographic origin of an individual, diet estimation may permit interpretations of subsistence related to differential resource access within a community versus differential resource availability in distinct environments. Theories related to dietary resource access may provide a more complete view of the challenges faced by members of a community, potentially as a result of contact with Europeans.

The goal of this study is to reconstruct diet and determine potential residential origin for the individuals interred at the La Capilla del Niño Serranito (CSMME-CNS) in the Lambayeque Valley on the north coast of Peru. Based on analysis of mortuary styles at the site, the human remains sampled during this research are suspected to be of Muchik individuals, and the site is dated to the late pre-contact through early contact periods. Therefore, stable isotope-based estimations of potential geographic location of origin for these individuals will prove invaluable to better understanding the demographics of this ethnically-Muchik community. Furthermore, the dietary analysis of the individuals interred at the CSMME-CNS site permits some interpretation of dietary resources accessed by the individuals sampled as they may be considered representatives of the population as a whole.

1.2   Ethnicity, culture, and social identity: The Muchik

Ethnic identity, or ethnicity, is typically approached through a multifaceted approach incorporating elements of social group membership and cultural affiliation that must be refer-

enced within a framework of historic events (Barth 2010:409-411). Expressions of ethnic identity are not both culturally- and historically- dependent. During any given historical period, agent-mediated social change, as an expression of ethnic identity, may be overt or less readily apparent as subgroups of a culture may act as independent representatives for the preservation of their cultural beliefs (Klaus 2009:3; Barth 2010:409-411; Swenson 2007:254). As cultural affiliation is a key element in defining ethnicity, it must be recognized that such an affiliation can be used for the purposes of social expression in an effort to unify a particular group of individuals (Klaus 2009:2; Barth 2010:409-411). Such expressions of cultural affiliation or cultural identity can potentially result in increased levels of solidarity among a given social group (Klaus 2009:3; Barth 2010:409-411). Ethnic or cultural identity may be apparent in the archaeological record through presence of material remains; however, this is not always true. The post-processual view of artifacts is that they are "solid metaphors which link different cultural domains and construct meanings" (González-Ruibal et al. 2011:1). Analysis of material culture assists with the chronicling of objects—from their creation, manipulation, or transformation—as symbols that are representatives of a culture (Klaus 2009:3; González-Ruibal et al. 2011:1; Hodder 1982:212). Furthermore, within the post-processual framework, material culture is not merely a reflection of a society (González-Ruibal et al. 2011:1). Rather, it is intertwined with the constitution and transformation of a "social organization according to the strategies of groups, their beliefs, concepts and ideologies" (Hodder 1982:212).

Through the use of objects and symbols, a cultural group may foster a sense of ethnic identity, thereby strengthening the bonds of the social group and uniting the group as an act of cultural cohesion (Klaus 2009:3). Throughout the archaeological record of the Central Andes, a

wide array of evidence has been revealed relating to behaviors that may potentially be expressions of ethnic or cultural identity. In particular, the analyses of mortuary practices (e.g. Bourget 1998; Bower 1988,Centúrion 2010; Gaither and Murphy 2012; Huchet and Greenberg 2010; Klaus 2009; Klaus 2011;Millaire 2004; Sutter and Cortez 2005), iconography (e.g. Bauer 1996; Bernier 2009; Cordy-Collins 1992; Quilter 2002; Swenson 2005; Vaughn 2006)), architecture (e.g. Quilter 2002; van Gijseghem 2001), and diet and subsistence strategies (e.g. Billman 2002; Contreras 2010; Covey 2008; Dillehay et al. 2004; Finucane 2009; Finucane et al. 2006; Knudson 2009; Moseley 1975; Park 1983; Pozorski 1979; Pozorski and Pozorski 1979) have yielded valuable information related to the indigenous peoples of the region that are frequently underrepresented or misrepresented within the historical record.

Cultural identity is considered to be fluid as it may be manipulated by the social and historical context in which it is framed (Knudson and Stojanowski 2009; Klaus 2009:3). To determine "how and why social identities are born, flourish, change, and disintegrate" (Klaus 2009:3), methods of ethnogenesis analysis may be applied. Ethnogenesis studies focus on the evaluation of archaeological evidence in relation to the historical and regional perspective of a society in an effort to garner a more detailed understanding of expressions of ethnic identity within a given society that may be preserved archaeologically (Klaus 2009:3-4). The concept of ethnogenesis reaches beyond the definition of a new culture based on a shared social or linguistic background (Barth 2010: 409-411; Klaus 2010:4). Ethnogensis is best conceptualized as "a social and political struggle to create one of the key foundations of social operations—an enduring group identity—in contexts of radical change and discontinuity" (Klaus 2012:4). Such analyses are required to foster a more complete view of the ethnic and cultural affiliations of

individuals through the interpretation of the objects, symbols, and culturally-mediated behavioral practices preserved within the archaeological record (Klaus 2009:4).

Examination of mortuary variation within a region when framed by ethnogenesis analysis permits a more comprehensive understanding of the social actions surrounding the burial process (Klaus 2009:4). Many complex Andean societies that ruled over the Lambayeque Valley, such as the Sicán and Inka, engaged in burial rituals that were laden with markers of culturally-mediated actions (Klaus 2009:4). The burial rituals of complex Andean societies frequently reflect the beliefs, social organization, and ethnic or cultural identities of both the deceased as well as the living (Klaus 2009:4-5; Klaus 2012:5). Such burial rituals might have served as a platform for the expression of belief systems as well as an opportunity to demonstrate resistance to newly imposed political or religious structures, the latter of which were common in the Lambayeque Valley from the Middle Horizon through Early Colonial periods (Klaus 2009:5; Klaus 2012: 5). Examination of mortuary settings and the bioarchaeological assessment, particularly through stable isotope analysis, of the remains of the individuals themselves within a historical and regional contextual framework may permit the formation of broad theories of ethnogenesis or cultural continuity for a given group identity. To formulate theories related to the ethnogenesis of identity for a specific group within the archaeological record, it is critical to develop a thorough understanding regarding the historic background and regional context of the group prior to the examination of their behavior, objects or symbols.

One the primary examples of ethnogensis in Andean Peru uncovered through bioarcaehological analysis involves the Muchik culture that evolved over an extended period of time beginning during the Moche Period (Klaus 2012: personal communications). The Muchik

people were the descendants of the Moche cultural legacy; however, they appear to have been

a fundamentally different culture that, through processes of ethnogensis, crystallized around

A.D. 200-300 (Klaus 2012: personal communications). Throughout the north coast of Peru, but

particularly in the Lambayeque Valley, the Muchik became regionally embedded as a cultural

group that experienced change. They remained a distinct subculture throughout the subse-

quent periods of increasingly hegemonic and authoritarian rule from the Sicán Period (A.D. 750

-1375) to the period of Spanish Colonial rule (A.D. 1533 – 1824) (Klaus 2012: personal commu-

nications).

1.3   The use of bioarchaeological methods at a Muchik site

The use of bioarchaeological methods involving stable isotope analysis to determine the

possible geographic movement of individuals within a population and possible dietary re-

sources for the population was employed on a subset of the population interred within the

boundaries of the La Capilla del Niño Serranito (CSMME-CNS), a secondary chapel to La Capilla

Santa María Magdalena de Eten (CSMME), on the northern coast of Peru. In A.D. 1533, the in-

digenous Muchik population of the region near the modern day cities of Cuidad Eten and Puer-

to de Eten in the Lambayeque Valley of north coastal Peru likely first came into contact with the

Spanish (Klaus 2011:5). It was during this time that a Spanish Franciscan friar settled in the ar-

ea, established a Catholic mission church, and initiated a forced resettlement of the Muchik

people (Klaus 2011:5). The main CSMME chapel was constructed near the site of the original

A.D. 1533 mission church between A.D. 1560- 1580 under the auspices of the Spanish Francis-

can friars as a center for the forced indoctrination of the Muchik indigenous people into the Catholic faith (Centúrion 2010:10; Ramírez 2008:78). The original CSMME chapel was abandoned between the A.D. 1750s and 1760s as the colonial settlement of Eten disbanded; however, in A.D. 1776 a third chapel called La Capilla de El Niño Serranito (CSMME-CNS)was constructed at the site (Klaus 2012: personal communications; Klaus 2011:5). In June 2008, Haagen D. Klaus of Utah Valley University proposed the excavation and preservation of the Colonial Period churches at the CSMME site (Klaus 2012: personal communications).

Excavations at the CSMME sites were co-directed by Klaus and Peruvian archaeologist Jorge Alberto Centúrion as part of a project funded by the Unidad Ejecutora 004 Naylamp-Lambayeque, the Wenner-Gren Foundation, and Utah Valley University. The CSMME project involved the emergency excavation and salvage of the Colonial Period churches (Klaus 2012: personal communications; Centúrion 2010:3).

Archaeological evidence related to the architectural form of the main CSMME structure, particularly the evidence related to the use of both Spanish- and Muchik-style interior fresco paintings, indicates the presence of influences from both cultures within the architectural elements of the site (Centúrion 2010:32, 37). The structural appearance of the main CSMME structure is commensurate with the construction style of other Colonial Period churches within the region; however, the incorporation of Muchik-based stylistic and structural elements within the chapel highlights the influence of the Muchik within the region (Centúrion 2010:32, 37).

At the main CSMME site as well as the CSMME-CNS site, over 200 human burials have been recovered from individuals ranging in age from infant to adult. With the exception of four burials at the main CSMME site, all burials were performed in the Muchik style. The bodies of

the individuals were oriented on a south to north or north to south line with their skulls facing a westerly direction (Centúrion 2010:38). Furthermore, with the exception of three burials located at the CSMME-CNS site, all of the individuals appear to have been buried without garments, textiles, or other associated grave goods which is also commiserate with Muchik burial traditions (Centúrion2010:38). Within the CSMME-CNS site, there is an indication of the influence of the Christian burial tradition as noted by the placement of the arms flexed towards the solar plexus or crossed across the chest in all of the burials within this site (Centúrion 2010:38). The aforementioned placement of the arms was not observed in the burials at the main CSMME site indicating the potentially limited influence of the Christian burial traditions on the Muchik burial styles during the Early Contact Period as compared to the more apparent influence of the Christian burial traditions in the later burials at the CSMME-CNS site. For the individuals at the main CSMME site as well as the periphery CSMME-CNS site, the mortuary treatment of the individuals may be considered to be predominantly Muchik in nature; however, as the sites are considered to be Early Contact and Contact Period sites respectively, the geographic origin of the individuals interred at the sites should be questioned.

Of the over 200 burials from the CSMME and CSMME-CNS sites, 17 individuals were selected for stable isotope analysis Of the 17 individuals selected for analysis, 15 of the individuals selected yielded both tooth and bone samples, one individual yielded only a tooth sample, and one individual yielded only a bone sample. All individuals selected were recovered from Level 5 (50-60 cm below the surface) of the CSMME-CNS site. Due to the construction of two different chapels (A.D. 1533 and A.D. 1776) at the same location, it is possible that the individuals interred at the CSMME-CNS site may have been from either the Late Inka/Early Colonial Pe-

riods or well into the Colonial Period. All of the burials appear to have been performed in either a traditional Muchik style or in one that is primarily Muchik with elements of Christian hybridization; thus, it is difficult to date the burials solely from an archaeological or archaeothanatological perspective. Bioarchaeological analyses, particularly stable isotopic analyses, may assist with the determination of the potential origin of the individuals interred at the CSMME-CNS site that are suspected to be from an indigenous Muchik origin.

1.4   Stable isotope analyses

The stable isotopes examined from the CSMME-CNS human remains are oxygen ($^{18}O/^{16}O$, or $\delta^{18}O$) and carbon ($^{13}C/^{12}C$, or $\delta^{13}C$) in enamel carbonate. Typically, the enamel of permanent tooth crowns form during the first decade of life (with the exception of the third permanent molar) and, once formed, enamel is metabolically inert and does not regenerate. Thus, the examination of the ratios of stable isotopes incorporated into the enamel hydroxyapatite of a tooth provides information related consumed foods and water during to the early life of an individual, when the tooth crown was formed. Bone constantly remodels over the lifetime of an individual with a complete regeneration cycle typically occurring approximately once every decade. Consequently, examining the stable isotope ratios contained within the structural carbonate of bone apatite reflects consumed food and water during the last ten years of the life of the individual being sampled (Holden 2003:761; Turner et al. 2005:127; White et al. 2009:1527).

Stable oxygen isotopes contained within tooth enamel and bone are dependent on the individual's consumption of meteoric (rain) or geological (ground) water that has different isotopic signatures depending on the evaporative pressures and different hydrogeological processes of the local environment. The approximate geographic location of origin may be determined through the stable oxygen isotope examination of the tooth enamel. Such data may be compared to the stable oxygen isotope examination of the bone apatite that provides information related to the geographic location of an individual during the last decade of life. From the aforementioned data, information related to geographic mobility during the lifetime of an individual may be established.

1.5   Providing a scientifically-based narrative to the under-represented or misrepresented indigenous Muchik population during the late Pre-Hispanic and Early Contact Periods

Before archaeological excavation of Muchik-associated sites along the northern coast of Peru, the main accounts of the Muchik were primarily provided by Spanish colonial settlers within the region (Myers 1974:138; Ramírez 2008:78). Many of the Spanish colonialists sought to force the resettlement of the indigenous Muchik populations into tightly controlled colonial settlement communities with the goal of indoctrination in the Catholic faith as well as the forced extraction of indigenous labor (Centúrion 2010:10; Ramírez 2008:78). The socioeconomic collapse, and subsequent political destabilization, of the indigenous populations of Andean Peru may be linked to the labor extraction processes of the Spanish as well as the removal of the indigenous populations from their ancestral territories and placement into colonial settle-

ment communities as part of *reduccíon* policies (Klaus 2011:3-4; Klaus and Tam 2008:1). In the absence of definitive Muchik accounts of the resettlement events, religious conversion processes, and labor provisioning of the indigenous people under the control of the Spanish colonialists, the only historical evidence for such events is provided through the writings of the colonialists. Furthermore, there is a marked lack of historical accounts of the Muchik culture prior to the arrival of the Spanish colonialists. As the historical records of the Muchik peoples are either lacking or potentially sullied by the influence of the Spanish colonialist perception of the indigenous population, archaeological and bioarchaeological evidence must be presented to provide a narrative to the underrepresented or misrepresented indigenous Muchik group. The examination of material correlates of culture, such as ceramics and architecture, may provide information related to the temporal sequencing of Muchik settlements throughout the expanse of the Lambayeque Valley Complex. Furthermore, such evidence may provide information related to both the ethnogenesis and persistence of the Muchik cultural substratum from the Moche Period to the Colonial Period. However, material culture provides only indirect means of tracking population, movement, admixture, and resource utilization, and must be analyzed in concert with bioarchaeological analyses of associated human remains themselves (Turner 2008). Stable isotope analysis may be used to provide a more complete understanding of demographic or dietary resource trends within the population. The archaeological and bioarchaeological analysis of Muchik burial sites, such as CSMME and CSMME-CNS, may provide valuable information related to the culture that is absent from or lacking in the Spanish accounts of this region. Additionally, analyses of pre-Contact Period Muchik sites may permit the comparison of pre-Contact versus post-Contact immigration trends as well as dietary resource

shifts. The use of stable isotope testing to provide a scientifically-based narrative to the indigenous Muchik populations of the CSMME sitesis essential to enhancing the understanding of the Muchik during the socially and politically tumultuous time frame surrounding the Early Contact Period. Providing a narrative to the underrepresented or misrepresented indigenous Muchik population of the CSMME-CNS site through archaeological and bioarchaeological methods, particularly stable isotope analyses, is essential to the development of a more comprehensive view of the Muchik both before and during contact with Spanish colonialists.

2   THE DEVELOPMENT OF THE MUCHIK IDENTITY IN THE LAMBAYEQUE VALLEY, PERU

2.1   Development of Muchik Identity: The Cupisnique, Salinar, and Gallinazo contributions

The Muchik identity began to formally crystallize through processes of ethnogeneis between A.D. 200-300 during the Moche Period (A.D. 100-750); however, prior to this time period there were multiple cultures within the Lambayeque Valley Complex that contributed significantly to the cultural milieu of the Muchik identity. Following the Paleo-Indian occupation of the region, yet prior the Moche occupation, there were three main sociopolitical groups to rule the Lambayeque Valley—the Cupisnique, Salinar, and Gallinazo.

2.2   The Cupisnique

Between 1500 and 500 B.P., the Cupisnique society existed primarily in the Lambayeque Valley Complex along the northwestern coast of Peru; however, evidence of Cupsinique style art and religion has been found in the regions spanning from the La Leche/Lambayeque to the Chicama/Moche Valley Complexes (Klaus 1008:118; Klaus 2009:5; Klaus 2012:8). As early as the Cupsinique era, there may have been a geographic bipartition of the coastal region of Peru into northern and southern zones (Shimada 1994; Klaus 2008:106). The northern zone is defined by the Lambayeque Valley Complex with its arable land, large coastal river drainages, and complex ecology (Shimada 1994; Klaus 2012:8). The southern zone extends from the Chicama/Moche Valley Complex to the Casma Valley with the Jequetepeque Valley acting as a transitional region between the northern and southern zones as well as the highland region of Cajamarca (Klaus 2008:107). In addition to a geographic bipartition, each of the zones may have experienced a

cultural bipartition as well and sociopolitical heterogeneity may have been common (Klaus 2008:107). Although the underlying cause of the bipartition is unknown, it is suggested that the regions may have been the result of differential access to water resources and arable lands (Klaus 2008:107). Alternatively, it is suggested that the cultural bipartition and lack of sociopolitical heterogeneity may have been the result of "divergences… formally initiated by regional Cupisnique tribes or chiefdoms or during the following Salinar or Gallinazo cultures" (Klaus 2008:107).

It has been proposed that there may have been a centralized, religious-based authority for the Cupisnique populations capable of directing the creation and controlling the operation of large, civic-ceremonial centers that may have integrated the population of the society on an intra-valley, tribal level (Shimada 1994; Klaus 2008:119). The architectural style of the Cupisnique civic-ceremonial centers varies from small mound structures in the Zaña and Jequetepeque Valley to structures with elaborate colonnades as is observed in the Huaca de los Reyes of the Moche Valley (Shimada 1994; Klaus 2008:119). Akin to the relatively broad range of architectural styles among the Cupisnique society, there were differential burial treatments observed throughout the society (Klaus 2008:120). Such differentiation in burial treatments may be indicative of social hierarchies (Klaus 2008:120). The emergence of metallurgy during the Late Cupisqnique Period led to the production of gold objects, such as pendants and ear spools (Shimada 1994; Klaus 2008:120). It has been suggested that gold objects may have been used as markers of religious or social authority within the society (Klaus 2008:120).

Within this region, the Cupisnique society developed complex burial rituals focusing on the placement of red pigment on the face or body and the positioning of the body in an ex-

tended position aligned with a cardinal axis (Shimada 1994; Klaus 2009:5). Members of different social groups were interred within designated areas and frequently grave goods in the form of ceramic vessels adorned with religious motifs were associated with Cupisnique burials (Klaus 2009:5). A central theme of Cupisnique mythology that was often featured on ceramic vessels focused on a feline and an arachnid with anthropomorphized features that is often depicted holding a decapitated head (Klaus 2008:118). Despite the rich religious and social traditions of the Cupisnique, as illustrated through their burial rituals, the decline of the society began in 700 B.P. (Shimada 1994; Klaus 2008: 121). The reasons for the decline are not fully understood; however, it has been postulated that there may have been a sociopolitical destabilization in the region due to environmental factors, such as the effects of an El Niño Southern Oscillation (ENSO) event or a possible tsunami that would have directly affected the coast (Klaus 2008:121). Despite the eventual decline of the Cupisnique society, their cultural legacy remained present force along the north coast of Peru.

2.3   The Salinar

The Salinar society occupied the northern coast of Peru during the last half of the first millennium B.P. (Shimada 1994; Klaus 2008:122). The territory of the Salinar extended from the Piura and Lambayeque Valleys in the north to the Nepeña Valley in the south with the core region being focused in the Chicama, Moche, Virú, and Santa Valleys (Shimada 1994; Klaus 2008:122). Population centers for the Salinar were typically established on the hillside and mid-valley areas of the coastal valleys (Shimada 1994; Klaus 2008:122). Although the Salinar occupied roughly the same territory as the Cupisnique, the societies were fundamentally different;

however, some elements of a potential cultural hybridization between the two societies have been revealed within the archaeological record (Shimada 1994; Klaus 2008:122). As evidenced through Cupisnique-style stirrup-spout ceramic vessels featuring Salinar-style decorative motifs and techniques, a cultural hybridization, at least on an artistic level, may be observed (Shimada 1994; Klaus 2008:122).

Although forms of cultural hybridization, as reflected in the art of the Salinar, may have occurred with respect to the Cupisnique culture, it is postulated that there may have been social strife present in the interactions between the indigenous populations of the region (likely Cupisnique descendants) and the intrusive Salinar (Shimada 1994; Klaus 2008:123). Competition for natural resources within the region may have resulted in stressful interchanges between the Cupsinque-descendant indigenous groups and the Salinar leading to the need for a measure of societal separation (Shimada 1994; Klaus 2008:123). Based on the construction of the first fortified structures in the region during the Salinar era, there is speculation that these structures may be indicative of social or political tensions between the indigenous populations and the Salinar (Shimada 1994; Klaus 2008:123). Although further archaeological and bioarchaeological research is required to clarify the role of the Salinar, it is clear that the Salinar society is not intermediate between the Cupisnique and Moche cultures (Shimada 1994; Klaus 2008:123). Rather, Salinar is a culture independent of the Cupisnique despite the hybridization of some artistic elements of that culture and close interaction with indigenous populations of Cupisnique descent.

2.4   The Gallinazo

Around the time of the Salinar decline, the Gallinazo culture began to fluoresce throughout the northern coast of Peru, with the possible exception of Piura Valley (Klaus 2008:123). The chiefdom-level society of the Gallinazo had numerous ceremonial-civic centerscomplete with residential villages situated around the ceremonial platform mounds of the centers (Klaus 2008:124). The use of adobe brick was common in the construction of Gallinazo structures and stone terracing was employed to modify the landscape (Klaus 2008:124). Within some of the ceremonial and residential centers, the presence of thick deposits of camelid remains may be indicative of the economic importance of pastoralism in the Gallinazo society (Klaus 2008:124). The strongest presence, as primarily noted through evidence of material goods (particularly, ceramics), of the Gallinazo culture is observed within the Chicama, Moche, Virú, and Santa Valleys (Klaus 2008:123-124). The Gallinazo ceramic style features stirrup-spout vessels, similar to both the Cupisnique and Salinar cultures, as well as pedestal bowls and jars with human or zoomorphic representations of facial features on the neck of the vessel (Klaus 2008:124). Additionally, the Gallinazo may have been the first culture to exploit the copper ores of the region (Klaus 2008:124).

The art and architecture styles of the Gallinazo are reflected in the subsequent Moche culture and beyond (Klaus 2008:125). The Gallinazo culture played a "deep role in Moche origins and the direction of subsequent local and ethnic group developments" (Klaus 2008:123), such as the Muchik ethnic group. Although further bioarchaeological and archaeological investigations within the region may serve to provide further clarity to the situation, it appears that the Gallinazo culture did not end at the beginning of the era of Moche domination (Klaus

2008:124). Additionally, it does not appear that the Gallinazo culture was terminated by a

forceful subjugation of their polities under the auspices of Moche control (Klaus 2008:125). As

mentioned previously, there was a continuation of Gallinazo artistic and architectural styles,

particularly in the form of polychrome murals and adobe brick-walled structures, respectively,

beyond the suspected termination of the Gallinazo era that are indicative of the continued

Gallinazo influence on the Moche culture (Klaus 2008:125). Within some regions, the Gallinazo

tradition of creation of face-neck jars extends as long as the Middle Sicán Period (A.D. 900-

1100).

The persistence of the Gallinazo tradition within the Moche culture may be at least par-

tially clarified through the archaeological evidence present at the site of Huancaco in the Virú

Valley (Klaus 2008:125). As evidenced through data at Huancaco, it appears that there was a

Gallinazo polity that persisted into the Moche era (Klaus 2008:125). The Gallinazo polity may

have actively engaged in the regional economy of the Moche and, furthermore, there is bioge-

netic evidence suggesting that the Gallinazo individuals are indistinguishable from the Moche

leading to the conclusion that the Moche and Gallinazo may be of the same genetic group

(Klaus 2008:125). Additionally, it has been suggested that the Gallinazo gene pool may be di-

rectly linked to both the earlier Cupisnique populations of the region as well as the subsequent

Moche, Sicán and Chimú populations (Klaus 2008:126). The continuation of cultural, as well as

biogenetic, elements of Gallinazo culture extended long beyond the termination of the original

iteration of the culture and "the Gallinazo may be hypothesized as representing the toots of the

widespread and recognizable north coast biocultural substratum that continued to exist under

the surface of the Moche and Sicán" (Klaus 2008:125).

2.5   Muchik Continuity: The Moche

From approximately A.D. 100- 750, the northwestern coast of Peru was occupied by the Moche (Bauer 1996: 334; Klaus 2011:1; Quilter 2002:145). The Moche civilization was the last of the complex societies to develop on the northern coast of Peru during the Early Intermediate Period and it is often recognized as the first indigenous state to have emerged in the Andes (van Gijseghem 2001:257). The biocultural basis of the Moche was derived from the earlier Gallinazo culture that was formed by elements of the Cupisnique and Salinar cultures. Between A.D. 200 and A.D. 300, the enthnogenesis of the Muchik identity began as a subculture of the Moche (Klaus 2012: Personal communications). Moche-based elements of the Muchik identity may be observed through the archaeological analysis of material remains as long as the Colonial Period within the Lambayeque Valley.

The expanse of the Moche territory is defined in terms of the cohesiveness of the artistic and architectural styles as a marker of a unified culture (Quilter 2002:153). During the height of the Moche reign (Moche II-V periods) the expanse of the territory extended from Chicama and Lambayeque Valleys in the north to the Nepeña Valley in the south (Quilter 2002:153; Klaus 2012: Personal communications).

Artistically, the Moche developed a number of distinctive ceramic styles (i.e. dippers, flaring bowls, modeled chamber bowls) and objects made from gold and copper (Donnan 1976). Metal-working traditions included the use of sheet metal and casting techniques used by Chavín culture centuries before the Moche, as well as depletion silvering and depletion gilding which were unique(Quilter 2002:157). Architecturally, the large, flat-topped, adobe-walled,

pyramidal *huaca* structures, such as the Moche Huaca del Sol, may have been co-opted from the Gallinazo culture that existed in northern Peru prior to the Early Intermediate Period of the Moche (Quilter 2002:152; Stanish 2001:53; van Geijseghem 2001:260). Similar to the construction the huacas, many Moche residential structures were composed of adobe brick; yet, cut stone masonry or *quincha* (botanical materials covered with clay similar to wattle-and-daub) were also used in the construction of the residences (van Geijseghem 2001: 260, 263). As reflected in the common and elite residential architecture at some Moche sites, the presence of increased levels of fortification in the form of additional walls may be indicative of the territorial, and perhaps martially driven, nature of competing polities (Stanish 2001: 58).

A proposed model for the organization of the Moche political organization focuses on each valley within the region functioning as an independent polity such that there are no large centers of control (Shimada 1994; Dillehay et al. 2004: 4326; Quilter 2002:159). The individual, *huaca*-centered polities within the bounds of the Moche territory would have likely been autonomous yet economically and territorially competitive with other polities (Shimada 1994; Dillehay et al. 2004:4326; Stanish 2001:56).

It is posited that the decline and eventual demise of the Moche state around A.D. 750 may be linked to the long-term environmental stressors of the region primarily linked to ENSO weather cycles (Contreras 2010: 260; Dillehay et al. 2004:4326; Quilter 2002:159). Such weather cycles led to a decline in agricultural production and a political destabilization as unrest among the lower classes resulted in revolts aimed at the elite ruling class (Contreras 2010: 260; Dillehay et al. 2004:4326; Quilter 2002:159). There are indications that there was marked political instability at the site of Pampa Grande in the form of conflagration of some of the adobe

structures (A.D. 750-800) that are typically associated with the elite class, including the main temple (Quilter 2002:160; Sutter and Cortez 2005:540).

Excavations at numerous Moche burial sites have been conducted over the past century; however, one of the most prominent excavations involves the sacrificial burials at the Huaca de la Luna. Many of the artifacts recovered at the Huaca de la Luna are ceramic vessels featuring iconography depicting both realistic and mythological activities and events. Of the scenes featured on the ceramic vessels, there are depictions of ritualistic sacrifices. Iconographic depictions of the supernatural decapitator figure appear as a crab, human, monster, bird, scorpion, fish and spider generally wielding a *tumi* ceremonial knife and a severed head (Bourget 1992: 43; Cordy-Collins 1992:212). Further credence to the theory that ritual human sacrifice occurred at the Huaca de la Luna is supported by the presence of a large sacrificial area as well as burial platform which have been incorporated into the architecture (Bourget 1992:41; Huchet and Greenberg 2010:2847). Based on iconographic evidence, many of the sacrifices may have occurred during periods of heavy rains and flooding which, most likely, would have occurred during ENSO-related weather events (Bourget 1992:44; Huchet and Greenberg 2010:2847). Additional iconographic evidence depicts sacrifice rituals forming part of agriculture-related religious ceremonies as the blood of the victims would likely have been offered to mythical beings as a form of payment for the continued flow of water through irrigation systems as a reaction to periods of ecological crisis (Bourget 1992:44,46).

The funerary practices of the Moche were highly complex and included not only delayed burials but the reopening of graves and the secondary offering of previously interred human remains as part of ancestral veneration activities (Huchet and Greenberg 2010:2847; Millaire

2004:373-374). Additionally, graves may have been reopened in an effort to obtain grave offer-

ings for use in another mortuary setting (Millaire 2004:378).

The mortuary presentation of the bodies within Level 5 of the Late Pre-Columbian to

Contact Period CSMME-CNS site is consistent with some Moche burial traditions indicating the

continued presence of the Muchik identity at this site. Typically, the Moche posed corpses in

an extended or supine position with the arms adjacent to the sides and wrapped the corpses in

one or more textile shrouds before placing the individual in a coffin or tube composed of cane;

yet, it must be noted that this configuration is not consistent throughout the entire Moche ter-

ritory (Millaire 2004:374). Frequently, deceased individuals were aligned with a cardinal axis,

most commonly the north-to-south axis, during burial placement (Klaus 2011:2). Offerings of

grave goods in the form of ceramic vessels, gourd containers, food, beverage, camelid bones,

and textiles have been associated with Moche burials (Klaus 2011:2; Millaire 2004:374). Sump-

tuous grave goods in the form of gold or worked metals (copper), as well as fineware ceramics,

have been associated with more elite burials in the Moche realm (Klaus 2011:2; Millarie

2004:374). Frequently, individuals were buried with grave goods which may have been indica-

tive of the social status and, perhaps, occupation of the individual, such as a spindle whorl used

in the creation of textiles for an individual who may have been a weaver (Millaire 2004:374).

Alternatively, the high degree of mortuary variability observed among the Moche may be the

result of an archaeological sampling bias. The complexities of the mortuary presentations of

Moche individuals are partially reflective of the religious ideologies of the culture. Although the

Moche civilization suffered a collapse around A.D. 750, there was a preservation of Moche tra-

ditions through the Muchik identity into the subsequent Sicán era.

2.6   Muchik Continuity: The Sicán

After the breakdown of the Moche polity at Pampa Grande (during the Moche V phase), the Sicán transitioned from a minimal local polity to serve as a force of regional domination from A.D. 800 to 1375 (Klaus 2008:136). The Sicán culture was centered in the La Leche Valley (Poma Forest region) and has frequently been misleadingly labeled as the Eten, Middle Chimú or Lambayeque Cultures (Klaus 2008: 137).The time span during which the Sicán culture was dominant can be divided into three periods partitioned by the application of secure radiocarbon dates linked to major cultural changes within the society (Klaus 2008:137). The three major periods of the Sicán may be defined as: Early Sicán (A.D. 750/800-900), Middle Sicán (A.D. 1100-1375), and Late Sicán (A.D. 1100-1375) (Klaus 2008:137).   Although there is a marked lack of material evidence for the Early Sicán Period, highly polished blackware ceramics that are similar to those found during the Moche V Period are evident (Klaus 2008:137). Within the Early Sicán Period there was an observable emulation of highland Wari and Cajamarca styles, particularly in the form of an avian-inspired figure that may have provided the basis for the Middle Sicán religious diety(Klaus 2008:137). The desire for blackware ceramics continued into the Middle Sicán Period and *paleteada*-style ceramics that are commonly associated with Muchik tradition began to emerge during this time period (Klaus 2008:136-137). Additionally during this period, arsenical copper object and items made of gold began being produced (circa A.D. 1000) (Klaus 2008:145). During the Middle Sicán period, the culture trends and processes of the Sicán were crafted into novel political and religious structures with the focus of the administration being centered within the La Leche-Lambayeque Valley region (Klaus 2008:139). There was a renaissance in the area of craft production and monumental mound construction experienced a

resurgence leading to the establishment of over a dozen monumental mounds (*huacas*) with platforms that formed a funerary zone for the elite within the Poma region (Klaus 2008:139, 141, 143). The construction of the monumental mounds required the contribution of adobe bricks, each complete with a makers' mark from specific communities or social groups as a form of tax (Klaus 2008:139,141). The configuration of the sociopolitical realm of the Middle Sicán focused on the: establishment of a hierarchical government featuring a centralized administration, creation of separate social classes each with differential access to resources, and resource exploitation models focusing labor extraction and the annexation of land (Klaus 2008:139). Based on genetic analyses, it is suggested that the Sicán elite may have been related to northern Andean population potentially from coastal Ecuador (Klaus 2008:150). The influx of the Sicán elite into the Lambayeque Valley Region is thought to have occurred after A.D. 750 (Klaus 2008:150). The non-elite members of the Sicán society are, based on genetic analyses, assumed to be from the central Andean populations and are most closely aligned with the Moche, and by extension the Muchik (Klaus 2008:150). There is genetic and biometric evidence that little-to-no gene flow between the social classes occurred (Klaus 2008:150).

Differential access to resources based on social class affiliation may be observed through the economy of the Sicán. The economy of the Middle Sicán was based on the horizontal model in which local resources were exploited up to an altitude of 1000 meters above sea level (m.a.s.l.) (Klaus 2008: 150). Subsistence strategies were centered on irrigation-based agriculture made possible through the access of water sources for irrigation at sites such as Cajamarca as well as camelid herding and the exploitation of marine-based resources. The Middle Sicán engaged in trade across a wide distance (over 1000 kilometers from the north to south)

and there is evidence of imported prestige goods, such as *Spondylus* shell, in the tombs of some

Sicán elite (Klaus 2008: 150). Although the elite class of the Middle Sicán may be from a differ-

ent genetic and cultural lineage than individuals in the commoner class, there is mortuary evi-

dence suggested that the Middle Sicán may have encouraged a form of sociopolitical integra-

tion of incorporating local lords from the already defined *parcialidades* (or sociopolitical re-

gions) into the lower levels of the Middle Sicán elite power structure (Klaus 2008:154). As pre-

viously noted, the majority of individuals with Middle Sicán society were of an indigenous group

of peoples that were likely the descendants of the earlier Moche society referred to as the

Muchik (Klaus 2008:154).

Although the Muchik culture experienced changes in political organization and material

culture preferences under the rule of the Middle Sicán, there appears to have been a continua-

tion of the Muchik cultural identity and practices within the Lambayeque Valley region (Klaus

2008:154). Examination of the material culture of the region, after A.D. 750, details the persis-

tence of the Muchik culture as noted through the presence of Muchik-style ceramics that were

often created with a semi-hydridization of both Muchik and Sicán stylistic elements (Klaus

2008:154). The *huaca*-style motif, as represented by a stepped pyramidal structure, may be a

remnant of the earlier Moche culture and is incorporated into many Muchik material remains

(Klaus 2008:155). Additionally, the *paleteada* method of pottery production is linked to a lower

echelon class of Muchik as individuals involved in the production of *paleteada* ceramics are

found in mortuary settings where metal offerings are absent potentially signaling a lower class

of artisan (Klaus 2008:158).

Further evidence of the influence of the Muchik within the Sicán society may be observed through the burial rituals of individuals from the lower echelons of Sicán social structure. The Muchik-influenced burials involved the placement of the corpse on a north-to-south line in a simple burial pit with ceramic, metal, or camelid grave goods (Klaus 2008:155-156). There is evidence of prolonged burials, the post-internment manipulation of remains, and secondary burials which would have served to link the living Muchik people with their ancestors (Klaus 2008:155-156). Such Muchik-style mortuary practices were pervasive both during the Sicán era and beyond until the time of contact with the Spanish (Klaus 2008:156).

The Sicán culture experienced a collapse that began around A.D. 1020 as the result of an ENSO weather system that caused a significant drought in the region for a period of about 30 years (Klaus 2008:158). During this period, systematic fires were set at the *huaca* temples of the Sicán by the Muchik commoners in an effort to remove the Sicán leadership from control (Klaus 2008:158). The perceived failure of the Sicán elite to manage the supernatural forces in an effort to ease the drought coupled with the consideration, from the Muchik perspective, of the Sicán as foreigners led to the destruction of the *huaca* temples (Klaus 2008:158). The abandonment of the temples signified the end of the Middle Sicán era and the beginning of the Late Sicán (Klaus 2008:158).

During the Late Sicán period, there was a marked religious and political restructuring resulting in the creation of a new capital at Túcume (Klaus 2008:159). The territory of the Late Sicán extended from the Piura region in the north to the Jequetepeque Valley in the south (Klaus 2008:159). As a result of the political restructuring of the Late Sicán Period, it is likely that the leadership returned to the local, indigenous Muchik elite who constructed numerous

civic-ceremonial centers near Túcume (Klaus 2008:159). The reorganization of the Late Sicán

empire became faced with a challenged from the predatory imperial polity known as the Chimú

Kingdom around A.D. 1375 (Klaus 2008:160).

2.7   Muchik Continuity: The Chimú

It is thought that the initial wave of Chimú imperialism occurred during the massive

ENSO event of around A.D. 1100 as many of the Chimú irrigation systems and agricultural fields

were destroyed (Moore 1991:30). Ultimately, the Chimú left their original territory and began

to parasitically exploit the resources of surrounding cultures (Klaus 2008:161; Moore 1991:30).

At the height of Chimú imperialism, the territory under their control spanned over 1000km

from southern Ecuador to central Peru (Moore 1991:29). The capital of the Chimú Empire was

the city of Chan Chan in the Moche Valley and it was the largest of the pre-Hispanic capital cit-

ies (Klaus 2008:160; Moore 1991:27). The political structure of the Chimú incorporated the ex-

isting regional policies and governing structures, including the incorporation of the Late Sicán

Period site of Túcume as a regional capital (Klaus 2008:163; Moore 1991:29).

Although the Chimú sought to incorporate the existing political structures of the regions

that they occupied, there was an explicit delineation between social classes within the Chimú

Empire (Moore 1991:29). The culture viewed individuals as having been created separately by

different celestial elements; therefore, there was a marked delineation between the elite and

non-elite classes of the north coast of Peru under the Chimú rule (Moore 1991:29).

For the Chimú culture, there is a marked lack of innovative ceramic styles instead there

is a reliance on the stirrup-spout vessels that were revivals of the Moche design (Klaus

2008:161). The *paleteada* ceramic style commonly associated with the Muchik was continued

during this period as well (Klaus 2008:164). Additionally, there is a lack of a unique deity form as

the Chimú were a secular culture (Klaus 2008:161). A lack of unique material goods may possi-

bly be explained by the brevity of the Chimú rule in the region. The period of existence for the

Chimú Empire may be considered to be comparatively short, as compared to other empires

such as the Sicán, as the Chimú came into contact with the Inka during the fifteenth century

(Klaus 2008:164).

2.8   Muchik Continuity: The Inka

When the Inka first came into contact with the Chimú, diplomatic advances were ex-

tended to the Chimú lords in return for their submission to Inka rule (Klaus 2008:165). Re-

sistance to the Inka rule was met with harsh penalty as noted by the A.D. 1460 conflict between

the Chimú king Chimu Capac and the Inka army led by Sapa Pachacuti (Klaus 2008:165; Turner

2012: personal communications). This conflict led to the direct domination and termination of

the Chimú Empire as well as the incorporation of the north coast polities into the Inka province

of Chinchasuyu (Klaus 2008:165).

Under the rule of the Inka, one of the most striking sociopolitical changes involved the

implementation of land tenure policies that set aside state-controlled hunting grounds, fishing

areas, forests, and mines (Klaus 2008:165). The labor tax system (*mit'a*) of the Inka resulted in

the resettlement of entire communities (or *parcialidades*) often to distant locations; however,

there is evidence that some relocated communities still maintained close socioeconomic ties

with their distant lords (Klaus 2008:165-166). Within the Lambayeque Valley, it is thought that

due to cultural and linguistic barriers there may have been limited gene flow between the

transplanted Inka populations and the indigenous Muchik populations of the area (Klaus

2008:166).

Within the Lambayeque Valley Complex, the Inka simulated the Chimú style of govern-

ance that delegated political policy management to the local lords (Klaus 2008:166). Under the

rule of the Inka there was a continuation of the production of Muchik-associated *paleteada* ce-

ramics; yet, the center of production was shifted to Inka-controlled sites within the La Leche

Valley region (Klaus 2008:167). Although the Inka did influence the socioeconomic landscape of

the indigenous peoples of the northern coast of Peru, the effects of their rule may have been

relatively limited due to several factors. These include the short period of Inka domination in

the region (less than a century) and the lack of centralization of settlements along the north

coast as compared to the Inka core region of the southern Peruvian highlands (Klaus 2008:166).

Along the north coast during the period of Inka rule there was little change in the local political

structures, economic foci, languages, ideologies, and cultural/ethnic identities of the indigenous

Muchik peoples of the region (Klaus 2008:166). The persistence of the underlying Muchik cul-

ture was not significantly altered during the relatively brief era of Inka imperialism and, as such,

existed well into the Early Contact Period.

2.9   Muchik Continuity: The Contact Period

Many of the accounts of life during the Early Contact Period in the Lambayeque Valley

Complex are based on European-based ethnohistorical accounts. Although there was an effort

by the European colonialists to transcribe the oral histories and chronicles of the Muchik indig-

enous people of the region, such transcriptions may be tainted with a European agenda or bias (Klaus 2008:282). Additionally, European records such as financial account information, government correspondence, trades records, church correspondence, and legal documents have been preserved from the Early Contact Period; yet, once again, these documents may express a decidedly Eurocentric view (Klaus 2008:282).

Prior to the physical arrival of the Spanish in Andean South America, an epidemic of smallpox, an Old World-based pathogen, was likely introduced to the region through trade routes with Central America during the late 1520s (Klaus 2008:283; Livi-Bacci 2006:199). The smallpox epidemic resulted in the deaths of upwards of one million indigenous individuals within Andean South America during this time period (Klaus 2008:283). In December 1530, the Spanish conquistador Francisco Pizarro landed on the coast of western South America (Klaus 2008:283). On November 16, 1532, Pizarro and his 168 soldiers encountered the Inka army of Cajamarca in the northern highlands. By November 15, 1533, the Inka city of Cuzco had fallen under Spanish control (Klaus 2008:283). Following the capture of Cuzco, the Spanish continued their campaign of violence throughout Andean South America until the Inka rebel leader, Manco Inka, and his army instituted a siege on the Spanish-dominated cities of Cuzco and Lima (Klaus 2008:283; Gaither and Murphy 2012:468). Manco Inka and his army were not able to force the Spanish from the cities; thus, the Inka fled to Vilcabamba where they independently maintained their own kingdom until 1572 (Klaus 2008:283). Throughout the lands dominated by the Spanish, the Early Colonial Period was marked by an economic system focused on mining activities through the use of indigenous labor; however, the continued spread of European-based disease further weakened the indigenous labor pool during this period (Klaus 2008:283;

Gaither and Murphy 2012:468). By the 1560s, indigenous resistance movements began in the

southern highlands; however, in 1569, representatives of the Spanish government ordered that

the indigenous peoples be resettled into communities called *reducciones* that were based on

Spanish residential models (Klaus 2008:154-155). Although the newly developed communities

were formally headed by local Andean lords, similar to the Chimú and Inka political models,

there was a marked remodeling of local political structures to serve the purposes of the Spanish

colonialists (Klaus 2008:285). Additionally, a forced, non-reciprocal labor policy was instituted

by the Spanish (Klaus 2008:285). Displays of Spanish force extended beyond the economic and

political realms when in June 1572, the last Inka stronghold of Vilcabamba was taken by Spanish

forces and the Inka leader was publically beheaded in Cuzco (Klaus 2008:285; Gaither and Mur-

phy 2012:468). Despite the siege of Vilcabamba, the political and economic reforms instituted

by the Spanish began to fail by the early seventeenth century (Klaus 2008:286). During this pe-

riod, large groups of indigenous peoples of the north coast of Peru, such as the Muchik, began

to resist participation in the Spanish-instituted economic system and they fled the region to

avoid the forced labor and tax policies of the Spanish (Klaus 2008:292-293). Additionally, be-

tween A.D. 1570 and A.D. 1600, the population of Peru fell from 1.3 to 0.9 million (Livi-Bacci

2006:199). It has been conjectured that between 40% to 95% of the individuals within some

Pre-Columbian indigenous societies perished due to the epidemics caused by contact or direct

militaristic conflict with Europeans (Livi-Bacci 2006:204, 207; Lovell 2006:436).

The application of political and economic changes to the Andean region of South Ameri-

ca led to the development of a social stratification system in which differential access to food

resources was evident (Klaus 2008:287). As the availability of workers from the Andean South

American indigenous population labor force declined due to sociopolitical and epidemiological factors, African slaves were imported into Peru to fulfill the labor demands of the Spanish (Klaus 2008:291). Additionally, under Spanish rule the labor force was divided along the lines of sex as the Contact Period societies of Peru were male-dominated (Klaus 2008:291). In the upper classes, women were barred from participating in manual labor; however, within the lower echelons of society, women contributed heavily to production within textile mills or the household (Klaus 2008:291). In Colonial Peru, indigenous women, such as those of Muchik identity, were considered to be minors and were often dehumanized by the Spanish Catholic clergy (Klaus 2008:291). Despite the rather aggressive nature of many of the Colonial Period policies instituted by the Spanish, there was a marked period of ethnogenesis among the indigenous groups of Peru (Klaus 2008:291). The introduction of the Spanish concept of *el indio* permitted the deconstruction of pre-Hispanic indigenous ethnic and cultural identities; thereby, limiting the economic and political power of the indigenous peoples (Klaus 2008:291). Even though the Spanish imposed the concept of *el indio* on the indigenous population of Peru, actions related to ethnogenesis may have persisted due to the efforts of the women of the indigenous community (Klaus 2008:291). Although the ethnogenesis of the Muchik identity occurred centuries earlier during the Moche Period, there was a marked persistence of the identity and associated culture throughout periods of relative political calm (Moche and Sícan) into periods of rapid, and increasingly harsh, sociopolitical change (Chimú, Inka, and Colonial).

Although the Spanish sought to fully indoctrinate the indigenous population in the Catholic faith, there is mortuary evidence suggesting such a full indoctrination was not completely successful. As late as the 1600s, in the highland regions of Peru, the tradition of burying

the dead in caves that could be accessed by the living was still prevalent (Klaus 2008:302). An-

cestor worship occurred in region such as Arequipa as late as the mid-1700s (Klaus 2008:302).

The persistence of traditional indigenous burial methods may be indicative of a preser-

vation of ethnic identity despite foreign interaction; or, in some cases, such as those observed

within the Early Contact Period CSMME and CSMME-CNS burial sites, the mortuary treatments

may reflect a hybridization of both indigenous, Muchik-centered and Spanish religious beliefs.

A hybridization of burial styles may result in issues with the interpretation of mortuary site in

terms of archaeothanatological and archaeological research. Archaeothanatological studies

primarily focus on the internment style and depositional environment in an effort to recon-

struct the initial burial context through accounting for post-depositional taphonomic distortions

(Valentin et al. 2010:218). These studies, in conjunction with archaeological research, provide a

more complete understanding of mortuary practices within a society (Valentin et al. 2010: 218).

Furthermore, for sites such as CSMME-CNS, the application of stable isotope analysis methods

as a form of bioarchaeological evaluation may provide valuable information as to the possible

geographic origin of the individuals interred at the site. Also, stable isotope analysis may pro-

vide information related to potential differential access to dietary resources within a communi-

ty. For the CSMME-CNS site, stable oxygen isotope analysis will be undertaken to determine

the potential geographic location of origin of the individuals interred at the site—are the indi-

viduals indigenous to the region, indigenous to another region of Andean South America, or are

they from the Old World (Europe or Africa)? Additionally, stable carbon isotope analysis may

provide data that will illuminate possible differential access to dietary resources within the in-

dividuals represented in the CSMME-CNS burial population. Through stable isotope analysis,

should the individuals within the CSMME-CNS population be determined to be from different

geographic origins and should patterns of differential access to food resource be revealed,

there may be the possibility to link the two factors to provide a more thorough understanding

of the social stratification within the Lambayeque Valley Complex during the Early Contact Peri-

od. The results from the stable isotope analyses may permit the formulation of interpretations

related to the lives of the indigenous Muchik population of the region during the Early Contact

Period that may not have been possible through the analyses of European-written documenta-

tion alone.

3   ISOTOPE ANALYSIS OF HUMAN REMAINS

3.1   Composition of human bone

Human bone is composed of organic collagen fibers embedded with the inorganic material hydroxyapatite (or, as it is referenced in some literature, hydroxylapatite) $(Ca_{10}(PO_4)_6(OH)_2)$ (Burns 2007: 13; Finucane et al. 2006:1767; King et al. 2011: 2222). Up to 70% of the mass of human bone is composed of inorganic mineral salts, such as calcium phosphate, and the inorganic substance hydroxyapatite (Burns 2007:13; Finucane et al. 2006:1767). The remaining 30% of the bone mass is composed of organic substances, particularly collagen. The combination of amino acids leads to the creation of peptide chains which may combine to form protein molecules (Price and Burton 2011: 7). Collagen, a form of large molecule protein, composes nearly 90% of the organic material contained in bone (White and Folkens 2005:42). Typically, modern bone contains approximately 20% collagen by weight and archaeological bone samples contain between 0 and 20% collagen by weight (Le Huray et al. 2009:103).

Although the structural hydroxyapatite and collagen of bone may be preserved within the archaeological record, there is the potential for post-depositional microscopic chemical alteration of the bone in the form of diagenetic alteration. Diagenetic processes occur primarily in post-depositional settings as "diagenesis is a process, during which skeletal bioapatite recrystallizes and reacts with ambient diagenetic fluid" (Gehler et al. 2011:85). The post-depositional diagenetic alteration of some skeletal elements may affect the isotopic analysis results (Finucane et al. 2006:1768; King et al. 2011:2222). The porous nature of bone leads to the possibility of high rates of post-depositional diagenetic alteration as "it is highly susceptible to contamination by calcite precipitation in voids or recrystallization after burial" (Hodell et al.

2004:487). Although the occurrence of diagenesis is site and specimen specific, it must be rec-

ognized as a potential factor for errors in stable isotope analysis (Aufderhiede et al. 1994:520;

Montgomery and Evans 2009:126).

In addition to the stable isotope analysis of the structural hydroxyapatite of bone, the

collagen fibers of bone may also be examined through stable isotope analysis. The collagen fi-

bers of bone are composed of amino acids formed from nitrogen, oxygen, hydrogen, and car-

bon atoms (King et al. 2011:2222). Preserved carbon in the bone collagen and apatite may be

compared to naturally occurring carbon isotopes. Such comparisons allow for the development

of ratios of carbon isotopes which may be indicative of the food resources consumed by an in-

dividual (King et al. 2011:2222).

Similar to the examination of stable carbon isotope ratios as an indicator of food

sources of an individual, the nitrogen isotopes present in the collagen of the bone may be used

to indicate possible food sources for the individual being examined (King et al. 2011:2222). It

must be noted that for examination of pre-weaning infants, there is a marked increase in $\delta^{15}N$

values (2-4‰ higher than the general population) indicative of an intraspecies shift in trophic

levels (Katzenberg and Harrison 1997:270, 274). Additionally, the nutrient dense maternal milk

contains large quantities of lipids exhibiting $\delta^{13}C$ values that are approximately 5‰ lower than

other macrocmolecular nutrients; therefore, pre-weanling infants may have significantly lower

$\delta^{13}C$ values present in their bioapatite than their post-weaning counterparts (Balasse

2002:160).

The stable isotope analysis of carbon and nitrogen with skeletal elements, such as bone,

permits interpretations related to the potential dietary resources accessed by an individual dur-

ing their lifetime. To glean information related to the approximate geographic origin of an indi-

vidual, a different form of stable isotope analysis is employed. Ratios of radiogenic strontium

isotopes preserved in bone, and also in teeth, may be analyzed to determine the potential geo-

graphic origin of the individual or patterns of sedentism within communities as strontium iso-

topes present in the soil vary with the chemical composition and underlying age of the lithology

from which it was derived (Hodell et al. 2004: 585, 587; King et al. 2011:2222).

For all isotopic analysis procedures, the cortical layer of bone is sampled as the pro-

cessing of this portion yields the greatest levels of isotopic data; yet, it is recognized that differ-

ent bones are affected by diagenetic processes at different rates (King et al. 2011:2224). Ribs,

which are commonly sampled for isotopic analysis purposes, are subject to high rates of

diagenesis due to their thin compact, cortical layer and large surface area (King et al.

2011:2224).

Although the stable isotope analysis of healthy, undamaged bone is ideal, such bone

may not be available in archaeological settings. Bone with evidence of pathologies, such as

osteomyelitis or antemortem fractures, may be avoided for purposes of isotopic analysis when

bone with no visible pathologies is available; however, such avoidance may not be necessary

depending on the type of isotopic analysis that is to be undertaken. Antemortem fracture re-

pair does not result in a variation of δ^{13}C assuming there is no change in diet; however, "the

wasting and consequent recycling of tissue protein can result in elevated δ^{15}N values" (Katzen-

berg and Lovell 1999:323). Depending on the nature of the isotopic analysis required, the se-

lection of bone free from pathologies may be necessary; yet, for δ^{13}C characterization such se-

lection is not essential. In settings, such as locations near the subsurface water table margin,

where the post-depositional diagenetic alteration of bone is of concern the stable isotope analysis of human tooth enamel is preferable.

3.2   Composition of human dentition

The formation of dentition occurs within the maxilla and mandible with the teeth erupting through the soft tissues of these skeletal elements once the formation of the enamel crown is complete (White and Folkens 2005:127). Ameloblasts secrete an enamel matrix composed of carbonated hydroxyapatite in a circadian fashion such that the earliest formed enamel occurs from the apex to the enamel-dentine junction (cervix) (Balasse 2002:156; Burns 2007:169; Dean et al. 2001:628-629; Kuczumow et al. 2011:1129; Montgomery and Evans 2009:129). Up to 98% of the mass of tooth enamel is derived from hydroxyapatite (Finucane et al. 2006:1767). The biomineralization of enamel has been defined as the transformation, through both cellular and biochemical processes, of organic gel-like substances into a mineralized inorganic substance that is up to 90% mineral by volume (Montgomery and Evans 2009:129). The final parameters of the enamel thickness and volume of a given tooth is a function of the formation of the protein matrix which is dependent on the rate of secretion, assembly, and formation processes of the ameloblasts (Balasse 2002:157; Montgomery and Evans 2009:129). The composition of the carbonated hydroxyapatite of enamel may be varied with elements from some or all of the following compounds or ions: Na^+, Mg^{+2}, F^-, Cl^-, and CO_3^{2-} (Kuczmow et al. 2001:1129). The enamel crown of human dentition is 97% mineralized and is avascular and acellular (White and Folkens 2005:130).

Total crown formation is a function of both occlusal and lateral enamel formation with the average crown formation period ranging between 3.0 to 3.45 years for human molars (Dean

et al. 2001:629; Reid and Dean 2006:341-342). It must be noted that enamel formation rates and mineralization rates of the enamel are not analogous as mineralization occurs during the maturation phase of tooth formation, which may take as long as five years in some individuals (Montgomery and Evans 2009:130). Also, enamel mineralization does not occur on a set schedule, nor does it occur in a uniform fashion as enamel mineralizes more quickly in thinner enamel regions than thicker enamel regions and from the outer enamel surface inwards to-wards the dentin (Balasse 2002:157; Montgomery and Evans 2009:130). Unlike other skeletal elements which may be remodeled prior to full-formation or remodeled over the life of the in-dividual, enamel crowns may be physically altered only after eruption of the dentition and re-modeling does not occur in dentition (Burns 2007: 15, 173; Holden 2003:761; White and Folkens 2005:127). The crown morphology of dental elements may be altered through attri-tion, occlusal wear, demineralization, or breakage (Burns 2007:173; White and Folkens 2005:127,130). For the purposes of isotopic analysis of human dentition, examination of the first molar is preferred as the enamel of this tooth begins to form during gestation and mineral-izes during early childhood as opposed to later enamel formation which occurs in other tooth types (Balasse 2002: 158; Price and Burton 2011:95).

Relative to other skeletal elements, human dentition is highly resistant to post-depositional chemical and physical alterations, such as diagenesis (Gehler et al. 2011:85; White and Folkens 2005: 127). The homogenized lattice formation of the regularly-shaped prismatic structures of the minerals which compose the apatite of dentition may prevent post-depositional diagenetic processes from occurring as is common with the irregular composition of bone; therefore, the isotopic analysis of dentition may be preferable in cases where both

dentition and bone samples are available (King et al. 2011: 2224; Montgomery and Evans 2009:129). Stable isotope analysis of tooth enamel permits interpretations of the diet of an individual during the time in which the enamel was forming, specifically the period during early childhood that may be defined as the first decade of life (Montgomery and Evans 2009:129).

3.3   Stable isotope analysis

3.3.1   Isotopes defined

An atom is defined by the number of protons contained in its nucleus and the mass of an atom is defined by the sum total number of the protons and neutrons contained in the nucleus (Le Huray et al. 2009: 99). An isotope of an element occurs when there are variations in the number of neutrons contained within the nucleus of an atom which result in a form of the atom with the same number of protons but a different number of neutrons; therefore, the mass of the atom is changed (Le Huray et al. 2009:99). Depending on the structure of the atom, isotopes may be classified as stable or unstable. Examples of stable isotopes include: ^{12}C, ^{13}C, ^{14}N, ^{15}N, ^{16}O, and ^{18}O. With the exception of oxygen (^{16}O and ^{18}O), all of the aforementioned stable isotopes may be used in the reconstruction of diet for individuals based on the chemical analysis of human remains. The stable isotope analysis of oxygen provides a proxy for the sources of water consumed by an individual. All isotopes of a given element, whether stable or unstable, all react in the same manner chemically; however, the mass difference between different isotopes of the same element may lead to a discrimination during chemical and physical processes which favors the isotope with the lower mass (Le Huray et al. 2009:100). Such a discrimination, called fractionation, occurs as chemical and physical processes favor the conserva-

tion of energy thereby selectively favoring the isotope with the lighter mass (Le Huray et al.

2009:100; Montgomery and Evans 2009:124).

The ratios (δvalues) of stable isotopes are defined in parts per thousand (‰) relative to

an international standard reference measure for individual isotopes as follows:

$$\delta(‰) = [(R_{sample} - R_{standard})/ R_{standard}] \bullet 1000$$

(Ambrose and De Niro 1989:408; Finucane et al. 2006:1767; Le

Huray et al. 2009:100; White et al. 2009:1528)

For oxygen, the international reference standard is Vienna Standard Mean Ocean Water

(VSMOW) for phosphate and Pee Dee Dolomite (PDB) for carbonate (Gehler et al. 2011:85;

Price and Burton 2011:92). The international reference standard for nitrogen is purified atmos-

pheric nitrogen that is calibrated using IAEA-N1 (0.4‰) and IAEA-N2 (+20.3‰) (White el at.

2009:1528). For carbon, the international standard reference measure is taken from the lime-

stone source of Vienna Pee Dee Belemnite (VPDB) (Finucane et al. 2006:1767; White et al.

2009:1528).

3.3.2   Oxygen isotopes

One of the primary examples of fractionation in nature occurs during the water cycle

when two common isotopes of the element oxygen, ^{16}O and ^{18}O, are evaporated and precipi-

tated at different rates (Le Huray et al. 2009:100). The relative abundance of the oxygen iso-

topes present is directly related to "temperature-related fractionation processes such as evapo-

ration, condensation, and transpiration" (Price and Burton 2011:91). During evaporation at the

surface of the ocean, the ^{16}O isotope is favored as it is lighter in mass and requires less energy to evaporate than the ^{18}O isotope (Price and Burton 2011: 91). As clouds move inland from the ocean, the heavier ^{18}O isotope is preferentially precipitated which ultimately results in ground-water and ocean water having different oxygen isotopic ratios (Holden 2003:761; Katzenberg and Harrison 1997:275; Le Huray et al. 2009:100; Price and Burton 2011:91). Furthermore, "in-land rain is lighter than tropical and coastal rain; summer precipitation is less depleted than winter precipitation... and further depletion of ^{18}O occurs at higher elevations and latitudes" (Price and Burton 2011:91).

The ratio of ^{18}O/^{16}O is expressed as δ^{18}O. Increased evaporation rates in arid regions leads to an increase in the presence of δ^{18}O in surface water sources and plants through leaf water fractionation processes as compared to more humid regions (Katzenberg and Harrison 1997:275; Price and Burton 2011:92). The presence of oxygen isotopes in the remains of fauna and humans results primarily from the ingestion of rain (meteoric) water as a drinking source with water ingested from foods, including breast milk, acting as a minor, secondary source (Knudson 2009:181; Price and Burton 2011:92; Turner et al. 2005:127). Additionally, the inhala-tion of atmospheric oxygen may contribute a minor amount of oxygen isotopes as compared to the oxygen isotopes absorbed by an individual through the ingestion of drinking water (Iacumin et al. 1996:2; Price and Burton 2011:92). According to Gehler et al. (2011:84), "skeletal apatite precipitates in equilibrium with body water [and]… for most mammals, skeletal apatite precipi-tates at a body temperature of 37˚C and has a δ^{18}O, which is ~17.3‰ higher than the δ^{18}O of the water from which it was precipitated". The precipitation of skeletal apatite in equilibrium with body water may result in the enrichment of the ^{18}O isotopic signatures in skeletal ele-

ments (particularly enamel and bone) during the time surrounding weaning from breast milk (Knudson 2009:181). Such enrichment in the ^{18}O isotopic signatures in skeletal elements formed during the time period both before and immediately after weaning may be normalized through the application of a -2‰ reduction in δ^{18}O$_{(V- SMOW)}$.

As determined through the establishment of oxygen isotope ratios in tooth enamel and bone collagen, information pertaining to residential mobility and past climate patterns may be determined (Mays 2009:187; Iacumin et al. 1996:2; Price and Burton 2011:91). Comparison of stable isotopic values for oxygen contained in enamel hydroxyapatite and bone apatite may permit a comparison of geographic location of origin (through analysis of enamel hydroxyap-atite) and geographic residence during the last decade of an individual's life (through analysis of bone apatite).

Since tooth enamel tends to be more highly resistant to post-depositional diagenetic al-teration processes than bone collagen, the analysis of tooth enamel for the determination of oxygen isotopes is preferential. The inorganic component of enamel, hydroxyapatite, contains oxygen in both the carbonate (CO_3) and phosphate (PO_4) groups. The oxygen isotope composi-tion of both the structural carbonate and the phosphate in the apatite of bone and enamel is directly related to the oxygen isotope signatures of the ingested meteoric water (Gehler et al. 2011:85; Iacumin et al. 1996:2). The analysis of the carbonate and the phosphate groups in the hydroxyapatite of enamel produces similar results yet the carbonate analysis requires far less sample mass (Price and Burton 2011:92). Due caution must be applied to analysis of the car-bonate group of the hydroxyapatite of enamel (and bone) as structural carbonate is considered less resistant to post-depositional diagenetic alteration than the phosphate group (Iacumin et

al. 1996:1-2). Tandem analysis of the oxygen isotopes in the structural carbonate and phosphate groups of apatite samples may yield information pertaining to possible post-depositional diagenetic alterations as markedly different results for both analyses may indicate potential post-depositional chemical and/or structural changes to the sample (Gehler et al. 2011:85).

3.3.3 Carbon isotopes

In addition to the stable oxygen isotope analysis of human remains, stable carbon isotope analysis may also be performed. Most terrestrial organisms, whether botanical or faunal, will demonstrate $\delta^{13}C$ values less than the VPDB standard so their $\delta^{13}C$ values will be negative (Finucane et al. 2006:1767). For the purposes of dietary analysis and, more specifically, the reconstruction of subsistence strategies in pre-historic populations, human bone collagen and enamel may be evaluated for $\delta^{13}C$ and $\delta^{15}N$ values as variations in such values directly reflect dietary practices (Ambrose 1991: 293; Aufderheide et al. 1994:520; Finucane 2009: 536; Finucane et al. 2006:1767; Le Huray et al. 2009:100; White et al.2009:1528). Although human bone may be evaluated for $\delta^{13}C$ and $\delta^{15}N$ values, a major limitation with such analyses is that bone reflects dietary patterns over only the decade of an individual's life, so it may fail to reflect life-long subsistence patterns (Holden 2003:761; Turner et al. 2005:127; White et al. 2009:1527).

The $\delta^{13}C$ values for human skeletal elements may assist in the development of an overarching dietary source profile for the individual; yet, the fractionation of carbon isotopes between trophic levels must be considered as part of this analysis. Between trophic levels, there is a marked increase in isotopic ratios of approximately +0.5-1‰ $\delta^{13}C$ and +2-4 ‰ $\delta^{15}N$ between organisms and their higher-order consumers (Finucane et al. 2006:1767; Le Huray et al.

2009:100). Differences in the $\delta^{13}C$ values present in collagen or enamel are reflective of differences in the consumption of C_3 versus C_4 plants (Le Huray et al. 2009:100). Bone collagen $\delta^{13}C$ values for consumers of only C^3 plants is approximately -7‰ and for consumers of only C_4 plants is approximately -21‰ (Finucane 2009:536).

The primary difference between C_3 and C_4 plants is that C_3 plants produce a three-chain carbon molecule during the first phase of photosynthesis whereas a four-chain carbon molecule is produced by C_4 plants (Ambrose and De Niro 1989:408; Finucane 2009:535; Le Huray et al. 2009:100). C_3 plants which utilize the Calvin Cycle during photosynthesis "have tissues with an average $\delta^{13}C$ of -26.5‰" (Finucane 2009:539; Finucane et al. 2006:1767; White et al. 2009:1528). Along the western slope of the South American Andes, C_3 plants are typically found in the temperate zones and produce a more negative $\delta^{13}C$ value (-22‰ to -35‰ relative to geological standards) than C_4 plants which are primarily found in more tropical regions (Goldstein 2005:220; Le Huray et al. 2009:100; Turner et al. 2005:125; White et al. 2009:1528). C_4 plants utilize the Hatch-Slack pathway cycle during photosynthesis and, similar to C_3 plants, have average $\delta^{13}C$ values of approximately -12.5‰ (range: -10‰ to -15 ‰, relative to geological standards) (Finucane 2009:539; Finucane et al. 2006:1767; Turner et al. 2005:125; White et al. 2009:1528). Within the South American Andean Region (western slope), the C_3 plant category includes most vegetable cultigens, nuts, fruits, some dicotyledonous weeds, and wild grasses (Ambrose and De Niro 1989: 408; White et al. 2009:1528). For this region, C_4 plants are tropical grasses including sugar cane, millet, and maize (Finucane et al. 2006:1767). White et al. 2009:1528). Additionally, in this region, cacti and succulents are neither C_3 nor C_4 plants, rather they have "flexible photosynthetic pathways" and utilize Crassulacean acid metabolism (CAM)

(White et al. 2009:1528). CAM plants have $\delta^{13}C$ values ranging between -27‰ and -12‰ which overlaps the values for both C_3 and C_4 pathway plants; therefore, it may be difficult to detect the importance of CAM plants in the diet of an individual when conducting $\delta^{13}C$ isotope analysis (White et al. 2009: 1528).

For all plant types, increased levels of aridity may artificially inflate $\delta^{13}C$ values as much as +1.5‰ (White et al. 2009:1529). Additionally, it has been demonstrated that for every 1000m of altitude above sea level that a plant is grown, there may be an increase of approximately 1‰ for the $\delta^{13}C$ values (White et al. 2009:1529). It must be noted that there may be marked discrepancies between isotopic values, particularly carbon isotopic values, between fauna and humans. Such differences are an "effect of dietary protein on the tissue-diet carbon isotopic fractionation factor" (White et al. 2009:1529). The expected variation between diet-tissue levels of $\delta^{13}C$ values in humans is approximately 5‰ higher in tissue, specifically collagen, than in diet (White et al. 2009:1529).

The analysis of $\delta^{13}C$ values present in human bone collagen may be coupled with the analysis of $\delta^{13}C$ values present in the structural carbonate of bone to provide a more complete proxy of the potential dietary sources accessed by the individual during their lifetime. When the phosphate (PO_4) and hydroxy (OH) are substituted for carbonate ($-CO_3$) in the apatite crystals of hydroxyapatite, structural carbonate is formed (Finucane et al. 2006:1767). Structural carbonate is a byproduct of cellular metabolism in which blood bicarbonate is generated (Finucane et al. 2006:1767). On average, blood biocarbonate is enriched approximately 9‰ by the ^{13}C present in the diet of an individual such that carbonate analysis is reflective of all components of the diet of an individual rather than just protein as in the case of collagen analysis

(Finucane et al. 2006:1768). Structural carbonate values for consumers of only C_3 plants is ap-

proximately -14.5‰ and for consumers of C_4 plants is approximately -0.5‰ (Finucane

2009:536).   When examining the carbonate and collagen isotopic profiles of a sample, the

$\Delta^{13}C_{carb-coll}$ value will be dependent on whether the organism has consumed a monoisotopic- or

polyisotopic-based diet (Finucane et al. 2006:1768). For organisms consuming carbohydrate

and protein sources with similar $\delta^{13}C$ values, the approximate $\Delta^{13}C_{carb-coll}$ values will be 4.4‰

(Finucane et al. 2006:1768). The $\Delta^{13}C_{carb-coll}$ values of organisms consuming food sources with

less negative $\delta^{13}C$ values than the overall diet will be <4.4‰ and that is demonstrated in or-

ganisms relying on marine protein sources and C_3 plants for their diet (Finucane et al.

2006:1768). Values for $\Delta^{13}C_{carb-coll}$ that are >4.4‰ are indicative of organisms that have a diet

consisting of protein sources with $\delta^{13}C$ values more negative than the $\delta^{13}C$ values of the over-

all diet and that is common in populations relying on terrestrial proteins and C_4 plants, such as

maize, as major dietary components (Finucane et al. 2006:1768).

3.3.4   Nitrogen isotopes

The analysis of $\delta^{15}N$ isotope values provides an estimation of the trophic level of an or-

ganism since $\delta^{15}N$ values are representative of the role of protein in the diet of an organism

(Reynard and Hedges 2008:1934). Higher order consumers, specifically carnivores and omni-

vores, have more positive $\delta^{15}N$ values than herbivores. The $\delta^{15}N$ values have been found to

increase in a step-wise fashion between trophic levels with herbivores having the lowest $\delta^{15}N$

levels and carnivores having the highest $\delta^{15}N$ values (Reynard and Hedges 2008:1934). Alt-

hough it must be noted that there is not a direct relationship between ^{15}N in the diet and ^{15}N in

the bodily tissues of an organism, the range of δ^{15}N present in human bone collagen ranges be-

tween -5‰ to +10‰ (Price and Burton 2011:93; Reynard and Hedges 2008:1934).

Tandem analysis of δ^{13}C and δ^{15}N isotope values permits an interpretation of the role of

marine-based food sources in the diet of an individual since marine-based food resources have

significantly more positive δ^{13}C and δ^{15}N values than terrestrial food sources (Goldstein

2005:220; Le Huray et al. 2009:100; Mays 2009:183). The isotopic signature of marine fish par-

allels the isotopic signature of C_4 plants; however, the isotopic signature of freshwater fish will

be reflective of "the differences in the concentration of dissolved inorganic carbonates which

are the source of carbon in many aquatic plants" (Finucane et al. 2006:1767). The $\Delta^{15}N_{diet-tissue}$

values for organisms vary based on the type of organism, type of tissue examined, and protein

level in the diet (Reynard and Hedges 2008:1934). Typically, the δ^{15}N values of tissues are

found to be approximately 2-3‰ higher than the δ^{15}N present in dietary sources (White et al.

2009:1529). Theoretically, if the $\Delta^{15}N_{diet-tissue}$ values for a human population are known, a com-

parison between the δ^{15}N values for humans and their potential dietary sources may be estab-

lished to determine the role of the potential dietary sources in the actual diet of the humans

(Ambrose 1991: 294; Reynard and Hedges 2008:1934). Unfortunately, the aforementioned

comparative analysis of δ^{15}N values for humans and their potential dietary sources is compli-

cated in archaeological populations due to a variety of factors including, but not limited to: the

establishment of accurate baseline measures for the δ^{15}N values of herbivores, calculation of

the role of marine-based food resources in the diet leading to higher-than-expected δ^{15}N lev-

els, and the role of aridity which may artificially inflate the δ^{15}N values in both human and fau-

nal remains (Ambrose 1991: 295-296; Reynard and Hedges 2008: 1934). Also, it is recognized

that undisturbed soil profiles have δ^{15}N values which increase with depth, so due caution must

be applied when selecting a soil sample for isotopic comparison (Ambrose 1991:296).

The δ^{13}C and δ^{15}N isotope ratios may be obtained through analysis of bone collagen or

enamel in fauna, including humans. Standard methods for isotopic ratio analysis employing

bone collagen focus on the extracted collagen yield of the bone as well as the C:N atomic ratio

of the extracted collagen (Le Huray et al. 2009:103). Typically, extracted collagen yields of less

than 0.5% should be treated with due caution in relation to stable isotopic analysis as the

amount of extracted collagen may be insufficient for accurate analysis (Le Huray et al.

2009:105). The quality of the collagen sample is highly dependent on post-depositional envi-

ronmental conditions as remains from areas with extremely high temperatures "may preserve

collagen for less than 1000 y[ears] while those from higher latitudes may preserve collagen for

up to 100,000 y[ears]" (Ambrose and De Niro1989:408). The C:N atomic ratio of human bone

collagen should theoretically be 3.23; however, the range for uncontaminated modern bone

ranges between 2.8 to 3.6 (Le Huray 2009: 105). As ranges of C:N for archaeological human

bone collagen has not been established, modern ranges should be applied (Le Huray 2009:105).

C:N ratios exceeding 3.6 may indicate contamination of the bone by external, exogenous organ-

ic carbon sources or through post-depositional diagenetic alterations (Ambrose and De Niro

1989:408; Katzenberg and Harrison 1997:274; Le Huray 2009:105).

3.3.5   Strontium isotopes

Radiogenic strontium (^{87}Sr/^{86}Sr) isotope analysis may be undertaken to assist in deter-

mining the potential geographic location of origin of an individual. Strontium may replace por-

tions of the calcium in the apatite of bone through diagenetic processes resulting from the in-

gestion of strontium in both food and water sources (King et al. 2011:2222). Unlike light stable

isotopes, such as nitrogen, carbon, and oxygen, "strontium isotopes do not undergo fractiona-

tion during biological processes" leading to a direct representation of strontium levels within

the preserved remains (Hodell et al. 2004:587).

3.3.6 Isotopes summary

The stable isotope analyses of various forms of skeletal material (i.e. bone collagen, and

bone and enamel carbonate) may be provide information related to a broad range of questions

formed through bioarchaeological lines of inquiry. Stable isotope data when employed in tan-

dem with the archaeological, archaethanatological, and osteological studies of mortuary set-

tings may permit interpretations to be formulated that would otherwise not have been possi-

ble. For burial sites, such as the CSMME-CNS, that may span several historic periods, the

aforementioned areas of research may be employed to provide a more thorough understanding

of the lives of the individuals interred within the cemetery.

4   RESEARCH DESIGN

4.1   Study background and objectives

The remains of a subset of individuals recovered from burials located in the secondary

chapel of the Capilla de Santa María Magdalena de Eten (CSMME), otherwise known as the

Capilla de El Niño Serranito (CSMME-CNS), were analyzed for both stable carbon and stable ox-

ygen isotopes. The CSMME and CSMME-CNS sites are located along the northern coast of Peru

in the Lambayeque Valley near the modern cities of Cuidad de Eten and Puerto Eten. As there

is a marked variability in the geographically- and climatically-mediated isotopic signatures of

oxygen values within the Andean region of Peru, individuals originating from the Andean region

may display different stable isotopic profiles than individuals originating in the coastal regions

of Peru (Turner et al. 2009:321). Furthermore, individuals originating from non-Andean re-

gions, such as those of European (specifically Spanish) or African origin, may display markedly

different stable oxygen isotopic signature profiles than individuals from within the Lambayeque

Valley.

- Are the individuals interred within the bounds of the CSMME and CSMME-CNS burial

   sites of local or non-local origin?

- If they are of non-local origin is it possible to firmly identify the possible geographic

   location of their origin?

The examination of stable isotopic oxygen signatures ($\delta^{18}O$ values) of tooth enamel car-

bonate permits the interpretation of the potential geographic origin of an individual since the δ

^{18}O values may be used as a proxy of local environment during the time in which the tooth

crown was formed (the first decade of life) (Turner et al. 2009:321). The stable oxygen isotopic

signature of structural carbonate of bone provides information related to the geographic locali-

ty of an individual during the final decade of life (Manolagas 2000). Through statistical analysis,

a comparison of the tooth enamel to bone carbonate stable isotopic oxygen values provides the

basis for theories related to the possible immigration status of individuals within the CSMME-

CNS sample population.

In addition to the aforementioned analysis of the remains sampled from the CSMME-

CNS site, stable carbon isotope analysis will be conducted. Analysis of stable carbon isotope (δ

^{13}C values) in tooth enamel carbonate permits interpretations related to dietary trends during

the tooth crown formation period. Examination of the stable carbon isotope in bone carbonate

provides information related to dietary trends during the last decade of the individual's life.

When such data are examined in combination with the stable isotopic oxygen data (both tooth

enamel and bone carbonate $\delta\,^{18}$O values), theories related to the relationship between social

status, dietary variability, and immigration may be formulated.

Indications of marked dietary variability (as determined through $\delta\,^{13}$C values) within a

population determined to have resided within the same geographic locale for the duration of

their lifespans (as determined through $\delta\,^{18}$O values) may be indicative of differential access to

dietary resources as a function of social stratification or social status.

- Are differences in access to dietary resources (per stable carbon isotope analysis) ev-
  ident for the subset of individuals sampled from the CSMME-CNS site?
- If so, how may these differences be explained in terms of the cultural context of the
  indigenous Muchik people suspected to occupy the region during the timeframe of
  the burials?

4.2 Site background

Excavations at the main CSMME site were conducted under the direction of Haagen D. Klaus and Jorge Alberto Centúrion in 2009 with the principle goal determining if the site was an early village of individuals of Spanish descent in an area previously populated by individuals of Muchik descent (Centúrion 2010:3). Based on local histories, the original iteration of the CSMME site was a chapel which was founded in A.D. 1533 by a Franciscan friar as a center for the forced resettlement of indigenous Muchik peoples (Klaus 2011:5). Based on the nearly consistent presence of the religious centers throughout their multiple iterations, it appears that there was a level of continuity within the community (Klaus 2012: personal communications). Also, it must be noted that during 16th and 17th centuries, the community of Eten appeared to have been thriving economically as they appear to have participated in broad trade networks that connected them with Central America (Klaus 2012: personal communications). Additional measures of economic security may be appreciated from a bioarchaeological/osteological perspective as the remains of individuals from the Eten region, particularly those contained within the CSMME and CSMME-CNS burial sites, appear to have had access to high quality nutritional resources (Klaus 2012: personal communications).

The main CSMME site is located approximately 2km to the southeast of the modern city of Ciudad Eten in the province of Chiclayo. Contained within the Lambayeque Valley Complex of Peru, the exact coordinates of the site are 6˚55'07.56"S, 79˚52'10.23"W (Centúrion 2010:6). The CSMME sites are located within 500 m of the Pacific coast, near the wetlands formed by the mouth of the Reque River, and they are surrounded by a multitude of semi-active Aoelian

sand dunes covered in phyletic plants (see Figure 1, below) (Centúrion 2010:9; Klaus 2012: per-

sonal communications).

Figure 1: Image of the semi-active Aeolian sand dunes covered with phyletic plants near the

CSMME site (Image Source: L. Brown, 2011)

Areas surrounding the CSMME site, including La Iglesia del Milagro de Eten (The Church of the Miracle of Eten) and the Restos de la Iglesia de Eten (The Remains of the Church of Eten) have been proposed as sites of potential cultural patrimony (Centúrion 2010:7). As of 2009, no formal legal acceptance of these claims has been validated; thus, there is a lack of protection awarded to both these sites as well as the adjacent CSMME and CSMME-CNS sites (see Figure 2, below) (Centúrion 2010:7).

Figure 2: La Capilla de El Niño Serranito (CSMME-CNS): The secondary chapel to the CSMME.

(Image Source: L. Brown, 2011)

At the beginning of the excavation, the only visible architecture associated with the CSMME site was a portion of the bell tower and some of the exterior walls (Centúrion 2010:7). Evaluation of the exposed walls of the CSMME structure revealed a stone base with overlying adobe brickwork ranging between 1.1m to 1.4m wide and 1.6m thick in the best preserved areas (Centúrion 2010:8). The adobe bricks are joined with a mud-based mortar layer composed of vegetable materials and gastropod shells (Centúrion 2010:28). There is evidence on at least one of the walls of ochre, black, red, yellow and orange pigments on the overall white-washed surface (high lime content paint) (Centúrion 2010:32, 37). Such decoration may have been consistent with both the Spanish and Moche traditions of fresco painting within the interiors of structures (Centúrion 2010:32, 37).The floor of the structure is lacking in adobe brickwork which was common in other colonial period churches (Centúrion 2010:32). Also, the composition of the building materials used to construct the CSMME-CNS chapel is markedly different than those used for the CSMME. In contrast to the adobe-bricked walls of the CSMME, the CSMME-CNS walls feature bricks composed of *quincha.*

4.3   Excavations at the CSMME sites

During 2009, excavations at the CSMME-CNS site were conducted in 10cm stratigraphic layers with Levels 1-3 yielding cultural information associated primarily with the 1949 construction of a memorial altar (Centúrion 2010:24). Contained in Level 4 was a fragmented, anthropomorphic, oxidized ceramic figure featuring colonial period vestments as well as adobe bricks (Centúrion 2010:24-25; Klaus 2012: personal communication; Moseley 1975: 192; van Geijseghem 2001: 266). The *quincha* bricks at CSMME-CNS frequently have remnants of broken

domestic ceramics (Centúrion 2010:29). Additionally, fragments of domestic ceramics were re-

covered within Level 4 in locations other than within the *quincha* bricks themselves (Centúrion

2010:25).

Level 5 was marked by a relatively flat surface layer of compacted, moist clay bearing

the visible marks of burial pits (Centúrion 2010:25). In this layer, the majority of the burials

were concentrated to the northeast and northwest sides of the structure (Centúrion 2010:25).

Contained within this level were the remains of 82 infants in a state of poor preservation due to

environmental factors (the high subsurface water table) as well as anthropogenic causes (the

use of heavy machinery at the site) (Centúrion2010:25).

Additional burials within Level 5 include those of 118 individuals ranging in age from in-

fant to older adult (Centúrion 2010:26). The individuals, of both sexes, are superimposed upon

one another and appear to have been interred with a lack of clothing or associated grave goods

(Centúrion 2010:26). Such a burial style is consistent with the Muchik style of burial. One ex-

ception is burial 5D-12, which appears to have been wearing a collar at the time of internment

(Centúrion 2010:26). All of the individuals were placed in a supine position (Centúrion

2010:26). Adults were placed with their heads to the north and their feet to the south; and ne-

onates and children were oriented with their heads to the south and their feet to the north

(with the exception of burials: 5D-9, 5D-12, 5D, and 5E-37-24) (Centúrion 2010:26). The afore-

mentioned positioning is, again, commiserate with Muchik burial styles (see Figure 3, below).

Figure 3: Multiple, overlying burials within the Stratigraphic Level 5 of the CSMME-CNS site

(Image Source: L. Brown, 2011)

It must be noted that in both the CSMME-CNS site and CSMME site the individuals interred within the confines of the sites' burial spaces range from in age from infant to adult; however, the north nave of the chapels were reserved solely for the burial of subadults (Centúrion 2010:37; Klaus 2012: personal communications). The individuals recovered from the nave of the CSMME chapel appear to have been buried without garments, textiles, or other associated grave offerings; however, three of the burials in the CSMME-CNS site feature grave offerings and textiles (Centúrion 2010:37). The internment styles of the individuals within the CSMME-CNS cemetery appear to be representative of a hybridized form of Muchik and Christian burial traditions (Centúrion 2010:38).With the exception of four individuals who were placed at an east to west orientation, all individuals were oriented on a south to north or north to south line with their skulls facing a westerly direction as was common with Muchik burial traditions (Centúrion 2010:38). All of the individuals were placed with their arms towards their solar plexus or crossed across the chest as is common in Christian burials (Centúrion 2010:38). Thus, the burials in the CSMME chapel anteroom and CSMME-CNS may be a reflection of a compromise between the Muchik and the Spanish colonialists regarding burial strategies (Klaus n.d., in press).

For the subadults buried at CSMME-CNS, their remains were recovered towards the western wall of the chapel in Level 3 of the stratigraphy and all of the individuals were interred in a supine position with the skulls to the south and their feet to the north (Centúrion 2010:40). Subadults recovered from Level 4 of the secondary chapel appear to follow the same burial positioning patterns as those in Level 3; however, in Level 4 there was some evidence of grave goods. Within Level 4 there were textiles and the presence of copper oxide residues near the

occipital region of some individuals that may have been indicative of a form of jewelry, such as earrings (Centúrion 2010:40). Within Level 5 of the stratigraphy at CSMME-CNS, there was a marked increase in the presence of water as a function of the upward infiltration of the water from the subsurface water table (Centúrion 2010:40). The infants and children recovered from Level 5 appeared to have some textiles associated with the remains; however, due to the increased presence of the water table in this level the preservation quality of the remains was markedly poorer than that of the higher levels within the unit (Centúrion 2010:40). Other than the presence and impressions of textiles, there were no associated grave offerings recovered from Level 5 (Centúrion 2010:41). Stratigraphic level 6 was determined to be devoid of remains and cultural materials (Centúrion 2010:41).

Based on evaluation of the matrix, all of the burials within the CSMME-CNS site appear to have been primary burials (Klaus 2011:9). With the exception of one individual buried at CSMME-CNS (not represented in the data set), there appears to have been no intentional secondary burials or post-mortem manipulations of the remains as is common at other Early Contact Period Muchik burial sites (Klaus 2011:4, 13; Klaus 2102: Personal communications).Additionally, with the exception of one burial (not represented in the data set), there appears to have been no intentionally delayed or prolonged burials, as evidenced by the presence of necrophagous insects, at the CSMME-CNS site (Klaus 2011:10).

4.4   Materials and methods

Bone and tooth samples obtained from burials at the CSMME-CNS (2009 field season) were provided for carbon and oxygen isotopic analysis (via carbonate) by Dr. Haagen D. Klaus of

Utah Valley University. There were 242 burials uncovered during the 2009 field season at the

CSMME-CNS site (Klaus 2011:6). Overall, 87 bone samples and 94 tooth samples were provided

for both carbonate and collagen analysis of O, C, N, and Sr stable isotopes as part of a more ex-

pansive project related to population mobility and dietary variations for the colonial site of

Eten. The majority of bone and tooth samples were collected from different individuals; how-

ever, there were 15 individuals that yielded both bone and tooth samples. For the purposes of

this study, bone and tooth samples derived from a single individual were examined since the

focus of the study involves the comparison of beginning of life to end of life data for both geo-

graphic location as well as dietary variability. Also included in the subset for analysis was an

individual yielding only a bone sample and one yielding only a tooth. These individuals were

selected to provide additional data points for the set bringing the total number of bone and

tooth samples analyzed to 32 (n = 32). Figure 4 (below) features a unit map with the locations

of the sampled burials shaded with the exception of burials 5E-27 and B19-43.

Unit 5D									
0	**1**	2	3	4	5	6	7	8	9
20	21	22	23	24	25	26	**27**	28	29
30	31	32	33	34	35	**36**	**37**	38	39
40	41	42	43	44	45	46	**47**	48	49
50	**51**	52	53	54	55	56	**57**	**58**	59
60	**61**	62	63	64	65	66	67	68	69
70	**71**	**72**	73	74	**75**	76	77	78	79
80	81	82	83	84	85	86	87	88	89
90	91	92	93	94	95	96	97	98	99

Unit 5E									
0	1	2	3	4	5	6	7	8	9
0	21	22	23	24	25	**26**	27	28	29

Figure 4: CSMME units 5D and 5E (not to scale). Sampled burials highlighted in blue. (Adapted from Centúrion 2010:38)

For the samples selected from the CSMME-CNS site for carbonate analysis, the internment setting appear to be above the water table and that greatly reduces the chance for post-depositional diagenetic alteration. Additionally, it must be noted that oxygen isotopic signature of a sample may be affected by the heating of the sample in excess of 300°C (Knudson 2009:173). Based on the site conditions at CSMME-CNS, particularly a marked lack of carbon deposits indicating an incineration event, it is highly unlikely that the human remains evaluated were directly heated above 300°C.

The samples provided were individually contained within small, zip-sealed plastic bags labeled with provenience information. Based on visual inspection, most of the tooth samples appear to be either second or third molars and all of the bone samples are ribs. Preparation for carbonate analysis was conducted in the Bioarchaeology Laboratory at Georgia State University in Atlanta, Georgia under the direction of Dr. Bethany L. Turner.

4.4.1 Enamel preparation

Preparation for carbonate analysis of tooth enamel was performed following established methods (Ambrose (1993), Garvie-Lok et al. (2004), Schoeninger et al. (1989), and van der Merwe et al. (1995))as adapted by Turner and colleagues (2005). Each tooth was cleaned with acetone and a cotton swab to remove surface contaminants while avoiding scratching of the enamel. Following the initial cleaning process, a polyvinylsiloxine mold of each tooth was created to permit further evaluation of microdental wear as the tooth is inevitably destroyed during the carbonate analysis process. The apex of the most prominent cusp to the cervical-enamel junction of each tooth was sampled using a Brasseler USA NSK:Z500 dental drill fitted with a NTI- Kahla GmbH tungsten carbide rotary wheel attachment. The residual dentine from each sample was removed at the enamel-dentine junction (cervix) using the same instrument. As diagenetic processes tend to affect only the outermost layers of enamel, approximately 1 mm of the exterior enamel surface was removed by abrasion using the same tungsten carbide rotary wheel attachment (Turner et al. 2009:321). Between tooth preparation processes, the rotary wheel was thoroughly cleaned with acetone and rinsed with ddH2O. A minimum of 0.0255 grams (range: 0.0255g to 0.11933g; average: 0.0.064363g) of enamel was sampled from

each tooth. The cut and abraded portions of each tooth were then individually pulverized using

an agate mortar and pestle which was cleaned between samples using acetone and ddH2O.

The samples were then soaked for 24 hours in a 3:1 solution of 2%NaOCl (sodium hypochlorite,

commonly referred to as bleach) and ddH2O in 15-mL falcon tubes (Turner et al. 2005:128).

The 24 hour time period was sufficient for degassing in the solution to cease indicating the re-

moval of organic material. After the NaOCl soak, the samples were centrifuged and rinsed to

neutral using ddH2O. Once the samples were verified to be neutral, they were soaked in a 0.2%

acetic acid solution for 2 hours at approximately 4˚C. The 0.2% acetic acid solution removes

any remaining diagenetic contaminants, as well as any exogenous carbonates, while reducing

the risk of both excessive dissolution and recrystallization of the sample (Garvie-Lok et al.

2004:765; Turner et al. 2009:322). Following the acetic acid soak, the samples were centrifuged

and rinsed to neutral using ddH2O. Then, the samples were freeze-dried and sent to the De-

partment of Geological Sciences at the University of Florida at Gainesville where they were di-

gested on an automated preparation system contained at 50˚C using 100% phosphoric acid.

Under the direction of Dr. Jason Curtis at the University of Florida, the samples were interfaced

with a VG prism mass spectrometer. All enamel carbonate samples were tested for both $\delta^{18}O$

and $\delta^{13}C$ values; yet, the testing was conducted during two separate periods. Results for the

both the $\delta^{18}O$ and $\delta^{13}C$ values of the samples from both evaluation periods were expressed as

per mil (‰) values relative to the Vienna Pee Dee Belemnite (VPDB) standard. The precision of

the NBS-19 standards for the evaluation periods for $\delta^{13}C$ were ±0.028‰ (n=8) and ±0.014‰

(n=6) and were±0.049‰ (n=8) and ±0.070‰ (n=6) for $\delta^{18}O$.

Methods for the preparation of bone for carbonate analysis parallel those for enamel. For each sample, a section of bone approximately 2 inches in length was divided along the longitudinal axis using the same dental drill and tungsten carbide rotary blade attachment that used in the preparation of the enamel samples. The trabecular layer of the bone was removed and the exterior cortical surface was abraded with the same rotary attachment to remove the layer of bone most likely to have been altered by diagenetic processes, as well as to remove any exogenous materials. The cut bone samples were then placed in a ddH2O bath and sonicated to further remove exogenous materials. The sonication process was repeated twice for each sample. Following sonication, the bones were permitted to fully dry (minimum of 24 hours) and then each sample was individually ground to a fine powder using an agate mortar and pestle. The mortar and pestle were cleaned with acetone and rinsed with ddH2O between the processing of samples. Following the pulverization of the bone samples, the samples were processed identically to the enamel samples. A minimum of 0.12g of bone was sampled for the purposes of carbonate analysis (range: 0.12g to 0.85g; mean: 0.40g). Both the sodium hypochlorite and acetic acid soaks were conducted. The samples were freeze dried and shipped to the same laboratory at the University of Florida for processing at the same time as the initial batch of enamel carbonate samples.

5 RESULTS

5.1 Stable isotope analysis results

The raw data for the carbonate analysis (δ^{18}O and δ^{13}C values) of the bone and enamel from the individuals sampled at CSMME-CNS are featured in Table 1, below.

Table 1: CSMME-CNS carbonate analysis results for bone and enamel

CSMME Site Codes	Enamel δ ^{18}O (‰, vs VPDB)	Bone δ ^{18}O (‰, vs VPDB)	Bone-Enamel δ ^{18}O (‰, vs VPDB)	Enamel δ ^{13}C (‰, vs VPDB)	Bone δ ^{13}C (‰, vs VPDB)	Bone-Enamel δ ^{13}C (‰, vs VPDB)
B19-02A	-3.3			-5.1		
5D-27	-4.5	-3.5	1.0	-3.3	-4.3	-1.0
5D-11	-5.1	-4.4	0.7	-5.0	-4.7	0.3
5D-36	-3.9	-4.8	-0.9	-2.1	-4.3	-2.3
5D-61	-4.2	-4.3	-0.1	-4.0	-5.0	-1.0
5D-51	-4.7	-4.2	0.5	-5.6	-4.5	1.1
5D-58	-4.3	-4.4	-0.1	-3.9	-2.8	1.1
5D-47	-4.6	-4.6	0.0	-4.0	-3.7	0.3
5D-75	-4.4	-4.5	0.0	-4.1	-4.4	-0.3
5D-60	-4.5	-4.5	0.0	-3.2	-4.6	-1.4
5E-26	-4.2	-4.2	0.0	-3.3	-4.0	-0.7
5D-71	-3.9	-4.7	-0.8	-3.5	-4.7	-1.2
5D-37	-4.3	-4.9	-0.6	-3.9	-4.4	-0.5
5D-57	-4.2	-4.4	-0.2	-3.1	-5.3	-2.3
5D-72	-4.3	-5.0	-0.7	-2.6	-4.4	-1.8
5E-31	-3.5	-4.7	-1.2	-4.6	-4.1	0.5
B19-43		-2.6			-3.8	

The values for δ ^{18}O and δ ^{13}C, as featured in Table 1, are reported as compared Vienna Pee Dee Belemnite (VPDB); however, it is standard practice to report the δ ^{18}O values for carbonate analysis with respect to Standard Marine Ocean Water (SMOW). The conversion equation for the $\delta^{18}O_{C(VPDB)}$ to $\delta^{18}O_{(VSMOW)}$ ($\delta^{18}O_{(VSMOW)}$ = (1.03091 x ($\delta^{18}O_{C(VPDB)}$)) + 30.91) as estab-

lished by Coplen and colleagues (1983) and used by Knudson (2009:177) results in the values featured in Table 2 (below).

Table 2: $\delta^{18}O_{C(VPDB)}$ to $\delta^{18}O_{(VSMOW)}$conversions

CSMME Site Codes	Enamel δ ^{18}O (‰, vs VPDB)	Enamel δ ^{18}O (‰, vs SMOW)	Bone δ ^{18}O (‰, vs VPDB)	Bone δ ^{18}O (‰, vs SMOW)
B19-02A	-3.3	27.5		
5D-27	-4.5	26.3	-3.5	27.3
5D-11	-5.1	25.7	-4.4	26.3
5D-36	-3.9	26.9	-4.8	26.0
5D-61	-4.2	26.6	-4.3	26.5
5D-51	-4.7	26.1	-4.2	26.6
5D-58	-4.3	26.5	-4.4	26.3
5D-47	-4.6	26.2	-4.6	26.1
5D-75	-4.4	26.3	-4.5	26.3
5D-60	-4.5	26.3	-4.5	26.3
5E-26	-4.2	26.6	-4.2	26.6
5D-71	-3.9	26.9	-4.7	26.1
5D-37	-4.3	26.4	-4.9	25.9
5D-57	-4.2	26.5	-4.4	26.4
5D-72	-4.3	26.5	-5.0	25.8
5E-31	-3.5	27.3	-4.7	26.0
B19-43			-2.6	28.3

Figure 5 (below) features the bone carbonate and enamel carbonate values for samples

taken from selected individuals interred at the CSMME site (as detailed in Table 1, above).
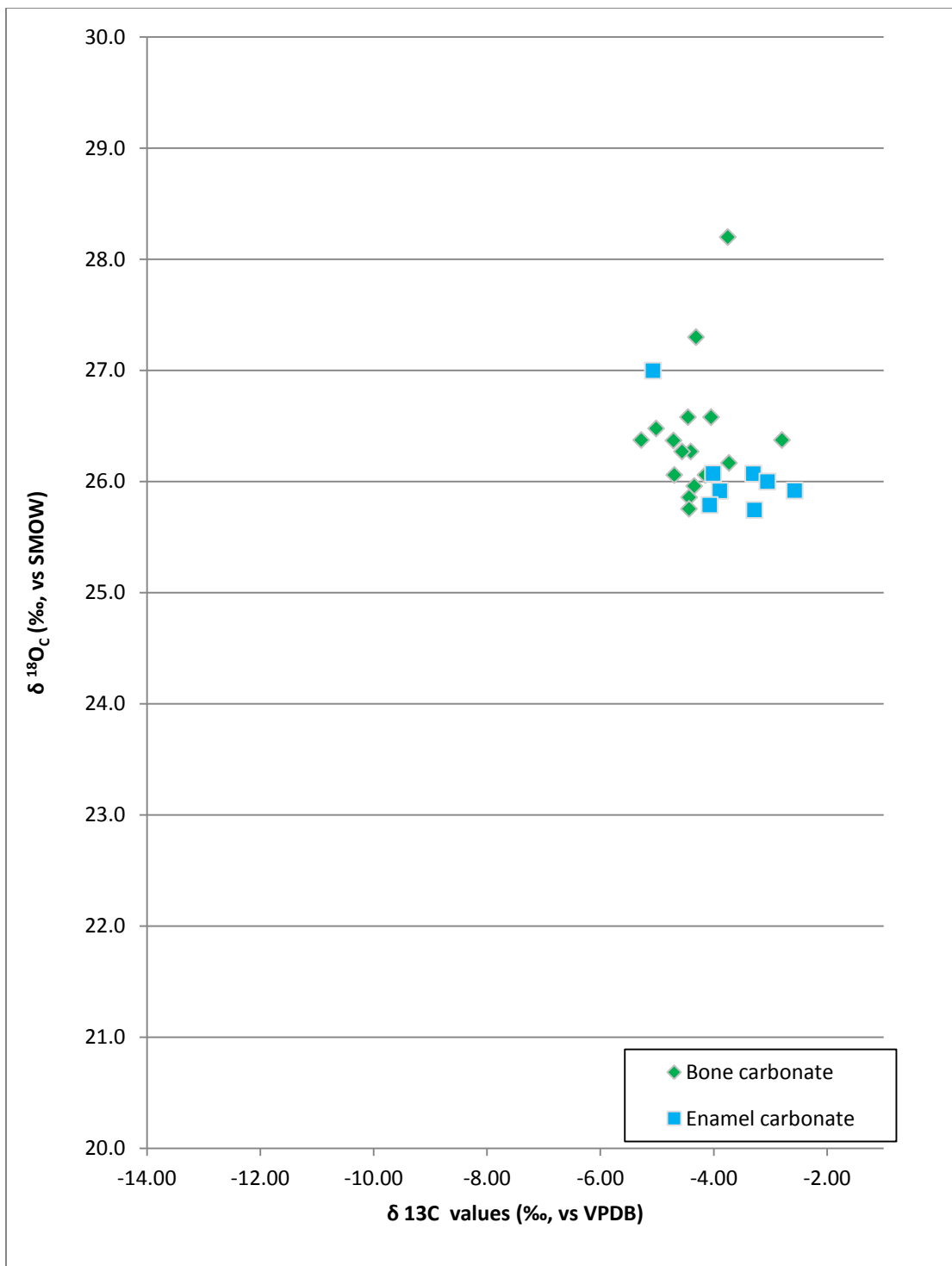
Figure 5: Bone carbonate and enamel carbonate values for individuals interred at CSMME-CNS (regional scale)

The scale of Figure 5 (above) features an expanded view of the values with relation to the carbonate values commonly determined for samples obtained in the Andean region of South America. Such a perspective permits the assessment of the carbonate values obtained from the CSMME-CNS samples with respect to regional carbonate values. A reduction of the scale of Figure 5 to provide a more focused, site-specific view of the carbonate results is featured in Figure 6 (below).
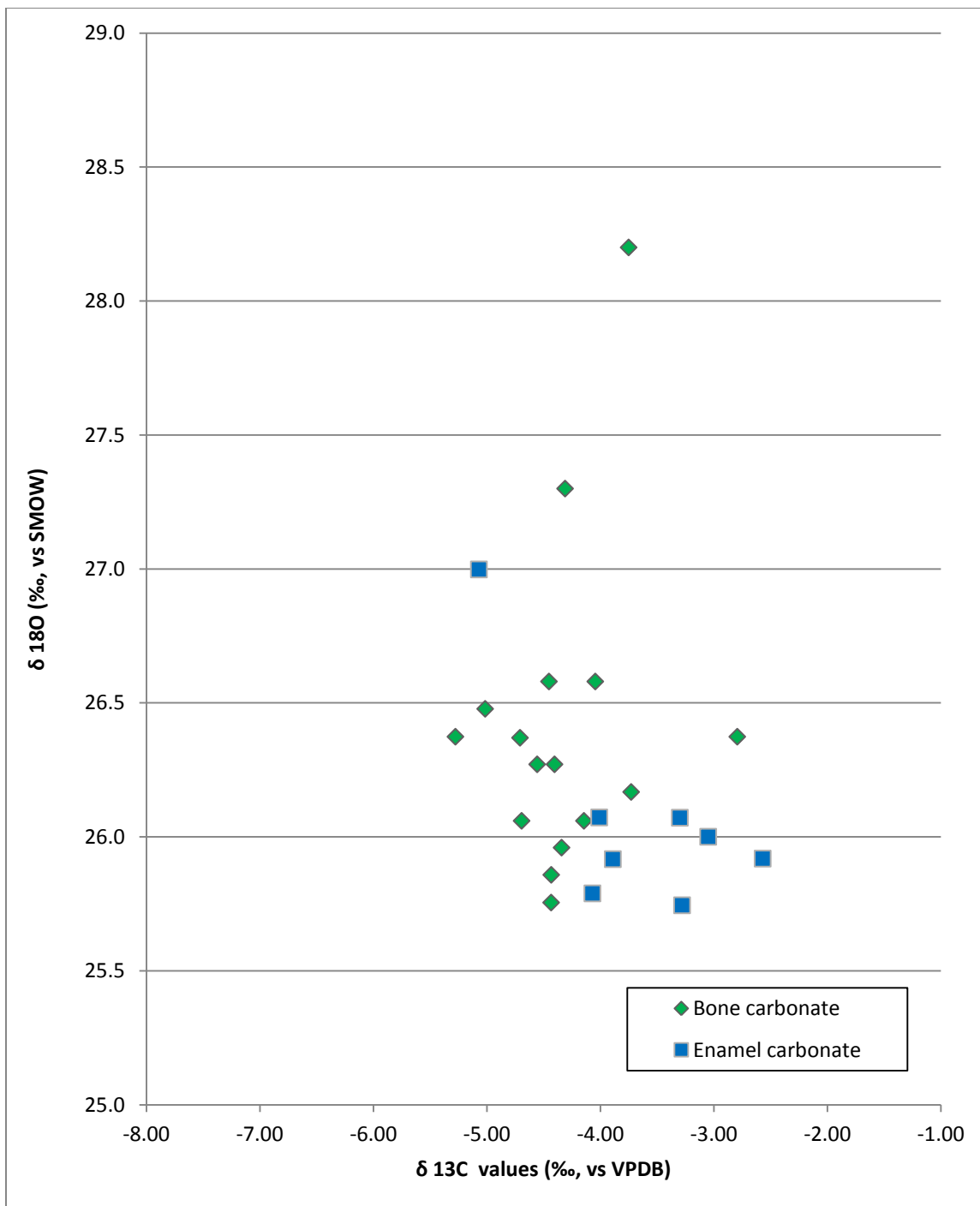
Figure 6: Bone carbonate and enamel carbonate values for individuals interred at CSMME-CNS (site-specific view)

Figure 7 (below) delineates the relationship between the bone and enamel carbonate values, as featured in Table 1, on an individual basis within the regional scale (as detailed in Figure 5).

Figure 7: Carbonate values (bone and enamel) for selected individuals from the CSMME-CNS site (regional view)

Figure 8 (below) details the individual relationship between carbonate data values for selected individuals from the CSMME-CNS site (per Table 1) on a site-specific scale (as featured in Table 7).
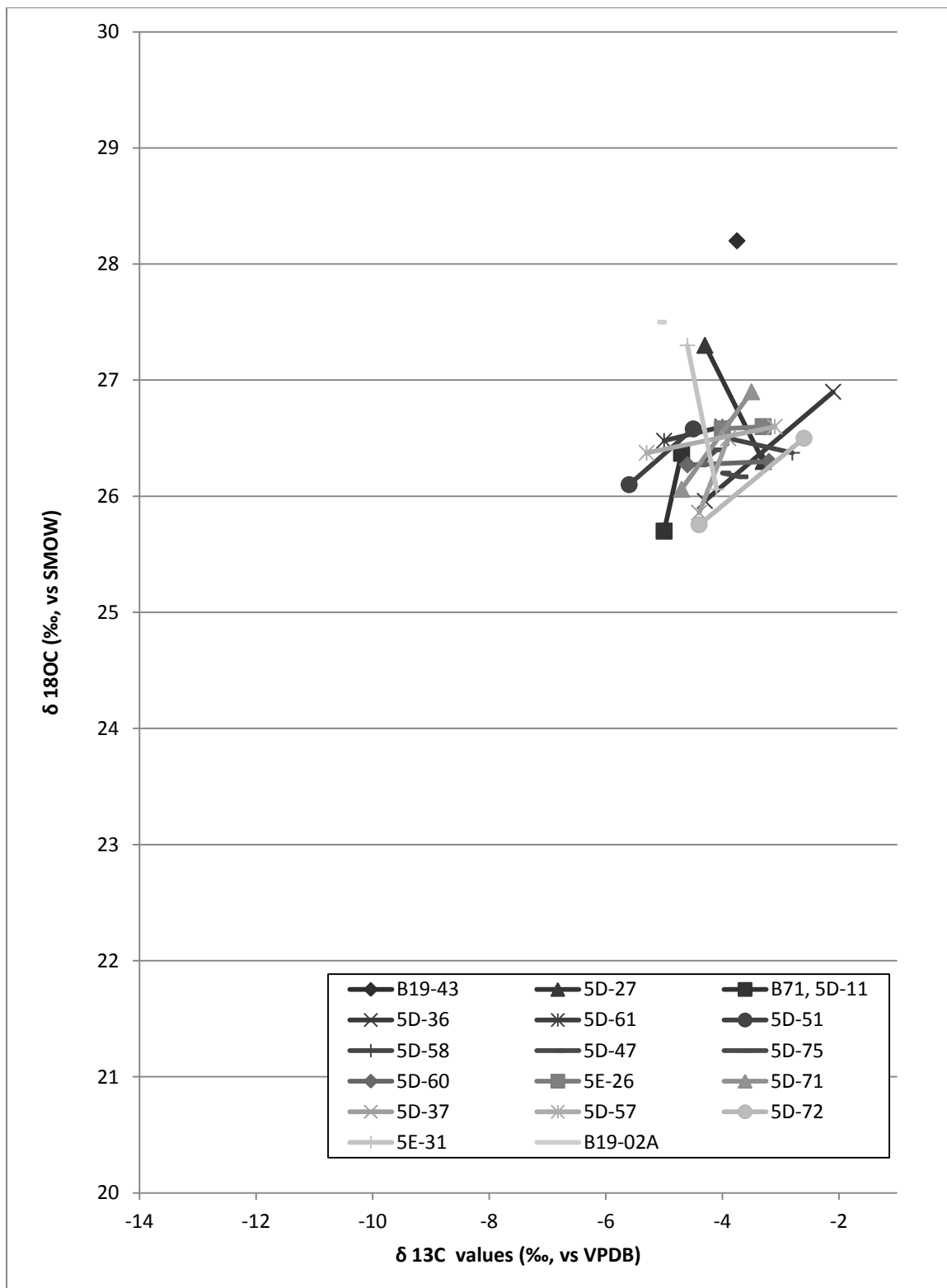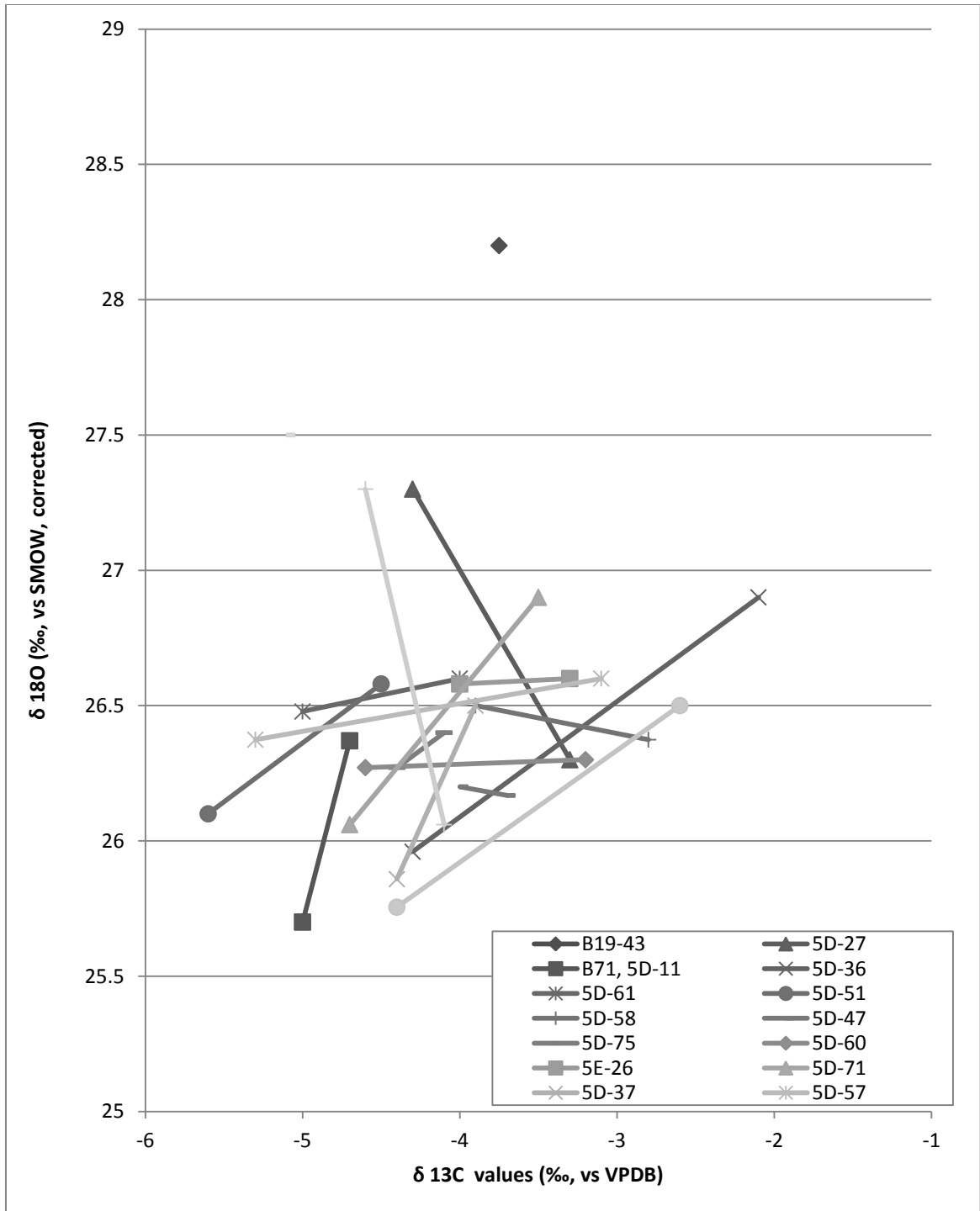
Figure 8: Carbonate values (bone and enamel) for selected individuals from the CSMME-CNS site (site-specific view)

Table 3 (below) features the mean, mode, range, and standard deviation values for each car-

bonate data set.

Table 3: Mean, standard deviation (St Dev), median, and range for the carbonate data sets

from selected individuals at the CSMME-CNS site

	Enamel δ ^{18}O (‰, vs VPDB)	Bone δ ^{18}O (‰, vs VPDB)	Enamel δ ^{18}O (‰, vs SMOW)	Bone δ ^{18}O (‰, vs SMOW)	Enamel δ^{13}C (‰, vs VPDB)	Bone δ ^{13}C (‰, vs VPDB)
Mean	-4.2	-4.4	26.5	26.4	-3.8	-4.3
St Dev	0.4	0.6	0.5	0.6	0.9	0.6
Median	-4.3	-4.4	26.5	26.3	-3.9	-4.4
Range	1.8	2.4	1.8	1.5	3.0	2.2

5.2   Discussion

5.2.1   Overview of results within an Andean context

The environmental conditions of the Andes present unique challenges for the interpre-

tation of the carbonate data. As the ^{16}O isotope is lighter in mass and requires less energy to

evaporate than the ^{18}O isotope, the ^{18}O isotope is preferentially precipitated at the lower alti-

tudes into groundwater and ocean water such that the water sources at higher altitudes within

the Andes may contain higher levels of ^{18}O than water sources at lower altitudes (Holden

2003:761; Katzenberg and Harrison 1997:275; Knudson 2009:172; Le Huray et al. 2009:100;

Price and Burton 2011:91). The coast of Peru is typically characterized as being a desert ecolog-

ical zone punctuated by small rivers (~50) that carry runoff water from the higher altitude re-

gions (Blom et al. 2005:153). Such rivers provide sources of water for both consumption as well

as irrigation for agriculture. The flow of the rivers is mediated by the seasonal flow of highland

Andean rainfall, but both the highlands and the coastal desert region may be affected by El Ni-

ño- Southern Oscillation (ENSO)-related weather events.

The Humboldt Current that drives many of the weather patterns on the Pacific Coast of

Peru is occasionally overridden by the ENSO weather phenomenon (Contreras 2010: 256;

Dillehay et al. 2004: 4325; Quilter 2002:156). The ENSO weather phenomenon introduces

warm waters into the normally cold waters of the Pacific Coast of Peru leading to torrential

rains along the arid coast, mass casualties of the marine life that is accustomed to the cold wa-

ter temperatures, and droughts in the south-central alti-plano area of the Andes as well as Am-

azon region (Blom et al. 2005:153; Contreras 2010:256, 259; Moore 1991:29). The torrential

rains and flooding in coastal regions produced by ENSO events may have led to irrigation sys-

tem damage which would impede agricultural production in post-ENSO event periods. It must

be noted that there is evidence of an increase in some groundwater-based agricultural activities

as well as additional opportunities for grazing of certain species of ruminant animals in normally

arid areas (Dillehay et al. 2004: 4326).

The ENSO weather phenomenon was first noted in colonial period literature and the se-

verity of documented ENSO events has varied considerably over the past 400 years (Contreras

2010:256; Moore 1991:29). Based on sediment core data, it has been demonstrated that ENSO

weather events have occurred off the coast of Peru since at least A.D. 3350 with 2-10 year cy-

cles that typically last for 2-6 years (Contreras 2010:257; Dillehay et al. 2004: 4325). Also, ac-

cording to data taken from the Quelccaya ice core from southern Peru, it has been determined

that there were wide-spread droughts in Peru from A.D. 524 and 540, A.D. 563 and 594, A.D.

636 and 645, and A.D. 1245 and 1310 (Dillehay et al. 2004:4325). Based on the frequency of

the ENSO-related events, the Muchik indigenous populations of the north coast of Peru would

have undoubtedly been affected by such weather systems.

The effects of ENSO-based weather patterns on the availability of water within the

northern Andes, particularly along the coast, may directly influence the stable oxygen isotopic

signatures for the indigenous peoples of the region. Water source availability may shift from

high altitude to lower altitude sources or vice-versa. The timing of ENSO events must be ac-

counted for during the interpretation of stable oxygen isotope data in the Andean region of Pe-

ru. Furthermore, the preparation of some food sources commonly consumed by the indige-

nous populations of Peru, such as the maize-based beverage *chicha*, requires the boiling of wa-

ter which results in the increased evaporation of ^{16}O leading to an enrichment of the ^{18}O lev-

els(Knudson 2009:173). The interpretation of δ^{18}O data from the carbonate analysis of human

bone and enamel from individuals interred in or suspected to originate from the Andean region

of South America must be considered in relation to the specific environmental, geographic, and

culturally-mediated food preparation conditions that exist within those areas.

5.2.2   Discussion of South Central Andean environmental zonation: The *chala* zone

There are multiple environmental and geographic zones within the South Central Ande-

an region of South America. The coastal zone of Peru and northern Chile, known as the *chala*

zone in the Quechua language, is located no more than 500 meters above sea level (m.a.s.l.)

(Knudson 2009:174). Most areas of the *chala* zone are highly arid with some portions receiving

less than 50 mm of precipitation per year, usually in the form of heavy fog and periodic rains (Knudson 2009:174). From 1988-2002, in La Serena, Chile located on the Pacific Coast (470 km north of Santiago, Chile) the observed δ^{18}O values (versus SMOW) averaged -5.6‰ ± 2.3‰ (Knudson 2009:174). Although this region is exceptionally arid, the rivers that flow through the area originate in the Andes mountains and flow west towards the coast and create land in the *chala* zone that is cultivable and habitable (Knudson 2009:174). Temperatures reach 25-35˚C within this zone permitting the cultivation of crops such as: beans, maize, peanuts, squashes, cherimoya, lúcama, sugar cane, and cotton (Knudson 2009:174). In addition to the terrestrial botanical resources of the *chala* zone, there are "coastal plant communities called *lomas*, which contain epiphytic plants adapted to the fog, [which] have resources for both humans and camelids" (Knudson 2009:174). *Loma*-based plants, as they are adapted to the fog, are enriched by ^{18}O from meteoric water sources resulting in "higher δ^{18}O values than rainwater values along the coast" (Knudson 2009:174). Soils within the highly arid *chala* zone contain higher levels of ^{18}O as compared to the oxygen isotopic signatures of the precipitation of the region due to the marked evaporation of ^{16}O due to the aridity of the region (Knudson 2009:174). Additionally, given the proximity to the ocean as well as the low altitude of the *chala* zone, an enrichment of δ^{18}O values is expected (Knudson 2009:174).

As much of the usable water sources in the *chala* region are from riverine sources which originate at higher altitudes within the Andes, there is a reduction of the δ^{18}O values in the high altitude-based river sources as compared to the zonal δ^{18}O values for precipitation(Knudson 2009:174). Also, precipitation from sources at higher altitudes than the *chala* zone is incorporated into the geological water found in underground aquifer systems that may

be accessed through natural springs or man-made wells (Knudson 2009:174). The flow of the water from higher altitude sources, whether through the rivers or underground aquifers, is subject to further evaporative processes leading to further enrichment of ^{18}O and increased δ^{18}O values (Knudson 2009:174). It must be noted that as compared to the high-altitude snowpack itself, the fractionation process of oxygen isotopes in snowmelt and glacial melt results in a depletion of ^{18}O (Knudson 2009:175). As compared to SMOW, δ^{18}O values for surface water taken from rivers in northern Peru ranges between -3.7‰ and -5.7‰ and groundwater derived from underground aquifers in the same region ranges between -4.2‰ and -5.1‰ (Knudson 2009:174).

5.2.3 Discussion of South Central Andean environmental zonation: The *yunga* zone

The zone located between 500-2300 m.a.s.l. is considered to be a mid-altitude zone referred to as the *yunga* zone in Quechua (Knudson 2009:174). It is characterized by higher levels of precipitation (50-200mm) and milder temperatures (as compared to the *chala* zone) (Knudson 2009:174). Common crops in the *yunga* zone include: maize, coca, cherimoya, lúcama, guayaba, and *ají* peppers (Knudson 2009:174). As the altitude of the *yunga* zone is relatively higher than that of the *chala* zone, it is expected that there will be less of an enrichment of ^{18}O values in the zonal precipitation (Knudson 2009:175).

Samples in the *yunga* zone were taken from springs at the same longitude and latitude as the river surface water and underground water sources that were sampled from the *chala* zone such that the main difference of sampling environment is the altitude (Knudson 2009:175). As expected, the δ^{18}O values (versus SMOW) are linked to altitude such that at 2020

m.a.s.l. the δ ^{18}O is -8.6‰, at 1450 m.a.s.l. the δ ^{18}O is -7.1‰, at 990 m.a.s.l. the δ ^{18}O is -6.1‰,

and at 105 m.a.s.l. the δ ^{18}O is -5.1‰ (Knudson 2009:175).

5.2.4   Discussion of South Central Andean environmental zonation: The *quechua* and *suni* zones

Although both the high-altitude *quechua* (2300-3500 m.a.s.l.) and *suni* zones (3500-4000

m.a.s.l.) are agriculturally productive zones, they experience temperatures with large diurnal

ranges (10˚C) and are semi-arid with annual precipitation averages between 500-1000mm

(Knudson 2009:175). In these zones, terraced agriculture systems are employed to grown high-

altitude crops such as quinoa, oca, and potatoes (Knudson 2009:175; Pozorski and Pozorski

1990:24). The aforementioned zones may experience an enrichment of δ ^{18}O values due to in-

creased rates of precipitation (Knudson 2009:175). River water in these zones includes both

precipitation from higher altitude sources as well as snowmelt and glacial melt waters. The in-

clusion of such water sources leads to depleted δ ^{18}O values in the river water (Knudson

2009:175).

5.2.5   Discussion of South Central Andean environmental zonation: The *puna* zone

The *puna* zone is located between 4000 and 8000 m.a.s.l. and is composed mainly of al-

pine tundra and grasslands with an average annual precipitation of between 200-1500mm

which is derived mainly from Pacific and Amazonian air masses (Knudson 2009:175). Due to air

flow patterns, the east-facing slopes receive markedly more precipitation than the west-facing

slopes (Knudson 2009:175). In this zone, the median annual temperatures vary by only 5˚C yet

daily temperature fluctuations can be as much as 20˚C (Knudson 2009:175). The grasslands of

the *puna* zone can be subdivided into the *páramo* (lower elevation, generally wetter) and *altiplano* (higher elevation, generally drier). Both of these grassland types are ideal for the herding of domestic camelids (llama and alpaca) and wild camelids (guanacos and vicuñas) (Knudson 2009:175).

Observed oxygen isotope signatures for precipitation in this zone were recorded as $\delta^{18}O$ $_{(V\text{-}SMOW)}$= -13.3‰ to -10.8‰ from 1996-2001 in La Paz, Bolivia; $\delta^{18}O_{(V\text{-}SMOW)}$= -13.3‰ ± -5.3‰ at Puno, Peru from 2001-2002; and $\delta^{18}O_{(V\text{-}SMOW)}$= -17.6‰ ± -4.5‰ at Isla Taquile in Lake Titicaca, Peru from 2001-2002 (Knudson 2009:175). At high altitudes, such as those in the *puna* zone, the $\delta^{18}O$ present in the precipitation is a combination of Atlantic-sourced moisture and the deposition and modification of glaciers and snow within the region and at higher altitudes (Knudson 2009:175). In this zone, the groundwater oxygen isotope signatures are less variable than those of the precipitation oxygen isotopic signatures as they reflect a combination of pre-cipitations, evaporation, and glacial melt water (Knudson 2009:175). Between 1998-2001 sur-face water collection from the Lake Titicaca Basin produced $\delta^{18}O_{(V\text{-}SMOW)}$ values of -17.6‰ to -12.6‰ and surface water collection of the Llinqui River produced a $\delta^{18}O_{(V\text{-}SMOW)}$ of -12.4‰ ± -2.2‰ (Knudson 2009:175). Groundwater samples taken in 1998-1999 from a spring near Juli, Peru exhibited $\delta^{18}O_{(V\text{-}SMOW)}$ values of -16.7‰ ± -0.3‰ (Knudson 2009:176).

5.2.6 Discussion of South Central Andean environmental zonation in relation to the CSMME-CNS stable isotope data

As the basic environmental patterns of the Andes have not changed significantly over the past 2000 years (based on core data from the Quelccaya ice cap and a comparison of stron-tium isotope data), modern oxygen isotope signatures of precipitation, groundwater, and river

sources may be used as a proxy for prehistoric oxygen isotope signatures (Knudson 2009:175).

Analysis of the enamel and bone carbonate values ($\delta^{18}O$ and $\delta^{13}C$) for samples selected from

throughout the Andean region of South America are featured in Table 4 (below).

Table 4: Bone and enamel carbonate values from select archaeological sites in the South Central Andean Region of South America (Knudson 2009:180)

Site	Geographic Location	Environ-mental Zone	Occupa-tion Period	Enamel δ ^{18}O$_{(VPDB)}$	Mean Enamel δ ^{18}O$_{(VPDB)}$	Enamel and Bone δ ^{18}O$_{(VPDB)}$	Mean Enamel and Bone δ ^{18}O$_{(VPDB)}$
Nazca Drainage	Southern Peru	*Chala*	Early Intermediate (AD 1-600)	-3.8‰ to -10.6‰	-7.8‰ ± 2.0‰		
Moquegua Valley	Southern Peru	*Quechua*	Middle Horizon (AD 600-1100)	-2.9‰ to -7.0‰	-6.0‰ ± -1.4‰		
Lake Titica-ca	Western Bolivia	*Puna*	Middle to Late Hori-zon (AD 600-1500)		-9.7‰ ± 2.9‰	-4.7‰ to -17.4‰	
San Pedro de Ataca-ma Oases: Loa River Valley site of Caspana	Northern Chile	*Yunga*	Late Inter-mediate Period (AD 100-1400)	-2.9‰ to -4.9‰	-3.8‰ ±0.6‰		
San Pedro de Ataca-ma Oases: Casa Pa-rroquial, Coyo Oriental, and Tche-car sites	Northern Chile	*Yunga*	Middle Horizon (AD 500-1100)			-2.9‰ to -4.9‰	-4.8‰ ± 1.3‰

For the sites featured in Table 4 (above) Knudson (2009:177, 184) converted the $\delta^{18}O_{(VPDB)}$ values for the carbonate analysis of the third-molar enamel and bone to drinking water $\delta^{18}O_{dw(V-SMOW)}$ values using conversion equations set forth by Luz and colleagues (1984). In the Nazca Drainage region, the mean enamel and bone $\delta^{18}O_{dw(V-SMOW)}$ = -11.3‰ ± 2.6‰ (n = 29); for the Moquegua Valley sites the mean enamel and bone $\delta^{18}O_{dw(V-SMOW)}$ = -8.9‰ ± 1.8‰ (n = 7) ; in the Lake Titicaca Basin mean enamel and bone $\delta^{18}O_{dw(V-SMOW)}$ = -12.6‰ ± 3.5‰ (n = 63); and at sites within the San Pedro de Atacama oases the mean enamel and bone $\delta^{18}O_{dw(V-SMOW)}$ = -7.4‰ ± 1.7‰ (n = 51) (Knudson 2009:184).

Due to a marked absence of academic literature relating to the stable oxygen isotope values for human remains along the north coast of Peru, comparisons to such values for the southern portion of Peru, as summarized by Knudson (2009), are developed. Although such comparisons are not ideal, they are the only feasible method for comparative data analysis available at the present time. Based on the construction dates for the CSMME-CNS site (spanning A.D. 1533- 1776), the individuals interred within the structure may have existed during the last Late Inka well into the Colonial Period. Efforts to accurately date the individuals interred within the site may be stymied due to the error associated with radiocarbon dating techniques. Although the error associated with radiocarbon dating is dependent on the type of test employed, average error may be expected to be around ±70 years (Vega 2009:89-90). Radiocarbon dating techniques cannot be used to accurately determine the historical time period during which the burials at CSMME-CNS occurred.

Since it is likely that the individuals interred at the CSMME-CNS site were interred sometime between the Late Inka and Colonial Period, consideration to both Inka and Spanish gov-

ernmental policies that would have potentially affected immigration patterns and differential access to dietary resources must be considered. Due to the mandatory relocation policies of the Inka and Early Colonial Period Spanish government, it is possible that the individuals examined at the CSMME-CNS site may have been forcibly relocated to the area from another portion of the Andean region.

Under Inka rule, indigenous people were forced to pay taxes to the Inka elite through a forced labor system referred to as *mit'a* (Klaus 2008:166). Under the *mit'a* system, it was not uncommon for entire indigenous communities to be relocated to meet the labor needs of the Inka Empire; however, there is evidence that the effect of the Inka rule on the north coast of Peru may have been relatively limited in scope (Klaus 2008:166). The Inka rule may have had only minor effects on the north coast polities since: the period of Inka rule was relatively short (<100 years); there was a marked lack of centralization of settlements along the north coast (as compared to the Inka core region); and, the strong ethnic identity of the people (the Muchik) of the northern coast was not easily swayed by the forces of Inka imperialistic domination (Klaus 2008:166). As the Muchik individuals of the north coast experienced less direct influence from the Inka than the indigenous people of the central region of Peru, it is likely that the individuals on the north coast may not have been directly affected by the *mit'a* policies of relocation; however, if the relocation of the north coast indigenous Muchik people did occur it is likely that they would have been required to provide service to the government within the bounds of another geographic location resulting in their absence at burial sites such as CSMME-CNS. Thus, for the individuals interred at the CSMME-CNS site, there is a chance that they either escaped

Inka-mandated relocation or were never required to relocate under the *mit'a* labor organiza-

tion policies.

Although the Inka *mit'a*-based labor force relocation efforts most likely did not directly

affect the communities of the north coast of Peru, including the CSMME-CNS community, the

Spanish relocation policies of the Early Contact Period may have affected those individuals. In

an effort to consolidate power, organize indigenous labor forces for the benefit of the Spanish

monarchy, and impose European ideals related to living practices and religion (Catholicism),

many indigenous populations in Peru were relocated to settlements called *reducciones* (Klaus

2008:154-155). Following the siege of the last Inka stronghold of Vilcabamba in June of A.D.

1572, many communities along the north coast resisted the Spanish-imposed taxes and labor

requirements and fled to the region (Klaus 2008:285). Although the fall of Vilcabamba occurred

following the A.D. 1533 establishment of the original CSMME mission, it is still possible that

some of the indigenous Muchik people of the area may have fled in advance of the events of

A.D. 1572 as a form of protest against the Spanish administrative policies.   Thus, the individuals

interred at the CSMME-CNS site may have been a subgroup of the original regional Muchik

population.

Another possible explanation for the fleeing of individuals from pre-colonial or colonial

settlements involves the spread of disease epidemics. As European-based disease epidemics,

such as smallpox, spread across the north coast of Peru through Central American sourced

trade routes during the 1520s, it is likely that individuals in the wake of the epidemics may have

fled to less populated, and potentially less disease-ridden, communities (Klaus 2008:283). It is

possible that the individuals represented in the CSMME-CNS burial site may have originated

elsewhere and moved to the region to escape an epidemic. Conversely, it is possible that

members of the indigenous Muchik population of the CSMME-CNS area may have fled to a dif-

ferent location leading to their absence within the burial record of the site.

5.2.7   Interpretation of CSMME-CNS $\delta^{18}O$ values

As previously noted, comparison with the South Central Andean model for ecological

zonation is not ideal; however, based on the availability of published academic literature relat-

ing to isotopic analysis of human remains in the Andean region, this is the only option possible

for the establishment of a comparative analytical perspective. Based solely on the altitude of

the CSMME-CNS site location, it may be most closely compared to the South Central Andean

model of the *chala* ecological zonation. Based on this altitudinal comparison, it is anticipated

that $\delta^{18}O$ values for CSMME-CNS site within the Lambayeque Valley Region would be similar to

the other *chala* zone sites in South America, such as the Nazca Drainage area detailed by Knud-

son (2009). As detailed in Table 1 of the Results Section, all $\delta^{18}O$ values presented are with re-

spect to SMOW. Conversion of the original CSMME-CNS bone carbonate (n = 16) $\delta^{18}O_{(VPDB)}$ val-

ues to $\delta^{18}O_{dw(VSMOW)}$ using the equations set forth by Copen and colleagues (1983) ($\delta^{18}O_{(VSMOW)}$

= (1.03091 x ($\delta^{18}O_{(VPDB)}$) + 30.91), Iacumin and colleagues (1996) ($\delta^{18}O_{c(VSMOW)}$ = (8.5 + (δ

$^{18}O_{p(VSMOW)}$)/0.98) , and Luz and colleagues (1984) ($\delta^{18}O_{p(VSMOW)}$ = (0.78 x ($\delta^{18}O_{dw(VSMOW)}$) +

22.70) as utilized by Knudson (2009:177) are featured in Table 5 (below). The conversions pro-

duced an average $\delta^{18}O_{dw(VSMOW)}$ of -7.8‰ with a standard deviation of 0.9‰ and values ranging

between -5.0‰ and -8.8‰.

Table 5: Conversion of oxygen isotopic values from VPDB to DWVSMOW

Bone δ ^{18}O (‰, VPDB to CSMOW)	Bone δ ^{18}O (‰, CSMOW to PSMOW)	Bone δ ^{18}O (‰, PSMOW to DWVSMOW)	Enamel δ ^{18}O (‰, VPDB to CSMOW)	Enamel δ ^{18}O (‰, CSMOW to PSMOW)	Enamel δ ^{18}O (‰, PSMOW to DWVSMOW)
28.2	19.2	-5.0			
27.3	18.3	-6.4	26.3	17.2	-8.0
26.4	17.3	-7.8	25.7	16.6	-9.0
26.0	16.9	-8.5	26.9	17.9	-7.1
26.5	17.4	-7.7	26.6	17.5	-7.5
26.6	17.5	-7.5	26.1	17.0	-8.3
26.4	17.3	-7.8	26.5	17.4	-7.7
26.2	17.1	-8.2	26.2	17.1	-8.2
26.3	17.2	-8.0	26.4	17.3	-7.8
26.3	17.2	-8.0	26.3	17.2	-8.0
26.6	17.5	-7.5	26.6	17.5	-7.5
26.1	17.0	-8.3	26.9	17.9	-7.1
25.9	16.8	-8.6	26.5	17.4	-7.7
26.4	17.3	-7.8	26.6	17.5	-7.5
25.8	16.7	-8.8	26.5	17.4	-7.7
26.1	17.0	-8.3	27.3	18.3	-6.4
			27.5	18.5	-6.1

The conversion of the enamel carbonate values (n = 16) of $\delta^{18}O_{(VPDB)}$ to $\delta^{18}O_{dw(V\text{-}SMOW)}$ using the aforementioned equations (see Table 5, above) resulted in an average $\delta^{18}O_{dw(V\text{-}SMOW)}$=-7.6‰ with a standard deviation of 0.7‰ and values ranging between -6.1‰ and -9.0‰.

As the altitude of the towns of Puerto Eten and La Cuidad de Eten located near the CSMME-CNS site are 9 m.a.s.l. it is anticipated that the average values for the $\delta^{18}O_{dw(V\text{-}SMOW)}$ of the bone and tooth enamel for the individuals sampled at the site should align more closely with values for other *chala* zone sites. Based on comparisons to Knudson's (2009) data for South Central Andean ecological zonation stable oxygen isotope values, the total bone and tooth enamel average (n = 32) $\delta^{18}O_{dw(V\text{-}SMOW)}$ value is equal to -7.7‰ and that is most consistent with values obtained for the higher altitude *yunga* zones.

The oxygen isotopic signatures of the individuals sampled from the interred CSMME-CNS population may be reflective of the consumption of water from subsurface aquifers. The consumption may be direct through the ingestion of drinking water or indirect through the use of such underground aquifer-based water sources for irrigation of crops; although, it must be noted that the use of water for irrigation may lead to further fractionation of the oxygen within the irrigated plants themselves. In late 2010, a well was excavated under the CSMME-CNS site (Klaus 2012: personal communications). The presence of such a well within the CSMME-CNS site may provide further evidence to corroborate the theory that individuals at the site were consuming water from an subsurface water source that potentially originated at a higher altitude source (Klaus 2012: personal communications).

Alternatively, it is possible that the individuals of the CSMME-CNS population were accessing water from riverine sources, such as the nearby Reque River, that originate at high alti-

tudes. Consumption of water from a high-altitude source rivers would lead to the ingestion of water that is fundamentally lower in ^{18}O (or higher in ^{16}O) than groundwater from local sources along the coast, such as ponds. Once again, if water from rivers originating at high altitude sources is used to irrigate crops, then the water would undergo further fractionation within the botanical materials as a function of cellular respiration.

Another possible explanation for the $\delta^{18}O_{dw(V-SMOW)}$ values for the tooth enamel and bone carbonate values of the individuals interred at the CSMME-CNS site being more closely aligned with the $\delta^{18}O_{dw(V-SMOW)}$ values of individuals analyzed from South Central Andean *yunga* sites rather than mimicking the South Central Andean *chala* sites is that the individuals sampled at the CSMME-CNS site may have originated in a *yunga* zone. As only 17 individuals (15 for bone and tooth enamel, 1 for bone, and 1 for tooth enamel) were sampled from a total popula-tion in excess of 200 individuals, it is possible that the selected individuals may have all origi-nated within the an area with a stable oxygen isotopic signature more closely aligned with the values for the higher altitude *yunga* zone (as reflected in enamel carbonate values) and lived within the *yunga* zone until a time immediately preceding their deaths (as reflected in bone carbonate values). Such an explanation may be possible as the $\delta^{18}O_{dw(V-SMOW)}$ tooth enamel values representing the first five years of the lives of the individuals sampled are within -0.3‰ of the values of the $\delta^{18}O_{dw(V-SMOW)}$ bone values representing the last ten years of the lives of the individuals sampled. If there was a marked discrepancy between the enamel and bone values, then interpretations related to residential mobility, particularly population mobility, may be developed; however, for the samples assessed at CSMME-CNS site this fails to hold true. The individuals selected for carbonate analysis were chosen based on the availability of both bone

and tooth samples being preserved for each individual with the exception of B19-02A (tooth only) and B19-43 (bone only) in which only single samples were preserved. Although the individuals selected for carbonate analysis were chosen based on the criterion that both bone and tooth samples were available (with the exceptions noted), they were all chosen from the same burial location and all samples were derived from adult individuals. The selection of individuals from only one level of the site when there were multiple levels with burials may result in the incomplete representation of the population as a whole as a function of population sampling bias. It is possible that the individuals selected for carbonate analysis may have been from the a region with a stable oxygen isotopic signature paralleling the values for the South Central Andean *yunga* zone while other individuals within the burial population of the stratigraphic level 5, as well as the other levels containing burials, at the CSMME-CNS site may have been from a completely different location.

All of the individuals sampled at the CSMME-CNS site fall within one standard deviation of the mean for the bone $\delta^{18}O_{dw(V\text{-}SMOW)}$ values except for B19-43 and 5D-27. The bone $\delta^{18}O_{dw(V\text{-}SMOW)}$ for B19-43 is -5.0‰ which falls within 2.5 standard deviations of the mean for the population bone $\delta^{18}O_{dw(V\text{-}SMOW)}$ values and for burial 5D-27 it is -6.4‰, which is approximately 1.5 standard deviations from the mean. For 5D-27, the corresponding tooth enamel $\delta^{18}O_{dw(V\text{-}SMOW)}$ value is -8.0‰, which is within one standard deviation of the tooth enamel $\delta^{18}O_{dw(V\text{-}SMOW)}$ mean. The difference between the tooth enamel and bone $\delta^{18}O_{dw(V\text{-}SMOW)}$ values for 5D-27 is -1.6‰. As the B19-43 sample did not yield a corresponding tooth sample for the analysis of the enamel carbonate, it is not feasible to determine whether geographic mobility may have played a role. In contrast to the bone-only B19-43 sample, there was a tooth-only sample (B 19-02A)

yielding information related only to the location of origin of the individual. As with the B19, 43 sample, the B19-02A sample fell outside of the bounds of one standard deviation of the mean for the enamel $\delta^{18}O_{dw(V-SMOW)}$ values for the sampled CSMME-CNS population. The $\delta^{18}O_{dw(V-SMOW)}$ value of the enamel for the B19-02A sample is -6.1‰ which is approximately 2.25 standard deviations above the mean $\delta^{18}O_{dw(V-SMOW)}$ for the sample CSMME-CNS population. The absence of a corresponding bone sample for the B19-02A enamel sample results in the lack of ability to establish the relationship between possible geographic movements of the individual over their lifetime. In addition to the B19-02A enamel carbonate sample falling nearly 2.25 standard deviation measures above the mean $\delta^{18}O_{dw(V-SMOW)}$ value, the 5D-11 (B71) sample enamel carbonate $\delta^{18}O_{dw(V-SMOW)}$ value is -6.4‰ which is approximately 1.5 times below the mean value. Also, the enamel carbonate $\delta^{18}O_{dw(V-SMOW)}$ value for 5E-31 is -6.4 which is nearly 2 times below the mean value.

5.2.8 Interpretation of CSMME-CNS $\delta^{13}C$ values

In addition to the oxygen isotopic data obtained for the individuals sampled at the CSMME-CNS site, carbon isotopic data for the same samples was evaluated as a measure of potential dietary variability. The relatively arid ecological zone where the CSMME-CNS site is situated receives very little precipitation (<50mm/year) and temperatures reach 25-35°C in this region permitting the cultivation of such edible C_3 crops as: beans, peanuts, squashes, cherimoya, and lúcama (Knudson 2009:174). The main C_4 crops of this zone include sugar cane and maize (Knudson 2009:174). The epiphytic plants which comprise the coastal plant communities known as *lomas* may be either C_3 plants or CAM plants and such *loma* communities may be utilized by both camelids and humans a food source (Knudson 2009:174; Zotz and Ziegler

1997:223). As previously mentioned, the relative importance of CAM plants within the diet of

an individual is difficult to discern as the $\delta^{13}C$ values for such plants overlap the range $\delta^{13}C$ val-

ues for both C_3 and C_4 pathway plants (White et al. 2009:1528).

Structural carbonate analysis results ($\delta^{13}C_{(VPDB)}$) for the skeletal elements of bone and

teeth from selected individuals at the CSMME-CNS site is featured in Table 1 of the Results Sec-

tion (Section IV, above). The average$\delta^{13}C_{(VPDB)}$ value for tooth enamel carbonate was -3.5‰

with a standard deviation of 0.5‰ and a range of -2.6‰ to -4.1‰. All values, with the excep-

tion of burials 5D-71 ($\delta^{13}C_{(VPDB)}$= -4.1‰) and 5D-72 ($\delta^{13}C_{(VPDB)}$= -2.6‰) fell within one standard

deviation of the average $\delta^{13}C_{(VPDB)}$ value for the tooth enamel carbonate.   The average

$\delta^{13}C_{(VPDB)}$ for bone carbonate was -4.3‰ with a standard deviation of 0.6‰ and a range of -

2.8‰ to -5.3‰. With the exception of burials 5D-61 ($\delta^{13}C_{(VPDB)}$ = -5‰), 5D-58 ($\delta^{13}C_{(VPDB)}$ = -

2.8‰), and 5D-57 ($\delta^{13}C_{(VPDB)}$ = -5.3‰), all of the bone carbonate values fell within the one

standard deviation of the mean value. There are no incidents of overlap between the burials

which fell more than one standard deviation outside of the mean $\delta^{13}C_{(VPDB)}$ values for tooth

enamel and those which fell within the same boundaries for bone $\delta^{13}C_{(VPDB)}$ values indicating

there is likely not a difference of dietary sources spanning the entire lifetime of a single individ-

ual as compared to the dietary sources of the population as a whole.

Overall, all of the values for the $\delta^{13}C_{(VPDB)}$ of both the enamel and bone carbonate data

sets range between -2.6‰ and -5.3‰. Such values are indicative of a diet, both early in life as

well as at the end of life, which is likely rich in C_4 pathway plant sources such as maize and sugar

cane. Although the $\delta^{18}O_{dw(V-SMOW)}$ results for the individuals sampled at the CSMME-CNS site

are indicative of the ingestion of water sources that appear to have originated in the higher alti-

tude *yunga* zone (as compared to the values established by Knudson (2009) for the South Central Andean region), the $\delta^{13}C_{(VPDB)}$ values are not indicative of a diet rich in C_3 plant resources that are commonly found within that ecological zone. The aforementioned finding lends credence to the theory that the individuals sampled at the CSMME-CNS site were indeed native to the lower altitude coastal zone since they may have been consuming water from subsurface aquifers or riverine sources that may have originated at a much higher altitude. Additionally, the preferential consumption of marine-based resources over terrestrial-based organisms may result in a markedly more positive $\delta^{13}C_{(VPDB)}$ values within the structural carbonate of a higher-order consumer. Marine-based food resources exhibit significantly more positive $\delta^{13}C$ values than terrestrial food sources (Goldstein 2005:220; Le Huray et al. 2009:100; Mays 2009:183). Also, the isotopic signature of marine fish parallels the isotopic signature of C_4 plants (Finucane et al. 2006:1767). Based on archaeological evidence, it is known that the Moche and their Muchik descendants developed large, woven fishing nets with gourd floats for use in wooden fishing vessels; therefore, it is highly probable that the Muchik were dependent on marine-based resources as a form of subsistence (Klaus 2012: personal communications; Quilter 2002:156; Pozorski 1979:180; Pozorski and Pozorski 1979:417, 424). To determine the level of dependence of the individuals sampled for bone and enamel carbonate on marine-based food sources for protein, nitrogen stable isotope analysis will be conducted. Nitrogen stable isotope analysis of bone collagen and tooth dentin permits the evaluation of $\delta^{15}N$ values allowing for a determination of the role of protein in the diet of an individual. As the carbonate $\delta^{13}C_{(VPDB)}$ values for the individuals in the CSMME-CNS population are relatively positive as compared to populations which are more highly dependent on terrestrial-based protein sources, it is sus-

pected that $\delta^{15}N$ values for the sample set will be more closely aligned with marine-based food source values than terrestrial-based food source values.

5.2.9 Future research

Through the continued chemical analysis, specifically nitrogen and strontium stable isotope testing, of the remains of individuals at the CSMME-CNS site, new information related to potential geographic mobility and dietary patterns may be gleaned. Tandem analysis of oxygen and strontium stable isotope data may permit a more solid understanding of the origin of individuals interred at the CSMME-CNS site. Were the individuals interred at the CSMME-CNS site from an area near the modern cities of Puerto Eten and Cuidad de Eten or were they from a different part of the Andean region? Alternatively, is it possible that the South Central Andean isotopic baselines (Knudson 2009) used for comparison have led to the development of erroneous conclusions since the isotopic baselines for the northern coast of Peru may be fundamentally different? Due to the possibility of community movement as directed and enforced by the Inka *mit'a* or Early Colonial Period *reducciones* labor policies, there is the potential that the individuals interred at the CSMME-CNS burial site may have originated within another geographic region. Alternatively, the individuals may have voluntarily relocated to the region in an effort to escape the Inka or Spanish labor policies or they may have resettled in the region to avoid a European-based disease epidemic. If the individuals are indeed non-local in origin, then they must have lived in the area surrounding the CSMME-CNS site for a relatively brief period of time prior to their deaths as there is not a marked change between the carbonate stable oxygen isotope values for tooth enamel and bone for in the individuals sampled. Although all of the individuals sampled appear to have been buried in a traditional Muchik style with some el-

ements of Christian mortuary technique hybridization, could the individuals actually be ethnically or culturally Muchik as possibly indicated through their suspected geographic location of origin? Or are they non-indigenous individuals who have adopted some of the Muchik mortuary traditions? Through radiogenic strontium isotope analysis of the tooth enamel and bone for the individuals sampled at the CSMME-CNS site, it may be possible to garner more detailed information as to their possible geographic origin.

The addition of radiogenic strontium isotope analysis data as a comparative measure to the stable oxygen isotope results may provide permit a more thorough understanding of the possible immigration patterns of the individuals interred at the CSMME-CNS site; however, additional forms stable isotope analysis must be undertaken to gain more information about the potential dietary sources accessed by the individuals. Analysis of carbon and nitrogen stable isotope values permits interpretations related not only to potential dietary sources, particularly a differentiation between protein sources of varying origin, but an estimation of the potential post-depositional diagenetic alteration of a sample. The stable nitrogen isotope results are necessary to determine the role of protein in the diet of the individuals interred at the CSMME-CNS site as the stable carbon isotope data may lead one to a rather ambiguous conclusion about the role of C_4-based plant resources versus marine protein resources within the diets of the sampled population. Although based on the preservation conditions at the site, it is unlikely that significant post-depositional diagenetic alteration of the skeletal remains occurred, that is still a possibility. Based on the tightly packed crystalline structure of the enamel hydroxyapatite coupled with the removal of the first millimeter of tooth enamel during carbonate preparation, there is little chance that post-depositional diagenetic alteration would have affected the tooth

enamel (King et al. 2011: 2224; Montgomery and Evans 2009:129). In contrast, the loosely packed nature of bone apatite within the organic collagen matrix of bone is more apt than the tooth enamel to be affected by the aforementioned alteration processes (Hodell et al. 2004:487). To establish a measure of the validity of the carbonate stable carbon isotope analysis results for the bone as a reflection of potential post-depositional diagenetic alteration, the development of a C:N ratio may be required. Comparison of the C:N ratio for the bone collagen may provide useful information related to the potential post-diagenetic alteration of the bone sample since values beyond a certain level are indicative of either contamination by exogenous carbon sources or post-depositional diagenetic alteration (Ambrose and De Niro 1989:408; Katzenberg and Harrison 1997:274; Le Huray 2009:105).

It has been proposed that all of the individuals interred within the CSMME-CNS burial site will be tested for O, C, N, Sr stable isotopes. Once the entire population has been tested patterns related to residential mobility and differential access to dietary resources may be established. Furthermore, the stable isotope analysis results when combined with data from the physical evaluation of the skeletal remains and archaeothanatological studies of the individuals sampled may permit a more thorough interpretation of the lives of the people interred at the CSMME-CNS burial site. As such individuals have traditionally been underrepresented or misrepresented in the European historical texts related to the Early Contact Period, the aforementioned bioarchaeological analyses may provide a view into the lives of the indigenous people of the CSMME-CNS region that was previously unavailable through the European-based historical interpretations alone.

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APPENDICES

Appendix A: Site codes and in-house codes

Site Code	In-house tooth	In-house bone
B19-02A	KGSU85T	
5D-27	KGSU134T	KGSU94
5D-11	KGSU84T	KGSU96
5D-36	KGSU144T	KGSU101
5D-61	KGSU132T	KGSU103
5D-51	KGSU139T	KGSU105
5D-58	KGSU133T	KGSU112
5D-47	KGSU142T	KGSU114
5D-75	KGSU140T	KGSU116
5D-60	KGSU143T	KGSU120
5E-26	KGSU136T	KGSU122
5D-71	KGSU140T	KGSU123
5D-37	KGSU130T	KGSU126
5D-57	KGSU119T	KGSU127
5D-72	KGSU118T	KGSU130
5E-31	KGSU140T	KGSU133
B19-43		KGSU90

Appendix B: Raw data: Enamel carbonate with NBS-19 standards

Identifier	Enamel δ^{13}C (‰, vs VPDB)	Enamel δ^{18}O (‰, vs VPDB)
NBS-19	1.96	-2.11
NBS-19	1.96	-2.22
NBS-19	1.93	-2.14
NBS-19	1.96	-2.18
KGSU84T	-4.97	-5.07
KGSU84T	-5.03	-5.09
KGSU139T	-5.55	-4.58
KGSU139T	-5.57	-4.80
KGSU140T	-3.45	-4.08
KGSU140T	-3.62	-3.71
KGSU142T	-3.88	-4.51
KGSU142T	-4.17	-4.63
KGSU143T	-3.19	-4.51
KGSU143T	-3.13	-4.53
KGSU144T	-2.04	-3.87
KGSU144T	-2.05	-3.85
KGSU148T	-4.58	-3.54
KGSU148T	-4.59	-3.55
KGSU127	-5.28	-4.40
KGSU131	-4.43	-4.99
KGSU133	-4.14	-4.73
NBS-19	1.99	-2.15
NBS-19	1.98	-2.23
KGSU85T	-5.07	-3.27
KGSU118T	-2.57	-4.32
KGSU119T	-3.05	-4.24
KGSU130T	-3.86	-4.33
KGSU132T	-4.01	-4.17
KGSU133T	-3.89	-4.32
KGSU134T	-3.28	-4.49
KGSU136T	-3.30	-4.17

Appendix C: Raw data: Bone carbonate with NBS-19 standards

Identifier	Bone δ ^{13}C (‰, vs VPDB)	Bone δ ^{18}O (‰, vs VPDB)
NBS-19	1.93	-2.17
NBS-19	1.95	-2.16
NBS-19	1.95	-2.16
NBS-19	1.95	-2.19
KGSU90	-3.75	-2.56
KGSU94	-4.31	-3.50
KGSU96	-4.71	-4.43
KGSU101	-4.34	-4.77
KGSU103	-5.01	-4.26
KGSU105	-4.45	-4.19
KGSU112	-2.79	-4.47
KGSU114	-3.73	-4.63
KGSU116	-4.40	-4.47
KGSU120	-4.56	-4.46
KGSU122	-4.04	-4.20
KGSU123	-4.69	-4.68
KGSU126	-4.43	-4.89
KGSU127	-5.28	-4.40
KGSU131	-4.43	-4.99
KGSU133	-4.14	-4.73
NBS-19	1.99	-2.15