HEALTH AND LIFE ON POINT SAL CALIFORNIA: AN
OSTEOLOGICAL ANALYSIS OF MIDDLE PERIOD
PURISIMEÑO CHUMASH

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A Thesis
Presented to the
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In Partial Fulfillment
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Master of Arts
in
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by
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Health and Life on Point Sal California: An Osteological Analysis of Middle Period

Purisimeño Chumash

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ABSTRACT OF THE THESIS

Health and Life on Point Sal California: An Osteological Analysis of Middle Period Purisimeño Chumash

by

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Master of Arts in Anthropology
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The Chumash are a Native American group who until a few hundred years ago were the exclusive occupants of the southern California coast between present day Point Conception and Malibu. The body of knowledge about the Chumash, although great, can be expanded through the bioarchaeological contributions of the study of skeletal tissue. The human skeleton is a malleable tissue, which often reacts to various stressors in a systematic and discernable way. By studying markers left in skeletal tissue, bioarchaeologists can postulate about the presence of violence, types of diet, lifespan, and the prevalence of chronic illness within a given population, which can in turn aid in deducing environmental conditions. This study has aimed to expand the body of knowledge that exists about the Chumash before Spanish contact through the skeletal analysis of prehistoric remains. To gain a more holistic understanding of how the Chumash lived, this project focused on the skeletal analysis of a group of individuals known as the Purisimeño, recovered seventy-five years ago at Point Sal California, an area now occupied by Vandenberg Air Force Base. By identifying skeletal anomalies such as certain pathologies this thesis was able to provide a better understanding in the overall population health and past environmental conditions of prehistoric Chumash.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
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</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Summary of Paleoenvironmental Data ......................................................60
Summary of Pathologies .......................................................................60
Comparative Data ...............................................................................65
Conclusion ..........................................................................................67

13 CONCLUSION .................................................................................68

REFERENCES .......................................................................................69

APPENDIX

A   RAW DATA .......................................................................................80
B   RAW DATA CONTINUED ...............................................................83
LIST OF TABLES

PAGE

Table 1. Radio Carbon Dates from Three Individuals in the Point Sal Collection ..................26
Table 2. Estimation of Age and Skeletal Elements Used in its Determination ......................32
Table 3. SCRI-100 and SCRI-83, Ven-110, Point Sal from Present Study .........................66
LIST OF FIGURES

PAGE

Figure 1. Major cultural sequences used for Southern California. ..............................2
Figure 2. Vandenberg region excavated by Glassow (1991, 1996) shown in larger blue circle and those by Carter (1941) shown in smaller red circle .........................17
Figure 3. Chronology of population density of prehistoric Purisimeño Chumash ..........22
Figure 4. Eight-point dental attrition ........................................................................30
Figure 5. Distribution of age at time of death in the Point Sal collection ..................33
Figure 6. Bisection of adult and sub-adult at time of death in the Point Sal collection ....34
Figure 7. Distributions of Cribra Orbitalia and Porotic Hyperostosis ......................38
Figure 8. Example of Porotic Hyperostosis from Individual 17661 in the Point Sal collection .......................................................................................................................38
Figure 9. Example of Cribra Orbitalia from Individual 17661 in the Point Sal collection ..............................................................................................................................39
Figure 10. Skeletal example of Spina Bifida Cystica from Individual 17811 in the Point Sal collection ...................................................................................................................43
Figure 11. Individuals in the Point Sal collection with Spina Bifida divided into slight, moderate, and extreme .........................................................................................................................43
Figure 12. Dental attrition rates for individuals in the Point Sal collection in the Point Sal collection divided up into slight, moderate, and extreme .................................................47
Figure 13. Individual 17752 in the Point Sal collection exhibiting extreme dental attrition .................................................................................................................................48
Figure 14. Distribution of Caries based on Severity in the Point Sal collection ..........50
Figure 15. Example of Caries scored at a 4 in Individual 17750 from the Point Sal collection .......................................................................................................................................50
Figure 16. Example of abscess formation in Individual 17862 from the Point Sal collection .................................................................................................................................52
Figure 17. Example of AMTL in Individual 17861 from the Point Sal collection .......52
Figure 18. LEH found on deciduous teeth in Individual 1780 from the Point Sal collection .................................................................................................................................55
Figure 19. Individual 17752 exhibiting moderate osteophytosis from the Point Sal collection .................................................................................................................................56
Figure 20. Holocene δ18 climate and inferred paleoproduction records for the Santa Barbara Basin.
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CHAPTER 1

INTRODUCTION

This thesis is an osteological study conducted on a collection of prehistoric Chumash Indians known as the Purismeño. The remains of these individuals were recovered in Point Sal, California, a region thirty miles north of Santa Barbara. For the purpose of this thesis, the remains of these individuals will be referred to as the “Point Sal collection” or the “Point Sal individuals.”

The Point Sal collection was exhumed in the 1930’s by George Carter, a curator for the San Diego Museum of Man (SDMOM). Carter (1941) published a brief description of the burials shortly after their discovery. Since that time, the Point Sal collection has been curated at the SDMOM and studied sporadically. One of the more significant studies, however, was conducted by Bruwelheide and colleagues and included direct radiocarbon dating of the human bone collagen. Bruwelheide et al. (2001) found that all of the burials dated between 1300 and 1800 cal BP.

Based on a long history of archaeological research and an extensive archaeology record, several chronological schemes have been developed for the Santa Barbara Channel region and the Purismeño Indians (Arnold 1992; Chartkoff and Chartkoff 1984; Erlandson 1994; Erlandson and Colten 1991; King 1990; Orr 1968; Rogers 1929). These schemes are based on cultural changes identified in the archaeological record and, often, related to regional environmental fluctuations. King’s (1990) chronology is the most detailed and widely used for the Chumash area and relies on the seriation of shell beads, shell pendants, and other artifacts from burial contexts, along with limited radiocarbon dating. Based on this scheme, the Point Sal collection falls into King’s (1990) Middle Period, dating between 2500 and 1000 BP (Figure 1).

Scholars agree that the Chumash were one of the most complex groups of hunter-and-gatherers in North America (Arnold 2001; Gamble 2008; Kennett 2005; King 1990; Lambert and Walker 1991; Rick 2007; Walker and Hudson 1993). The reasons for the rise of Chumash complexity have resulted in various theoretical debates (Arnold 1993, 2001;
Figure 1. Major cultural sequences used for Southern California. Source: Braje, Todd J. 2009 Modern Oceans, Ancient Sites Archaeology and Marine Conversation on San Miguel Island, Anthropology of Pacific North America. Salt Lake City: University of Utah Press.

Gamble 2005, 2008; Kennett and Kennett 2000; Raab and Larson 1997; Rick 2007), which will be addressed in this thesis.

A robust body of archaeological, historical, and ethnographic literature exists regarding the way the ancient Chumash lived (Blackburn 1975; Gamble 2008; Hudson et al.
A number of archaeological excavations (Arnold 2001; Carter 1941; Gamble et al. 2001; Glassow 1991, 1996) and bioarchaeological studies (Lambert 2002, 2007; Lambert and Walker 1991; Walker 1978a, 1986, 1989; Walker and Erlandson 1986) have been conducted in the Chumash world, along with several paleoenvironmental studies (Hughes and Milliken 2007; Kennett and Kennett 2000; Pisias 1978, 1979; Stine 1994). I hope to enrich the Chumash human biological literature through the skeletal analysis of the Point Sal individuals.

By conducting a thorough osteological and paleopathological investigation, conclusions regarding the diet and overall health of the Purismeño population were established. In particular, skeletal indicators inferring lack of sufficient nutrients and poor health (Berry et al. 1999; Botto et al. 1999; El-Najjar et al. 1975, El-Najjar et al. 1976; Larsen 1997; Lemire and Beckwith 1984; Ortner 2003; Walker et al. 2009) were identified, as well as indicators of biomechanical stress (Larsen 1997; Ortner 2003). The osteological analysis of the Point Sal Collection was further supported by archaeological, ethnographic, and paleoenvironmental data, allowing for a more comprehensive interpretation.
CHAPTER 2

THE CHUMASH

OVERVIEW

Subsistence opportunities provided by the coast, as well as a range of microclimates, attracted a variety of human populations to California. The Chumash are a group of Native Americans that, at first European contact, occupied present day Topanga Canyon on the south, extending north to the Monterey County line and east to the San Joaquin Valley (Gamble 2005:6). They also inhabited the northern Santa Barbara Channel Islands of Anacapa, Santa Cruz, Santa Rosa, and San Miguel (Kennett 2005:5). The Chumash and their ancestors inhabited this area beginning at least 13000 years ago (Erlandson et al. 2007; Glassow 1991; Johnson and Lorenz 2006), and possibly earlier (Erlandson et al. 2007), until the California Mission Period began in AD 1769. The first known documented sighting of the Chumash was made during the Juan Rodríguez Cabrillo expedition in AD 1542 (Arnold 1992).

Present knowledge about the pre-contact Chumash comes from studying post-contact Chumash ethnographic data and archaeological sites in concert with paleoenvironmental analyses. It is because of these studies that the Chumash have been referred to as a ‘complex’ group of hunter-and-gatherers who have captured researchers’ fascination for over a hundred years (Lightfoot and Simmons 1998). Complexity in a hunter-and-gatherer society is defined by Arnold (1992:61) as:

ascribed status differentiation (hereditary inequality), regional organization of the economy on one or more levels above the domestic sphere, relatively large population (2,000 or more) with some form of regional sociopolitical integration, and chiefs with the power to manipulate the labor of their supporters.

This definition along with material culture studies has been adopted for the purposes of this thesis in advocating that the Chumash were a complex group of hunter-gatherers.
ETHNOGRAPHIC BACKGROUND

The ethnographic work of John P. Harrison in the early 1900’s revealed much about Chumash social structure. The Chumash population was organized into what can be described as villages. Each village contained at least one head person or wot, often called a “chief” by various researchers. The position of a wot was hereditary. The wot’s responsibilities included mediating village affairs, planning gatherings, caring for the poor as well as visitors, and representing the village when interacting with other villages (Blackburn 1975; Hudson et al. 1978). Harrington’s notes also suggest that there may have been chiefs who had influence over more than one village (Hudsen et al. 1978). A village also would typically have a praxa. The praxa would assist the wot with ceremonial duties, as well as collecting any debts owed to the chief (Blackburn 1975). The size of the village had a proportional relationship with the influence and power of the residing chief. Some larger villages had a few chiefs with one of them being the head or big chief (Johnson 1989). The wot and praxa were members of the elites in Chumash society called the ‘antrap. The ‘antrap possessed considerable wealth in relation to the rest of the village (Johnson 1989).

Except for chiefly status and other elite held positions, which were passed down paternally, the Chumash had a matrilineal descent system (Glassow 1996; Johnson 1988). This general social structure was by no means fixed and sometimes shifted from village to village. There are accounts of women chiefs as well as a patrilineal descent lines within some villages (Gamble 2008; Johnson 1988).

The Chumash language, originally grouped with Hokan languages, was later separated as its own distinct language group (Campbell 1997:127; Mithiun 1999:390). The Chumash language is further divided into several language groups correlating with different geographical regions and named for the surrounding missions. The Obispeño Chumash inhabited the northern most part of Chumash territory, close to Monterey; while the northern regions of Santa Barbara County to the northern regions of Ventura County were inhabited by Purismeño, Ineseño, Barbareño, and Ventureño, respectively. The Island Chumash shared a language group known as Cruzeño (Gamble 2008).

Gamble’s (2008) assessment of diaries kept by early Spanish explorers traveling up the coast, Cabrillo (1542), Unamuno (1587), Cermeño (1587) and later, overland expeditions of Crespí and Portolá (1769), complement data gathered by Harrison as well as provide
population estimates for the Chumash at the time of contact. By consulting mission registers, King (2000) was also able to estimate Chumash population levels at the time of European contact. Judging from the above sources, by AD 1769 there were anywhere from 15,000 to 25,000 Chumash living on the coast. Each community had a range of 60 to 800 people, probably averaging 200 (Gamble 2008; King 2000). There is still ambiguity regarding the accuracy of these numbers due to the attenuating effect Old World diseases may have had on the Chumash (Erlandson et al. 2007; Preston 1996; Walker and Hudson 1993).

**Material Culture**

The material culture of the Chumash is rich and extensive. However, shell beads and the plank canoe are unique to the Chumash and warrant a brief discussion. The use of shell beads as currency and the manufacturing of the plank canoe or *tomol* are often attributed as symbols of the high level of social complexity within ancient Chumash society (Arnold 1987, 2007; Gamble 2008; King 1990).

Chumash living on the Channel Islands were experts in the manufacturing of shell beads mostly from the purple olive snail (*Olivella biplicata*), but also *Mytilus californica* and *Haliotis rufescens* (Gamble 2008). They would then trade these beads with Chumash on the mainland for resources not available on the islands. These beads held intrinsic value and were traded throughout the Chumash territory, and sometimes beyond for a variety of goods and services (Bennyhoff and Hughes 1987; Eerkens et al. 2005; Hughes and Milliken 2007). Production of these beads required skill and time as well as the use of specialized tools (King 1990), which are all facets of a complex society.

Also requiring the use of specialized tools and skill was the production of the plank canoe, or *tomol*. The plank canoe was one of the most valued possessions in Chumash society (Arnold 1987; Arnold and Bernard 2005). The Chumash relied on plank canoes for trade with Chumash living on the Channel Islands. Since food was traded for shell beads, the use of the *tomol* was intimately tied with the distribution of shell beads. They also provided a means of acquiring marine foods. The *tomol*, which held as many as ten adults, could endure long durations at sea making it possible to fish kelp forests and deep-water habitats (Hudson et al. 1978). Knowledge about manufacturing the *tomol* was a coveted secret that only a
select few, called “The Brotherhood-of-the-Canoe,” were privy (Arnold 1987; Gamble 2008; Hudson et al. 1978).

**Subsistence**

The Chumash had a large and rich range of dietary strategies by the time the Mission Period began in 1769 (Gamble 2008; Walker and DeNiro 1986). The three main categories of subsistence for the Chumash were, marine animals, terrestrial animals, and botanical, which will be discussed in further detail below.

Marine foods were heavily utilized by the Chumash (Braje et al. 2011; Erlandson 2001; Kennett 2005). The amount and type of marine foods acquired changed because of available technologies, time period, and region (Kennett 2005). As technology became more complex, success in marine food acquisition increased. Shellfish are the earliest and most commonly utilized marine food for the Chumash (Braje et al. 2011; Glassow and Wilcoxon 1988). Shellfish includes abalone, sea urchins, and much more. But the most frequently type of shellfish consumed by prehistoric Chumash were marine mollusks, more specifically the California Mussel (Glassow 1996; Glassow and Wilcoxon 1988). The procurement of mollusks has its advantages because it does not require sophisticated tools, has good nutritional value, and can be easily gathered (Kennett 2005). Fishing also provided an abundant source of nutrition (Erlandson 2001). Early on Chumash fishing employed simple bone gorge and line technology (Braje 2009). Improved technologies such as the plank-canoe and circular shell fishhooks allowed a much higher return rate, making fish a more common food source (Gamble 2008; Glassow 1996; Kennett 2005). Sea mammals such as otters and seals were also incorporated into the diet (Erlandson 2001; Gamble 2008).

Terrestrial animals were also a key food resource for the mainland Chumash. Generally, they were sought less frequently than marine resources (Gamble 2008). Various animals such as lizards, birds, rabbits, and deer were all sought for not only food, but for utilitarian uses. Gamble (2008:165) mentions, “tools made from deer and other large mammal bones included fishing equipment, awls, and needles. Bone was also used as ornamentation and in rituals.” Similar to fishing, success in the quantity and size of terrestrial animals hunted relied on the advancement of technologies such as the bow and arrow (Blitz 1988), as well as the use of different stone tools to aid with butchering (Walker 1978b).
Information regarding botanicals used by the Chumash is more difficult to determine, as plants are not usually well preserved in the archaeological record. Gamble (2008) identified several plants used for food and utilitarian purposes, excavated at the ancient Chumash town of Helo’. These plants ranged from pigweed used for soap, to snakes head and barley used for food. Also, giant rye found at the site was likely used for tools such as arrow stems, thatching house roofs, and making baskets.

Further information about the use of plants comes from the journal accounts of Juan Crespi (Brown 2001). These journals mention gifts of food given by the Chumash as the Crespi expedition traveled through the Santa Barbara Channel Region. These gifts included sage, small raisin like fruits, as well as a variety of fresh fruits, which were sometimes boiled and mashed with water to form a type of preserve, a gruel of sorts (probably made from acorn), and bowls of seeds. There is also mention of a variety of nuts and dried acorn (Brown 2001). The types of plants possibly used by Purisimeño Chumash can be determined by looking at the research of Philip Munz and David Keck (1968) who compiled a thorough list from the region. These plants are chamisso bush lupine (*Lupinus chmissonis*), common yarrow (*Achillea millefolium*), cottenbatting cudweed (*Gnaphalium chilense*), and giant corepsis (*Coreopsis gigantean*). Additionally, Glassow (1991) notes some plants in the region that would have been utilized: black sage (*Salvia mellifera*), which could provide edible seeds; cattail (*Typha domingensis*), which has edible roots as well as other utilitarian uses such as weaving mats and blankets; bulrush (*Scirpus hirtella*) and juncus (*Juncus lecurri*) both provide food in their roots and seeds as well providing leaves that serve as material for weaving baskets.

**ETHNOGRAPHIC KNOWLEDGE ABOUT THE PURISIMEÑO**

The central study of this thesis is a group of Chumash called the Purisimeño, a name derived from the local mission of La Purísema Concepción (Glassow 1996). The Purisimeño inhabited the northern Chumash regions, 30 miles north of Santa Barbara in an area known today as Point Sal. The population occupied a total of 22 villages ranging from about 30 to 200 people per village (Glassow 1996; King 1984). Ethnographic information about the historic and proto-historic Purisimeño is scarce. What knowledge exists mostly comes from studying mission registers (King 1984). Through these studies we know that although there
was hierarchical stratification it was not as fixed as other Chumash groups. Also, unlike other groups, once married a couple would reside in either the house of the wife or the husband (Glassow 1996; King 1984), which indicates that a strict matrilineal descent, common among most Chumash, may not have existed for the Purisimeño (Glassow 1996). It is hypothesized that the Purisimeño may have not reached the level of social complexity of other Chumash (Glassow 1996). However, there are accounts of each village containing a man with multiple wives, a trait usually specific to that of a chief (King 1984), which is an example of some level of complexity. Although there is no evidence the Purisimeño used the famous plank canoe, they certainly did fish, but probably from shore (Glassow 1996).
Protohistoric Chumash displayed a high degree of social-complexity for a hunter-and-gathering group. The level of complexity, which was observed during the beginning of the Mission Period was most likely established around AD 1300 (Arnold 2001; Lambert and Walker 1991; Walker and Hudson 1993). When and how such complexity arose is the subject of debate. Many researchers have connected environmental shifts with cultural change (Cashdan 1987; Colson 1979; De Garine and Harrison 1988; Dirks 1980; Halstead and O'Shea 1989; Price and Brown 1985; Spielmann 1986). In the Santa Barbara region, the role of environmental shifts was connected to the rise of Chumash complexity first by Arnold (1992, 1993), where she linked archaeological data from Santa Cruz Island with data regarding past environmental conditions compiled by Pisias (1978, 1979). Arnold (1992, 1993) claims that between AD 1100 and 1300 sea-surface temperatures (SST) rose and marine productivity decreased. At the same time, drought affected terrestrial food sources. These environmental shifts put considerable strain on the Chumash, which provided an opportunity for a select few to control labor as well as food. Put simply, the control of labor and food led to the stratification of classes, triggering the social complexity later seen in Chumash society. Raab and Larson (1997) also agree that environmental stresses triggered a change in social structure. However, they do not agree that there was a decrease in marine productivity. Instead, Raab and Larson (1997) argue that between AD 800 and 1400 severe drought conditions forced Island Chumash populations to coalesce around limited water supplies, and increased concentrations of populations led to the rise of social complexity. Kennett and Kennett (2000) also contend that drought conditions and not lack of marine productivity put stress on Island Chumash populations. They successfully refute Pisias’s (1978, 1979) data by presenting their own data, which analyzed a marine core extracted from the Santa Barbara Channel. Kennett and Kennett (2000) recalculated sea-surface temperatures by studying oxygen isotope fluctuation of two planktonic foraminiferal species. Their data show cooler SST and higher marine productivity between the years AD 450 and
1300, which is the inverse of Pisias’s (1978, 1979) claim of increased sea-surface temperatures and decreased marine productivity. Kennett and Kennett (2000) assert that if marine productivity was abundant, then dry terrestrial conditions around AD 900 and 1300 led to the rise of social complexity in the Chumash. Like Raab and Larson (1997), Kennett and Kennett (2000) assert that waning water supplies forced cooperative efforts which led to the rise of complexity within the Chumash. Drought conditions in the region have been documented by use of tree ring analyses (Stine 1994) and pollen analysis (Davis 1992). Jones et al. (1999) have made a compelling argument for drought conditions between AD 800 and 1350, not only in the Southern California coast, but much of the western North America. They further connect drought conditions to cultural change in four different regions including the Southern California coast (Jones et al. 1999). Environmental hardships causing stresses on Chumash populations during this time period has also been confirmed through osteological studies in the region (Arnold 1992:76; Brickley and Ives 2006; Lambert 1993; Lambert and Walker 1991; Stuart-Macadam 1987; Walker 1986, 1989; Walker and Thornton 2002). This is because certain environmental hardships have a biological impact that can show up on bone.

Resource scarcity as the cause for social complexity is contested by Brian Hayden (1995). Hayden makes an argument that it is, in fact, resource abundance that leads to stratification of power and social complexity. Hayden’s argument is adopted by Lynne Gamble in regard to the Chumash (Gamble 2005, 2008). Gamble argues against the reliability of the Arnold’s (1993, 2001) and Kennett and Kennett’s (2000) interpretation of paleoenvironmental data. Gamble states that tree-ring data used by Kennett and Kennett (2000) might not be the best source for assessing conditions in the Santa Barbara area. This is because it was based on trees in the Sierra region, a region known to differ from Santa Barbara in annual rainfall (Gamble 2005). Further, the archaeological sites Kennett and Kennett (2000) use to support their data are limited to the Channel Islands and not the mainland, which may differ markedly. Gamble (2005) also claims drought and decrease in terrestrial resources pose a greater threat to agricultural societies than to hunter-and-gatherers. This is because hunter-and-gatherers such as the Chumash have a wider range of prey food types, thus giving them an advantage. Gamble (2005, 2008) contends that the rise of social complexity is owed to resource abundance rather than scarcity. She theorizes that as
the mainland Chumash population size increased, they developed buffers against possible risks from the environmental pressures. These included storage of foods such as dried acorns, fruit, and smoked fish, with the use of shell-bead currency in its distribution and regulation. The tenet of Gamble’s (2005, 2008) theory is that shifts in power came gradually as individuals who established control over such storage and exchange gain status over others, leading to political and social inequality and the rise of social complexity.

Both sides of this theoretical debate about the rise of complexity amongst the Chumash make a convincing case. However, additional data is needed to resolve chronology ambiguities and flush out the role environmental hardship in the rise of cultural complexity among the Chumash (Gamble 2005), especially if this data were to come from the mainland rather than the Channel Islands. Debates on the issue are still alive and well (Arnold and Green 2002; Gamble et al. 2001; Gamble et al. 2002).
CHAPTER 4

BIOARCHAEOLOGY AND SIGNIFICANCE OF RESEARCH

Bioarchaeology has contributed much to research on the prehistoric Chumash (Lambert 2002, 2007; Lambert and Walker 1991; Steckel et al. 2002; Walker 1978a, 1986, 1989; Walker and Erlandson 1986). At the heart of bioarchaeology is the study of human skeletal remains, or osteology (Ortner 2003). Much like other tissues in the human body, bones react to their environment. Unlike other tissues, evidence of these reactions can survive long after the individual has passed away. By studying the remnants of these reactions on skeletal material, bioarchaeologists can learn about past environmental conditions (Larsen 1997).

When studying human remains, bioarchaeologists first attempt to gather general information such as an inventory of the individual’s remains, the person’s age at time of death, and the individual’s sex. The skeletal remains are then examined for changes that help deduce the conditions in which the individual lived. These changes include evidence of pathologies (including those resulting from malnutrition), the condition of dentition, biomechanical stress markers, and evidence of trauma (Larsen 1997). Although one set of remains may tell much about how one individual lived, studying multiple individuals reveals one of the most important facets of bioarchaeology, patterning (Larsen 1997). In analyzing skeletal data and looking at patterns, researchers formulate theories about the condition of past environments and a population’s general health (Larsen 1997).

Some diseases manifest symptoms on the skeleton. Researchers can learn about the health of past populations by identifying pathological changes and understanding their etiology (Larsen 1997). For instance, bony changes due to nutritional deficiencies produce varying reactions on the human skeleton. Anemia, or lack of enough iron in the body, can leave lesions on the skull called porotic hyperostosis (Larsen 1997; Ortner 2003; Stuart-Macadam 1987) While a lack of vitamin C leads to scurvy, which gives a porous appearance to specific regions of the skeleton as well affecting bone formation (Brickley and Ives 2006;
Skeletal shifts such as the ones described above are a result of environmental insults. Therefore, much can be learned about the environmental conditions a person lived through by studying their skeletal remains.

The study of teeth is an important asset in osteology. The combination of durability, which insures survival into antiquity, and the deductions that can be made about an individual’s life by observing their teeth, make dentition valuable to study. Malnutrition, illness, or other stresses in early childhood leave marks as deciduous or permanent teeth are being formed. These marks are expressed in the form of horizontal lines called linear enamel hyperplasia (LEH) (Goodman and Rose 1990). By looking at patterns of LEH, researchers have been able to deduce periods of biological stress in past populations (Larsen 1997; Walker and Erlandson 1986).

The frequency of caries on teeth reflects a person’s diet. Foods rich in carbohydrates increase the risk of carious lesions (Berg 2007; DePaola 1982). Because lowered immunity makes people susceptible to caries, a prevalence of caries within a population can be an indicator of that population’s overall health (Mayes and Barber 2008; Smith 1984; Walker 1978a). Another dental indicator of diet is attrition rates on teeth. For example, rougher foods such as roots and tubers, and foods containing grit or sand, such as shellfish, accelerate the rate of dental attrition (Smith 1984; Walker 1978a).

Studying pathological changes on skeletal remains of ancient populations are not the only skeletal indicators of past environmental conditions. Skeletal markers left behind by biomechanical stresses provide clues for activities in a person’s life. For example, muscle attachment sites build up on bone as a result of heavy use, which can be used to deduce daily repetitive actions (Larsen 1997). Inferences about different forms of subsistence strategies are possible through studying patterning in osteoarthritis (Larsen 1997; Ortner 2003; Walker and Hollimon 1989).

Patterns of trauma on skeletal remains can indicate violence and/or dangerous activities (Larsen 1997). By studying skeletal remains, correlates have been made between increases in violence, environmental stresses, and cultural change (Andrushko et al. 2010; Haas 1990; Lambert and Walker 1991; Milner 2007; Walker and Lambert 1989; Walker 1989).
Aside from osteology, the study of mortuary practices is also important in bioarchaeology. These studies include qualitative and quantitative analysis of grave goods and burial methods (Larsen 1997). For example, Gamble et al. (2001) noted a relationship between the distribution of grave goods, ethnographic data, and skeletal analysis in order to argue for the existence of a heritable ranked society amongst the Chumash during the late Middle Period.

Theoretical debates regarding environmental shifts and resource scarcity amongst prehistoric Chumash have relied heavily on bioarchaeological data (Arnold 1992:76; Brickley and Ives 2006; Lambert 1993; Lambert and Walker 1989, 1991; Stuart-Macadam 1987; Walker and Thornton 2002; Walker 1986, 1989). The osteology of prehistoric Chumash populations seems to support environmental stresses between AD 900 and 1350, which is during the Late Period (Arnold 1992:76; Walker 1986, 1989). Further, a majority of these studies focus on the Channel Islands. The osteological analysis in this thesis is significant because not only does it offer insight to environmental conditions for the mainland Chumash, the collection studied for this thesis dates between AD 500 and 1500 (Table 1 on pg. 26), which falls firmly in the Middle Period. This study provides a snapshot of the health of a Chumash population immediately prior to the extreme environmental and socio-political changes that marked the Middle to Late transition in Southern California.
CHAPTER 5

ARCHAEOLOGY

Since the turn of the century, thousands of archaeological investigations have been carried out along the Santa Barbara coastline, adding to and complementing knowledge about ancient Chumash culture. Archaeology of Chumash sites has since expanded outside of Santa Barbara to encompass all Chumash occupied land. There is a vast amount of Chumash archaeological sites, since the research in this thesis is on the Purisimeño, three archaeological endeavors warrant detailed consideration.

In order to gain a better understanding about the life of ancient Purisimeño it is important to first look at two excavations led by Michael Glassow in the 1970s and 1980s (Figure 2). The first excavation, conducted at Point Sal, California, provides a geographical overview of the Point Sal region and how the Purisimeño may have lived (Glassow 1991). The second excavation, at Vandenberg Air Force Base, provides an in-depth analysis of ancient Purisimeño subsistence strategies and shifts in population density (Glassow 1996). Also warranting consideration is an archaeological excavation conducted in the 1930’s by George Carter (1941) at the northeastern border of Point Sal. In addition to cultural items, this excavation yielded forty-six burials. The skeletal material found in these burials was analyzed and are the focus of this thesis.

POINT SAL EXCAVATION BY GLASSOW (1991)

Glassow’s (1991) excavation at Point Sal came about when the Bureau of Land Management, Bakersfield District, teamed up with the University of California Santa Barbara (UCSB) to determine the nature of archaeological sites in the region and to what degree these resources were being affected by natural and human factors. Michael Glassow, a professor at UCSB, was the lead investigator.

Observations of the surrounding environment made Glassow doubt whether this area was occupied year-round. Point Sal is at the west end, of an east-west oriented ridge, at an elevation of 1000 feet. Although there are intervals of flat land that would be suitable for
habitation, steep gradients throughout most of the area would dissuade any extended stay (Glassow 1991). Also, covering much of the project area are stabilized dunes. Although the antiquity of these stabilized dunes is not known it is hypothesized that they are no more then 3,000 years old (Glassow 1991). The ocean creates strong onshore winds that seem to prevail all year. There is some relief from these winds on the southern part of the ridge, however, this part of the ridge is rather steep and uncomfortable for long stays (Glassow 1991). The surrounding surf is treacherous, discouraging any ocean activities away from the shoreline.

**Figure 2.** Vandenberg region excavated by Glassow (1991, 1996) shown in larger blue circle and those by Carter (1941) shown in smaller red circle. Source: Glassow, Michael A. 1996 Purisimeño Chumash Prehistory: Maritime Adaptations Along the Southern California Coast. Orlando: Harcourt Brace College Publishers.
Despite this, there are bedrock shelves to the north, in the intertidal zones, ideal for gathering California mussels (*Mytilus califonianus*) (Glassow 1991). The pools left behind by the receding tide as well as a small sandy beach to the north makes fishing possible. There are also a few fresh water springs in the project area, which flow year round and are invaluable for habitation (Glassow 1991).

The majority of this project was dedicated to surveying and recording all archaeological sites. The project was divided into two phases that commenced between 1985 and 1990. During this time twenty-eight sites were recorded. Profile drawings and column samples were taken at the site locations, and several of the sites were excavated with .5m x 1m units. Glassow (1991) noted that each site contained medium to high frequencies of shellfish remains, as well as a moderate amount of chert flakes, both offer clues about subsistence strategies. Several of these sites are relevant to the current discussion because they provide good insight about living conditions and subsistence strategies and will be paraphrased here.

Site CA-SBA-232 was originally recorded in 1930. This site is the largest in the project area (260m x 75m). It is adjacent to the ocean, about 15 to 20m above sea level, providing easy access to shellfish. This may be the reason this site has the densest shell-midden deposit in the project area. Dense shell-middens are evidence that the population at this site was using shellfish as a major source of sustenance. Glassow (1991) states that this site may be the ancient Purisimeño village of Atejes, which would provide an interesting historical context.

Another site of interest is CA-SBA-2144, located on the northern portion of the project area, between 68m and 100m above seal level. A large disturbed area in the southern portion of this site has evidence of looting. When mentioning details of the site, Glassow (1991:39) states, “several human long bones were found in the vegetated area just north of the blowout.” Although there is a good chance that there are more human remains in this area, they were not excavated, nor was any attempt made to locate them. The presence of human remains is important because it suggests that the site was occupied for long interim, and that it was important enough to the Purisimeño that they buried their dead at this location.
The third site reviewed, CA-SBA-2399, here in the southeast corner of the project area, located on a slope. Unlike most of the other sites, CA-SBA-2399 contained bird and mammal bones. However, there might be animal bones in larger quantities at the other sites, which have not yet been identified. Additionally, this site had fire-altered rock scattered throughout, suggesting the presence of hearths or campfires. This site shows evidence of dietary shifts from marine to terrestrial food resources.

Presence of *Ollivella* shells associated with the Late Middle Period (1700 to 800 B.P.), and ethnographic accounts of occupation as late as 300 B.P, suggest that this project area was occupied for the entire duration of this time period (Glassow 1991). However, the high frequency of sites in such a small area, coupled with the shallowness of the sites, suggests these sites may have not been a permanently occupied, but, rather, seasonal (Glassow 1991). Further, the small surface area of these sites implies that there was never a dense population (around ten people) (Glassow 1991), as a larger population would have necessarily occupied a larger surface area. Although this area seems to have been important to the Purisimeño, perhaps there was a denser population elsewhere for which the sites served as satellites.

Analysis of the middens from the project area shows very little lithic material resulting from stone tool manufacturing (Glassow 1991). This may be because the project area is some distance from quality chert sources. Also, no evidence of terrestrial faunal bone suggests there may not have been a use for stone tools. Archaeological analysis suggest that much of the protein consumed, just under 40%, came from California mussels, which is not uncommon for this area (Glassow and Wilcoxon 1988). However, most of the protein from the site seems to have come from fish (Glassow 1991).

Through studying the fish bones recovered during excavations, the most abundant type of fish exploited were those found in rocky intertidal zones, shallow rock reef areas, and deeper rock reef zones, i.e. different species of rockfish (*Sebastes*) and surffperch (*Embiotocidae*), as well as lingcod (*Ophoniodon elongatus*) (Glassow 1991). Glassow (1991) believes that these fish were caught with the use of a net, as well as a hook and line, although there is no evidence of these items in any of the site deposits. There is also a high frequency of smaller fish such as sardines (*Sardinops sagax*) and anchovy (*Engrulis mordax*). These fish may have been acquired with a net or they may have been brought to
the site in the stomachs of larger fish. Since there is no evidence of canoes anywhere in the vicinity of Point Sal, most of the fish were probably fished from the beach to the north or out of small pools around the area.

Glassow (1991) was able to meet his project goals. He determined that there is a significant amount of archaeological sites in the Point Sal Area, as well as a need for preservation. In determining this, Glassow (1991) was able to make predictions about food sources, as well as the seasonal occupation of these sites.

**VANDENBERG EXCAVATIONS BY GLASSOW (1996)**

Initial archaeological interest in the Vandenberg Air Force Base region began in 1974, when the National Park Service, funded by the Air Force, contracted Michael Glassow to conduct a survey of the base. The primary goal of the survey was to determine whether there were any significant archaeological sites that would be negatively affected by the expansion of Air Force facilities. Ethnographic data indicated that Purisimeño Chumash prehistorically inhabited the Vandenberg Air Force area. Test excavations of thirty-one sites determined the presence of rich archaeological material within the region. In 1978 the Air Force’s need to expand a road that would inevitably destroy three sites called for a more thorough archaeological investigation. Between 1978 and 1980 Glassow (1996) worked on excavations of these sites.

Several themes guided the investigations at Vandenberg. One was (in light of optimal forging theory) studying the relationship in nutritional efficiency between shellfish and other food sources. That is, what food source would provide a better return in calories for the amount of energy invested in order to acquire it. Glassow (1996:36) also wanted to learn about “the dual role of population growth and long-term environmental fluctuations in affecting the course of cultural development.” In the initial survey, shell beads, used for currency by the Chumash, were found indicating that the Purisimeño were part of the larger Chumash exchange economy (Glassow 1996).

Aside from the three sites excavated in 1978-1980, eight of the original thirty-one sites surveyed were included in the analysis. Excavation units were complemented by core samples. All eleven sites analyzed yielded different radiocarbon dates, which were then used to establish a range from 9000 to 200 B.P. Several items were common in most of the sites,
these were: shell beads called *Olivilla* cup beads made from the callus portion of the *Olivilla* shell; projectile points; fishhooks; seal and sea lion bone; rockfish remains; cormorant bird bones; rabbit bones; California mussel (*Mytilus califonianus*); abalones (*Haliotis*); chipped flakes; and hammerstones. Some of the sites contained bi-face points as well. There was also a cobblestone that appears to have been used to weigh down a fishing line. Present in some sites, but not others, were metates and mortars used in seed and acorn processing, projectile points, and flake tools with micro-wear on the edges indicating their use in the butchering of animals (Glassow 1996).

The findings in the Vandenberg region became important for Glassow’s themes when the distribution of these items, within, as well as between each site was analyzed. Dates were connected to strata within each site either through radiocarbon analysis, or through seriation of archaeological material.

Next these dates were connected to the amount and types of food deposits found in respective strata. Glassow (1996) was able to establish a chronology with respect to shifts in subsistence strategies and population fluctuations. He then aligned what was known about the region’s paleoenvironmental conditions with the chronology he had established and was able to describe a correlation between shifts in climate, with shifts in populations and trends in food sources. Glassow was able to paint an impressive picture of the changes in population and climate throughout prehistory (Figure 3). However, the paleoenvironmental information utilized by Glassow used in part the findings of Pisias (1978, 1979), which was later proven to be erroneous by Kennett and Kennett (2000). This calls some of Glassow’s findings into question. I have summarized Glassow’s chronology, correcting, when appropriate with Kennett and Kennett’s (2000) updated paleoenvironmental data.

From 9000 to 7400 B.P (Paleocoastal to Initial Early Period) there was low population density. A slight spike in population occurred from 8000 to 7400 B.P., and then dropped again. A significant amount of metates and manos were found dating to 8500 B.P. signifying an emphasis on seed production. Environmental information for this period is scarce yet it does appear to have been cool and wet (Pisias 1978, 1979).

From 7400 to 3600 B.P (Initial Early to Terminal Early Period) populations remained low in the Vandenberg region, differing from the Santa Barbara region, which showed an increase in population after 5200 B.P. Use of the metate and mano persisted. Also, in this
period there is evidence of a surge in gathering of shellfish. Hunting (small land mammals) and fishing began to appear during this time period. Bird remains start to appear at 8000 B.P., but remain infrequent till the Late Period. After 4500 B.P. mortars and pestles replace metates and manos. This shift indicates a greater emphasis on acorn processing. There is a
spike in the reliance on smaller land mammals from 7400 to 4500 B.P. with a shift to larger land mammals around 3600 B.P. Around 3600 B.P. there is an increased focus on fishing as well as hunting sea mammals. Although there was some warming of the environment from 7000 to 4700 B.P., it was generally cool and wet during this time period (Glassow 1996).

From 3600 B.P. to 3100 B.P. (terminal Early to Middle Period) there is a decrease in population and an increase in sea-surface temperature. Also, there is an increase in the quantity of mortars and pestles indicating a greater amount of acorn production. Information is lacking on what other subsistence strategies may have dominated during this time period (Glassow 1996).

Between 3100 and 800 B.P. (the Middle Period) there are fluctuations in population, with a decrease until 1400 B.P., and a sharp increase afterwards (Glassow 1996). Although land mammals, shellfish, and acorns are still important food sources, sea mammals and fish slowly take precedence (Glassow 1996). Water temperature was thought to have been relatively warm in the initial portion of this period. Vegetation in the Vandenberg region indicates lower precipitation levels (Glassow 1996). At 3000 B.P. there is divergence in paleoenvironmental data interpreted by Glassow (1996) and the revised more accurate data gathered by Kennett and Kennett (2000). According to Glassow (1996) between 3000 B.P. and 800 B.P there was a trend toward warmer SST and an ebb and flow in population density. Although Glassow (1996) does state that the population increased significantly around 1400 B.P., he does not provide any environmental conditions for this time period. Kennett and Kennett (2000) conclude that around 1400 B.P. there was a period of low and unstable SST with an increase in marine productivity. This makes sense, as increased marine productivity would provide necessary food sources for a surge in population. Glassow states that after 800 B.P. population seems to grow with a period of cooler weather, but does not specify SST temperatures. Kennett and Kennett (2000) suggest that this period had an increase in upwelling resulting in even greater marine productivity. Increased marine productivity according to Kennett and Kennett (2000) is supported by archaeology conducted in the area as there is an increase in shellfish deposits, as well as other marine foods during these times (Glassow 1996).

Glassow (1996) was able to create a timeline for population fluctuation in the prehistoric Vandenberg region. He concluded that rather than a steady increase in population,
there were increases and decreases till about 1400 B.P., after which population increased steadily until the beginning of the Mission Period.

Glassow (1996) also concluded that there is a connection between subsistence strategies and an increase in population size. The archaeological evidence gathered and interpreted by Glassow, matches Kennett and Kennett’s (2000) paleoenvironmental data regarding increased marine activity. We are then able to conclude that an increase in marine-life, and marine-life food acquisition, had a positive impact to population levels.

**Point Sal Excavations by Carter (1941)**

One of the earlier archaeological excavations in the Point Sal region was conducted in the mid 1930’s to the early 1940’s by SDMOM’s assistant curator, George Carter, and curator, Malcolm J. Rogers. This excavation took place approximately two and half miles east of Glassow’s 1985-1990 excavations at an elevation of 1100 feet (Glassow 1991). The excavation sites were located among what were at that time, a house, a shed, and two barns on relatively flat ground (Carter 1935).

Three strata were noted with distinct lines of separation. These lines were theorized as periods of less or no occupation. Radiocarbon dating did not exist at this time, thus there are no chronometric dates for any of the strata. Discounting the possibility of disturbance by burrowing animals, stratum one is the earliest and three the oldest (Carter 1941).

In stratum one, there was a metate, large projectile points with one side notch, knife blanks, and a drill. The second stratum revealed mortars and metates, as well as duel notched projectile points. And the third stratum had no evidence of manos or metates, however there was the infrequent arrow point. Noted was the absence of fishhooks, thought to be because of the distance this site is from the ocean. The presence of metates and manos are also indicative of seed and plant processing (Carter 1941).

The most important facet of this excavation was the exhumation of burials in the northeastern quadrant of the site at stratum three. These burials yielded human skeletal remains that serve as the basis for this thesis.
CHAPTER 6

PRIOR ANALYSIS OF THE POINT SAL COLLECTION

CARTER (1941)

In George Carter’s analysis of the individuals he exhumed at Point Sal, he noted that there were features common for Chumash burials as well as ones that were not. Regarding the positioning of each individual, Carter found 64% of the burials were seated and 34% were flexed. Although a flexed position is common in Chumash burials, seated is not (Gamble et al. 2001). Carter counted forty-seven individuals, however my reanalysis revealed that the collection consists of fifty-five.

In his field notes, Carter (1935) states that a good deal of these burials seem to be secondary internments with postmortem disturbances to the burials. Carter notes several burial characteristics that vary based on sex: mandible absence is said to only be found in females; males are seated more often, and facing west; and only males have had their foremen magnum (a naturally occurring hole at the base of the skull where the spine terminates) physically expanded through postmortem manipulation. Carter (1941) believes this expansion to be a result of having the head mounted on a short stick for a brief period, before having it put anatomically back on the body then buried.

The smaller bones, such as rib or hand bones, are missing from most of the burials. Carter (1941) claims that this is either the result of a complex burial ritual that would involve mutilation of the corpse, the posthumous tampering of the burials, or the byproduct of borrowing animals.

Three of the individuals were found holding large blades, believed to have been daggers. One young adult male was found with the remnants of an antler headdress. Another individual had an unusually high number of associated grave objects, as well as the remains of an eagle. An uneven distribution of shell beads as well as abalone shell bowls were also found in almost all the burials. Stone bowls and metates were commonly found in graves.
THE SMITHSONIAN (2001)

In 2001 Kari Bruwelheide of The Smithsonian Institution, along with several colleagues, conducted an analysis of the Point Sal collection (Bruwelheide et al. 2001), and gave a brief description of most individuals in the collection. They contributed to the data Carter had gathered by pointing out several individuals with specific pathologic changes in the collection, as well as possible burnt bone and several instances of trauma.

They provided radiocarbon dates from three individuals within the collection (Table 1). These dates allow for a more accurate assessment of this important collection from the Santa Barbara region. Based on the dates provided The Point Sal collection falls into a range of 1000 – 1510 BP (one sigma), the Middle Period (King 1990). According to the previously discussed research (Jones et al. 1999; Kennett and Kennett 2000; Raab and Larson 1997; Stine 1994) the individuals in The Point Sal collection lived in a time of warm to cooler SST and increase marine activity as well as drought conditions. It is through the osteological analysis of these individuals that we can determine if these environmental shifts posed any biological stress.

Table 1. Radio Carbon Dates from Three Individuals in the Point Sal Collection

<table>
<thead>
<tr>
<th>Provenience</th>
<th>Material</th>
<th>Lab#</th>
<th>Measured $^{14}$C age</th>
<th>Conventional $^{14}$C age (cal BP 1 sigma)</th>
<th>Age range (cal BP 1 sigma)</th>
<th>Age range (cal BP 2 sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>Bone</td>
<td>Beta</td>
<td>1320 ± 40</td>
<td>1450 ± 40</td>
<td>1140 -</td>
<td>1180 -</td>
</tr>
<tr>
<td>17809</td>
<td>collagen</td>
<td></td>
<td></td>
<td>1000</td>
<td></td>
<td>960</td>
</tr>
<tr>
<td>Individual</td>
<td>Bone</td>
<td>Beta</td>
<td>1450 ± 40</td>
<td>1600 ± 40</td>
<td>1280 -</td>
<td>1305 -</td>
</tr>
<tr>
<td>17750</td>
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<td></td>
<td>1180</td>
<td></td>
<td>1130</td>
</tr>
<tr>
<td>Individual</td>
<td>Bone</td>
<td>Beta</td>
<td>1710 ± 40</td>
<td>1850 ± 40</td>
<td>1510 -</td>
<td>1550 -</td>
</tr>
<tr>
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<td>collagen</td>
<td></td>
<td></td>
<td>1410</td>
<td></td>
<td>1350</td>
</tr>
</tbody>
</table>

Note: $^{14}$C dates from email correspondence 2009. Calibrated with CALIB 6.0 and a local reservoir correction of 225 ± 35 years (Stuiver and Reimer 1993, 1999). Adapted from: Bruwelheide et al. 2001
CHAPTER 7

METHODOLOGY

All research was conducted at the SDMOM between June 2010 and May 2012 (summary of data found in Appendixes A and B). Data collection was based on previous protocols set forth by Jane Buikstra and Douglas Ubelaker (1994) in the *Standards for Osteological Collection*. Data collected from skeletal remains was assigned a numerical value representing percentage of complete bone. The number 1 represents 75% or more complete; the number 2 is for 25% to 75% complete; and a 3 is given to less than 25% complete. If the bone is absent then no mark is given. A separate form exists if the remains are either comingled or too scant to warrant an inventory form.

AGE AND SEX DETERMINATION

Another form included in this manual aided with the determination of age and sex. This form employs methods developed by several different authors. For determining sex, Buikstra and Ubelaker (1994) followed Phenice (1969) on several features of the os-coxae. Each feature is scored using a graded system with 1 representing a characteristic that is considered strongly to a grade representative of traditionally male and intermediate grades in between. Once these skeletal characteristics are looked at as a whole, sex is determinable within 95% accuracy (Phenice 1969). Other authors have tested Phenice’s technique and, although at times they have not experienced the same accuracy (Lovell 1989), praised this method for reducing subjectivity error and its general ease for determining sex (Bruzek 2002; Lovell 1989). Cranial morphology also aids in determining sex. More robust features on the cranium are indicative of males and more gracile features are attributed to females. This approach does not carry as much merit as Phenice’s technique due to variation in skull morphology between populations (Buikstra and Ubelaker 1994). However, a working knowledge of a group can allow for an investigator to make population adjustments regarding which traits are helpful. Nevertheless, cranial morphology for this group was not weighed as heavily as pelvic-girdle morphology in sex determination.
For determining age at time of death, two sets of methods were employed. The first relies on skeletal development in sub-adults, the second on age-related morphological changes in the skeleton of adults. Individuals younger than 18 are considered sub-adults here. For sub-adults, age determination was based on dental development and eruption, using a dental chart adapted from Ubelaker (1987). Because dental development is genetically controlled and timed, it is most useful in aging children. Comparisons on dental development (when possible) and eruption are made to Ubelaker (1987) and allow for an estimate of age. After an individual has reached twenty-one years of age, dental development is complete. Similarly, skeletal development follows a discernable pattern. Bones in the human body develop at different ages, which follow a documented pattern with complete fusion at approximately 29 years (Scheuer and Black 2000). An age range can be estimated by observing which bones have completed development and which have not.

Once an individual’s skeleton is fully developed, the combination of changes in features of the pelvic girdle and the cranium can be used to determine the individual’s age. When estimating age using the pubic symphysis I employed a combination of the Todd and the Suchey-Brooks scoring systems. The Todd method of aging, developed in 1921, utilizes morphological changes in the pubis. This method has been tested, critiqued, and deemed accurate in age determination (Meindl et al. 1985; Katz and Suchey 1986). However, one drawback of the Todd method is that it does not account for sexual variation in pubic symphysis morphology (Gilbert and Mckern 1973). This problem is alleviated through the employment of the Suchey-Brooks scoring system, which has specific descriptions of the shifting phases of the pubic symphysis based on sex. One drawback of the Suchey-Brooks system is the wider range of possible ages at the time of death. The changing morphology of the auricular surface is also useful in determining the age of the individual at time of death. Although it is harder to differentiate between phases in the auricular surface, the high rate of preservation makes it a valuable resource (Lovejoy et al. 1985). Cranial suture closure also is useful in calculating age at time of death. A drawback of aging using cranial sutures is a much wider age range, and increased susceptibly to inter observer error (Nager and Hershkovitz 2004). Therefore, here, it was only used if it was the only skeletal element present. A final aging technique employed in this study was rib-end morphology, which, when present, can provide accurate age ranges (Iscan et al. 1984; Osteoware 2011).
By using all of the aforementioned methods together, a high degree of confidence is established regarding the range of age and sex in the collection. Ambiguity in the sexing and aging of certain individuals occurred when necessary skeletal elements were not present.

**Skeletal Pathology**

Each individual was examined thoroughly a second time for skeletal anomalies. All results were described and recorded. Major pathologies found in this collection include, cribra orbitalia, porotic hyperostosis, spina bifida, and osteoophytosis. Of the pathologies noted, cribra orbitalia and porotic hyperostosis were given a score of 1 if present and 2 if absent. Spina bifida was noted as SL for slight if only the superior portion of the sacral canal was incompletely fused; MR for moderate if more than half of the sacral canal was incompletely fused; and EX for extreme if there was no fusion at all. For stress markers in the skeleton, osteoophytosis was graded using the Smithsonian guide (Osteoware 2011).

When observing dentition, pathologies such as attrition, caries, abscesses, antemortem tooth loss, and linear enamel hypoplasia were all found in this collection. Tooth number was used to specify location of any pathology within the dental arcade. For all observations if the element necessary was absent then the space was left blank. Dental attrition is usually denoted using an eight-point scale (Figure 4), (Molner 1971; Smith 1984; Walker 1978a). Due to the extreme amount of wear on the dentition, however, this scale was condensed into three categories. Dental attrition was denoted with slight (SL) for 1 through 3; moderate (MR) for 4 through 6; and extreme (EX) for 7 through 8. All present skeletal elements also were observed for the presence of caries. If caries were present, tooth number was indicated. A modified form from the one provided by Buikstra and Ubelaker (1994) was used, where severity rather than location was emphasized. The severity of caries was based on a range of 1 through 4, with 1 being the least severe and 4 being the most. Abscess formation as well as antemortem tooth loss was noted with the correlating tooth number. All dentition also were examined for linear enamel hypoplasia (LEH). When LEH was observed, tooth number and presence or absence were indicated.
CHAPTER 8
SEX AND AGE DISTRIBUTION IN THE POINT SAL

The minimum number of individuals within the Point Sal collection is fifty-five. This is slightly more than George Carter’s (1941) original estimation of forty-seven. The analysis to determine the amount of skeletal material present for each individual yielded forty-five individuals with 25% or less present; six individuals with 25% to 75% present; and three individuals with 75% or more complete. The amount of skeletal material present is particularly important for the determination of sex and age. Due to the high number of individuals less than 25% complete (n=45), twenty individuals lacked the skeletal elements necessary for determining sex. Of the remaining thirty-five, 74% (n=26) were determined to be male and 26% (n=9) female. The disproportional amount of males to females may be because the general gracility of the female skeletal system decreases the chances of it surviving in antiquity (Walker et al. 1988), which probably accounts for the twenty individuals that were unable to be sexed.

Age was categorized as child (0 to 7 years), sub-adult (8 to 19 years), young adult (20 to 30 years), middle adult (31 to 40 years), and old adult (40+ years). Fourteen of the individuals lacked sufficient skeletal elements for aging (Table 2). Using a Chi-Squared test, it was determined that there is no significant shift in age distribution in the remaining forty-one individuals ($p=.8614$) (Figure 5). However, when the population is divided into sub-adult or younger (< 19 years) and young-adult or older (> 20 years), it is apparent that the majority of this collection (64%, n=26) lived through childhood and into adulthood ($p=.08581$) (Figure 6).

This survival rate is important to consider when observing pathologies and other skeletal indicators of bad health. The evidence of survival into later years by the majority of the Point Sal collection is an indicator of the population’s resilience to possible life-threatening stresses (Ortner 2003).
Table 2. Estimation of Age and Skeletal Elements Used in its Determination

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Skeletal Elements Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>17683</td>
<td>&gt;50</td>
<td>S</td>
</tr>
<tr>
<td>17704</td>
<td>25-32</td>
<td>P;R</td>
</tr>
<tr>
<td>17688</td>
<td>60</td>
<td>S;P;R</td>
</tr>
<tr>
<td>17811</td>
<td>20-25</td>
<td>F</td>
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<tr>
<td>17697</td>
<td>24-28</td>
<td>R;F</td>
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Table 2. (continued)

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Note: Key: R=Rib ends; S=Suture Closure; Dh=Dental Eruption; F=Epiphysis Closure; P=Pelvic Features

Figure 5. Distribution of age at time of death in the Point Sal collection.
Figure 6. Bisection of adult and sub-adult at time of death in the Point Sal collection.
CHAPTER 9

PATHOLOGY

POROTIC HYPEROSTOSIS AND CRIBRA ORBITALIA

Porotic Hyperostosis (PH), a term coined by Angel (1966), is used by researchers to describe spongy-like lesions on the cranial vault. These lesions result from the expansion of the diploë or spongy bone found between the inner and outer tables of cranial bones (Larsen 1997; Ortner 2003). There has been ongoing debate regarding the etiology of PH. However, for the last 60 years the majority of researchers believe PH to be the result of acquired or genetic iron deficiency anemia (Larsen 1997; Stuart-Macadam 1987). In some cases PH may be a result of scurvy or chronic infections (Ortner 2003).

Prevailing theories on the etiology of PH explain the processes as a direct link to the lack of iron (Larsen 1997). Iron is important not only for the production of red blood cells, but also, their ability to bind with oxygen (Ortner 2003). Without adequate amounts of iron, red blood cells begin to die. This triggers the hypertrophy of red marrow (found in the diploë), which is responsible for the production of red blood cells (erythropoiesis) (Ortner 2003). As the red marrow works to create more red blood cells it expands past and absorbs the cortical bone forming lesions on the skeleton (Ortner 2003). PH, in its active phase, is found in parietal and frontal bones, mostly in individuals under the age of 12 (Larsen 1997; Ortner 2003; Walker et al. 2009). This is because the primary center for blood production in children is located in the bones of the skull (Larsen 1997; Walker 1986). Also, children have mostly all red marrow with the only room for expansion being past the cortical bone. Adults have some yellow marrow allowing room for expansion within the diploë (Ortner 2003).

Cribra orbitalia (CO), a lesion similar to PH, forms on the superior portion of the eye orbits. Research has shown PH and CO are related and share iron-deficiency as a common etiology (Larsen 1997; Stuart-Macadam 1989).

Environmental factors rather than genetic mutations are responsible for iron-deficient anemia in North America (Walker 1986). Because most North American cases of iron-deficient anemia are a result of environmental factors, researchers have used the presence of PH/CO to gauge the nutritional health of archaeological populations (El-Najjar et al. 1975;
Fairgrieve and Molto 2000; Larsen 1997; Mayes and Barber 2008; Ortner 2003; Vercellotti et al. 2010). In the Santa Barbara region, PH/CO have been signifiers of a population’s reaction to environmental stresses as well as a gauge of population health, which has been used in theoretical discussions about the rise of complexity in the Chumash (Arnold 1992; Lambert and Walker 1991; Walker 1986; Walker and Lambert 1989).

In recent years the correlation between insufficient iron and PH/CO has come under scrutiny (Stuart-Macadam 1992; Walker et al. 2009; Weinberg and Miklossy 2008). A new theory connects the decrease of iron in the body as an immune system’s response to disease (Weinberg and Miklossy 2008). The successful spread of pathogens throughout the body requires the use of iron. The body’s immune system withholds iron as a response to pathogenic assault (Weinberg and Miklossy 2008).

The relationship between pathogens and the formation of CO or PH has been noted in skeletal analysis of Island Chumash populations, thought to have contracted from parasites in marine foods (Walker 1986). Further archaeological evidence for parasitic reasons behind PH and CO has also been found in Anasazi agricultural sites, through coprolite analysis (Reinhard 1988). Both samples suggest that the cause of PH or CO stem from the presence of parasites in combination with foods deficient in iron and not one or the other exclusively. Further, contamination leading to PH or CO comes from crowding around water sources (Raab and Larson 1997; Walker and Lambert 1989).

Walker et al. (2009) used recent hematological research to suggest that iron-deficiency anemia alone does not stimulate bone marrow growth and cannot cause PH. They suggest that megaloblastic anemia is the cause of most cases of PH in prehistoric North American skeletal populations.

Megaloblastic anemia is caused by deficiencies in cobalamin (vitamin B12) and folic acid (vitamin B9). The most common source of B12 is found in animal products (Stabler and Allen 2004); B9 is found in leafy greens (Retelny and Milivojevic 2011). Insufficient access to these vitamins would be enough to stimulate hypertrophy of the bone marrow causing PH (Walker et al. 2009). Aside from insufficient access, the body may lose these vitamins because of diarrheal diseases, which can be contracted from either contaminated food or water (Raab and Larson 1997; Walker and Lambert 1989; Walker 1986; Walker et al. 2009).
Walker et al. (2009:115) also reassesses the etiology of CO, “Although anemia-induced marrow hypertrophy is probably a common cause of cribra orbitalia, other pathological processes such as those associated with scurvy, rickets, hemangiomas, and traumatic injuries can produce subperiosteal hematomas that can lead to orbital roof lesions.” Such roof lesions can be easily categorized under CO. These results are considered in my analysis of the Point Sal collection.

**Methods**

Observations for the presence of CO and PH were done macroscopically with the occasional use of a magnifying glass. Results were recorded as present or not present. Whether the lesion was active, healing, or healed was elaborated on supplemental notes. If the skeletal elements needed for observing CO and PH were absent the space provided was left blank and was not included in the analysis.

**Results**

Out of the fifty-five individuals in the Point Sal Collection only thirty-five retain the upper portion of the eye orbits necessary for observing CO. Out of these, 31% (n=11) show signs of CO. Only one of the individuals has active lesions (Figure 7).

In analyzing the presence of PH, only the crania of forty-four individuals are intact enough for adequate observation. Within this subset, PH is present in 46% (n=20) of individuals. Two of the individuals have active lesions (Figure 8).

While analyzing skeletal elements, I found that every time there was enough skeletal material present to search for CO in the eye orbits (Figure 9), then there would also be enough skeletal material to search for PH in the crania. Out of the thirty-five people with skeletal elements present adequate to observe both lesions, 17% (n=6) showed signs of both PH and CO (Figure 7).

**Discussion**

Interpreting these results in light of past and present research on the etiologies of PH and CO can lead to several deductions about the Point Sal collection. Members of this population endured and survived periods of nutritional stress, which manifested as
Figure 7. Distributions of Cribra Orbitalia and Porotic Hyperostosis.

Figure 8. Example of Porotic Hyperostosis from Individual 17661 in the Point Sal collection.
megaloblastic anemia leading to PH and CO (Walker et al. 2009). The presence of PH and CO would either be a result of lack of proper nutritional intake, nutritional loss as a result of diarrheal diseases resulting from parasites, or a combination of both. (Walker 1986; Walker et al. 2009).

Megaloblastic anemia manifests because of insufficient amounts of vitamins B12 and B9 in the body (Walker et al. 2009). Vitamin B12 is commonly found in animal meat (Stabler and Allen 2004), as well as marine organisms such as fish and shellfish (Greenwood-Robinson 2008:27). Although a lack of terrestrial resources is supported by drought conditions during the time these individuals lived (1000 to 1500 BP) (Davis 1992; Jones et al. 1999; Raab and Larson 1997; Stine 1994), lack of marine resources is not. On the contrary, not only was there an increase in marine productivity (Kennett and Kennett 2000), but also, marine resources were an invaluable and consistent food source for prehistoric Chumash (Braje et al. 2011; Kennett 2005). Further, archaeology in Point Sal region supports the role of shellfish in diet (Glassow 1991, 1996). If nutritional needs were being met by an adequate intake of foods, then the presence PH and CO as a result of megaloblastic anemia is likely due to rapid nutritional loss. Diarrheal diseases, often resulting from parasitic
infections, can deplete the body of essential nutrients triggering the formation of PH and CO (Larsen 1997; Ortner 2003; Walker et al. 2009). Foodborne parasites as a result of shellfish consumption have been connected to diarrheal diseases elsewhere in the Santa Barbara region (Berg 2007; Walker 1986). Further, drought conditions during this time, forced populations to coalesce around diminished fresh water sources, increasing risk of parasitic infection and furthering susceptibility to diarrheal diseases (Kennett and Kennett 2000; Raab and Larson 1997).

Vitamin B9 or folic acid is found in a variety of foods most notably beans, nuts and leafy greens (Retelny and Milivojevic 2011). Of these foods only leafy greens, seeds, and acorns have been known to exist in the Point Sal region (Glassow 1996). The manifestation of PH and CO indicates that the individuals in the Point Sal collection were consuming very little, if any of these foods. It may be possible that the particular seeds being consumed lacked B9. Acorns are another food source that has been linked to the region (Glassow 1996). Although acorns are a great source of nutrients, they are low in Vitamin B9. It is also possible that the level of parasitic infection was lapsing any positive benefits from the acorns.

If CO is due to bone marrow hypertrophy as a result of megaloblastic anemia, then it provides evidence for inadequate B12 and B9. Although not as likely, scurvy, due to vitamin C deficiency, or rickets, as a result of vitamin D deficiency, have also been connected to CO (Ortner 2003; Walker et al. 2009) and warrant examination in the context of Point Sal. Vitamin C is commonly found in a variety of fruits and vegetables. If CO occurred as a result of scurvy it would indicate the absence of these foods. The lack of sunlight, which is important in vitamin D production, is the main cause of rickets (Ortner 2003). Since it is not probable that there would have been inadequate sunlight in this region, it is unlikely rickets led to CO.

By looking at the evidence regarding this region, the most probable contributing factor in PH and CO would be parasite borne diarrheal diseases. The availability of marine food sources (Kennett and Kennett 2000; Kennett 2005) would have made up for inadequate intake of nutrients as a result of diminished terrestrial resources (Jones et al. 1999; Raab and Larson 1997). The presence of PH and CO in the Point Sal population would then have to have been from a rapid depletion of nutrients, probably due to diarrheal diseases because of
parasites found not only in shellfish (Walker 1986), but contaminated water sources (Kennett and Kennett 2000; Raab and Larson 1997).

**Spina Bifida**

Spina bifida, Latin for ‘split spine,’ is a congenital disorder where the neural arch of the spinal column fails to properly fuse (Botto et al. 1999). The mal-fusion of the neural arch is located, primarily, on the dorsal spine of the sacrum called the sacral crest, but may also involve some of the vertebrae, namely lumbars 4 and 5 (James and Lassmen 1981). The severity of spina bifida depends on how much nerve tissue is involved. Spina bifida occulta is the least severe form, in which there is no nerve involvement and often no symptoms (James and Lassmen 1981). In the most severe form, spina bifida cystica, the spinal cord and nerves protrude out of the spine and form a small sack on the base of the spine called a meningomyelocele (Botto et al. 1999). Spina bifida cystica is accompanied by paralysis, pain, and eventually death (Botto et al. 1999). Because soft tissue does not survive in antiquity, the severity of spina bifida is determined by the amount of skeletal elements involved. In other words, the more skeletal elements involved, the more severe spina bifida was likely to have been (Ortner 2003).

The exact etiology of spina bifida is still the subject of research. Recent studies show genes play a role in the development of spina bifida, specifically the mutation of the gene that controls the production of methylenetetrahydrofolate (MTHFR) reductase (Morrison et al. 1988; Van der Put et al. 1995). MTHFR is an enzyme that assists with regulation of certain amino acids (Van der Put et al. 1995). However, the mutation of this gene only accounts for a small number of the occurrences of spina bifida. More likely, a gene’s complex relationship with environmental factors, such as nutritional intake, is the main reason behind the development of spina bifida (Botto et al. 1999; Shaw et al. 2002).

To illustrate, in 1976 Smithells and colleagues conducted a study where they concluded that the development of spina bifida is connected to a mother’s insufficient intake of folic acid (vitamin B9) before pregnancy (Smithells et al. 1976). Subsequent studies have confirmed that a woman’s inadequate intake of B9 is the primary cause of spina bifida in her children (Berry et al. 1999; Botto et al. 1995; Lemire and Beckwith 1984).
Methods

In the Point Sal collection, the presence of skeletal elements with spina bifida was recorded on a scale. Extreme cases of spina bifida are defined as lacking fusion for all portions of the sacral crest, and were denoted by an EX. Because of the amount of skeletal involvement, an extreme case would mean the individual suffered from spina bifida cystica. If 50% or more of the sacral crest had not fused, it was labeled as moderate (MR). Moderate cases could be either spina bifida cystica or spina bifida occulta. Since the mortality rate on spina bifida cystica is high, observing age at death on moderate cases is a good indicator of the type of spina bifida that individual may have had (Dickel and Doran 1989; Dickel et al. 1984). If less than 50% of the sacral crest had not fused, the individual was labeled as slight (SL). SL cases are attributed to spina bifida occulta.

Results

Out of fifty-five individuals, twenty-seven had a sacrum present. Macroscopic observation of the sacrum revealed that 26% (n=7) showed some sign of spina bifida. Of those that exhibited spina bifida, 14% (n=1) were denoted as extreme, 57% (n=4) as moderate, and 29% (n=2) as slight.

The one individual labeled extreme (Figure 10), exhibited no fusion of the sacral crest indicating they suffered from spina bifida cystica. This individual lived longer than expected. Based on suture closer of the skull, age at time of death was between twenty and twenty-five years.

Of the individuals denoted as moderate, 75% (n=3) had not survived into adulthood. The low age of mortality indicates that, although there was moderate fusion, they had probably suffered from spina bifida cystica. The remainder of the individuals had slight mal-fusion of the sacral crest meaning they most likely had spina bifida occulta.

Out of those exhibiting signs of spina bifida, 57% had spina bifida cystica. If this total is compared to the collection as a whole, 7% (n=4) of individuals had spina bifida cystica, which most likely led to their deaths (Figure 11).

Discussion

Spina bifida occurs in 1 out of 1000 births (.001%) in the US and even less frequently worldwide (Botto et al. 1999). Given these statistics, a 7% occurrence in the Point Sal
Figure 10. Skeletal example of Spina Bifida Cystica from Individual 17811 in the Point Sal collection.

Figure 11. Individuals in the Point Sal collection with Spina Bifida divided into slight, moderate, and extreme.
collection is considerable. Such a high occurrence of spina bifida within one population would signify a strong genetic factor coupled with strong environmental factors. The lack of B9 (folic acid) is the biggest known environmental contributor to the formation of spina bifida (Botto et al. 1999; Smithells et al. 1976). It would stand to reason that such a high prevalence of spina bifida in the Point Sal collection would indicate the population had little, if any, access to foods rich in B9, such as leafy greens and vegetables and cereals (Greenwood-Robinson 2008). This is consistent with the types of vegetation found in the area (Glassow 1996). However, if conclusions about PH and CO are taken into account, then it is also plausible to conclude here that depletion of nutrients from diarrheal diseases led to a low enough level of B9 causing the formation of spina bifida.

Aside from the prevalence of spina bifida in the population as a whole, it is worth noting that the individual exhibiting no fusion, and thus spina bifida cystica, lived until age of twenty. For an individual to survive to twenty years of age, near continuous care would be required. In order to provide such care, considerable time must have been invested in this person.
CHAPTER 10

DENTAL PATHOLOGY

INTRODUCTION

Dentition is an important source of information in bioarchaeological studies as they are the “only part of the skeleton that interacts directly with the environment” (White et al. 2012:102). The resilience of teeth allows for preservation in most archaeological contexts mainly because the outer layer of teeth, enamel, is the hardest material in the human body (Hillson 1996; White and Folkens 2005). Further, once enamel has been formed it is not readjusted by the body’s basic biological functions. Any changes in crown shape throughout a person’s life are a result of outside influences. Because of this, dentition is a permanent record of a person’s life. Many alterations to dentition due to outside factors can be put under the broad term of “dental pathologies.” By assessing the types and patterns of dental pathology in a population, conclusions can be made regarding diet and overall health (Mayes and Barber 2008). Analysis of the dentition within the Point Sal collection resulted in five categories of dental pathologies: dental attrition, dental caries, abscesses, antemortem tooth-loss, and linear enamel hypoplasia. Each category will be briefly discussed then synthesized.

A tooth is divided into two parts, the root, which attaches the tooth to the jaw or alveolar bone, and the crown, which projects outside the jaw (White and Folkens 2005). A layer of enamel encases the crown, and a thin layer of cementum adheres to the root (Hillson 1996), securing the tooth within the alveolar bone. The core of the tooth is made up of a dense bone-like material called dentine (White et al. 2005). Running down the center of the tooth, from the crown to the root, is a small canal, the pulp chamber. The pulp chamber contains soft tissue as well as nerves (White and Folkens 2005). Once the tooth has been formed in the body it cannot not be remodeled or regenerated (Hillson 1996).

DENTAL ATTRITION

Dental attrition is present in all human populations and is a natural product of use and aging (Molner 1971). The rate and extent of attrition varies based on age, what types of foods
are being masticated, and if the teeth are being used as tools (Hinton 1981; Larsen 1997, Mayes and Barber 2008). Larsen (1997:248) describes the process of tooth wear as beginning with the loss of occlusal enamel. When this happens a deposit dentin is made to protect the pulp chamber. If dental attrition continues all enamel eventually disappears; nerves retreat from the pulp chamber as dentine takes their place, accompanied by a loss of crown size.

Although high attrition rates have been associated with tougher foods (Smith 1984), recent research suggests grit as the main cause for observable attrition (B. Wood 2013; Lucas et al. 2013). In plant food, grit has been connected to production methods. Chumash populations use stone to grind most plant foods, which leaves behind grit (Walker 1978a; Walker and Erlandson 1986). Attrition found in other Chumash populations has been connected sand found in shellfish and dried fish (Walker 1978a).

**Methods**

There are different methods and scales for measuring the degree of dental attrition. One of the most effective is an eight-point system developed by Smith (1984) (Molner 1971; Walker 1978a). Due to the high amount of attrition in the Point Sal collection, Smith’s (1984) eight-point system was truncated into three categories of slight, moderate, and extreme.

Tooth number was used to specify location within the dental arcade. For all observations if the element necessary was absent then the space was left blank. Dental attrition was denoted with slight (SL) for 1 through 3; moderate (MR) for 4 through 6; and extreme (EX) for 7 through 8. Every individual noted on excel was also described in detail on a correlating word document.

**Results**

Of the fifty-five individuals within the collection only thirty-one had the dental elements necessary for scoring. From these thirty-one observable individuals 32% (n=10) were scored as SL, 29% (n=9) as MR, and 39% (n=12) as EX (Figure 12). Not surprisingly, older individuals exhibited a greater amount of attrition with 19 years being the average age for those whom scored SL. MR had and average of 35 years and EX was 38 years of age. The first molar had disproportionally more wear on most individuals, which is common as it is the first tooth to erupt (Walker 1978a).
Figure 12. Dental attrition rates for individuals in the Point Sal collection divided up into slight, moderate, and extreme.

**Discussion**

Dental attrition found in the Point Sal collection (Figure 13) is indicative of a diet of grit filled foods. This may be attributed to the production methods of plant foods such as tubers and roots (Walker 1978a). Another likely cause for attrition is sand found in shellfish as well as dried fish (Walker and Erlandson 1986). Given the extreme amount of dental attrition, it is most likely that a combination of these factors contributed to the dental wear found in the Point Sal collection. Roots and tubers have been attributed to high rates of attrition amongst other groups of ancient Chumash (Walker 1978a). Such roots and tubers are common in the Point Sal region (Glassow 1996). Further, these foods are not high in either vitamin B9 or B12, and, thus, consistent with pathological findings on individuals in the Point Sal collection. Metates and morters found alongside the buirals (Carter 1941) is evidence that stone tools were being used in the production of these plants. Dental attrition can also result from sand grit found in shellfish and dried fish (Walker 1978a). If, as suggested above, individuals within this collection were contracting parasites from not only water sources, but also shellfish consumption, then the attrition observed in the collection is to be expected.
Figure 13. Individual 17752 in the Point Sal collection exhibiting extreme dental attrition.

Caries

Although enamel is one of the hardest materials in the human body, its integrity can be compromised by caries. Caries are the gradual destruction of the multiple layers of teeth as a result of acid deposits from bacteria (Hillson 1996; Ortner 2003). Although there are several types of bacteria that can cause caries, the most common is *Streptococcus mutans* (Ortner 2003). The first sign of caries is the appearance of brown or white spots on the enamel surface. As bacterial acids slowly eat away at the enamel, the surface of the affected area becomes rough and forms into a cavity (Hillson 1996). As the caries progresses, it will eat through the enamel and reach the dentin where the destructive process increases speed (Ortner 2003). If not treated or suspended, the caries will work its way through the dentine, destroy the crown and portions of the root and expose the pulp chamber (Hillson 1996). With the pulp chamber exposed the risk of infection increases “with almost inevitable sequelae of abscess and destruction of the supporting alveolar bone and process” (Ortner 2003:590). The root of teeth can also be directly affected by caries if they are exposed from periodontal disease (White et al. 2012).
Foods rich in carbohydrates are the main reason behind the formation of caries (Hillson 1996; Mayes and Barber 2008). However, the overall health of an individual also plays a role in how susceptible they are to caries (Mayes and Barber 2008; Ortner 2003).

Methods

The presence of caries in the Point Sal collection was observed macroscopically. If caries were present, tooth number was indicated and further scored using a modified version of the Buikstra and Ubelaker (1994) scoring method, focusing on severity rather than location. A number 1 was used to indicate whether the caries was a lesion on the enamel. A 2 was used if a pit had made its way to and through dentine. A 3 was used if caries had exposed the pulp cavity. If the caries had eaten away most of the crown and began affecting the root, it was scored as a 4.

Results

Out of fifty-five individuals in the Point Sal collection, thirty-five had teeth present and could be investigated for the presence of caries (Figure 14). Out of these thirty-five individuals, 40% (n=14) exhibited some degree of caries formation. Out of the individuals that exhibited signs of caries, 71.4% (n=10) had caries on two or more teeth. The severity of the caries within the collection is moderate. Out of the individuals with caries, 14.2% (n=2) of the individuals had lytic destruction involving the enamel only (score 1); 43% (n=6) had caries formation severe enough to involve the enamel and dentin (score 2); 21.4% (n=3) showed and exposed root (score 3); and 21.4% (n=3) had the root and alveolar bone affected (score 4).

Discussion

The presence of caries in the Point Sal collection is evidence of a diet rich with carbohydrates (Figure 15). Roots and tubers, found in the Point Sal area, are rich in carbohydrates and have been connected to caries formation in similar populations (Walker and Erlandson 1986). A diet involving such foods would be congruent with the amount of attrition also found in the collection as the preparation of these foods often leaves behind grit (Walker and Erlandson 1986). It should be taken into consideration that the attrition on the teeth might have worn away what probably would have been a higher rate of caries. This is
Figure 14. Distribution of Carries based on Severity in the Point Sal collection.

Figure 15. Example of Caries scored at a 4 in Individual 17750 from the Point Sal collection.
because as the abrasion rate of course foods may have been faster then caries formation, thus what would have been a caries was wiped out before it could form. Another contributing factor to high caries rates in the Point Sal collection would be a general decrease in health within the population. Decreased health in the Point Sal collection may be a result of malnourishment, presence of disease, or a combination of both (Ortner 2003).

**ABSCESS/ANTEMORTEM TOOTH LOSS**

If the pulp cavity is exposed, either as a result of caries, a fracture, or wear, the probability of infection increases (Ortner 2003). Inflammation of the pulp cavity, and, in turn, pulp death, leads to the production of pus, which will be contained by the pulp cavity for a short while (Hillson 1996). As infection spreads throughout the pulp cavity, pus, pressure, and inflammation form an abscess in the associated alveolar bone (Figure 16). As the abscess progresses, the alveolar bone is resorbed to form a hole, or cavity, called a periapical abscess, for pus drainage (Hillson 1996). If untreated, the infection causing the abscess ultimately leads to death, as the infection becomes systemic (Hillson 1996). Similar to caries, the prevalence of abscesses throughout the alveolar bone is related to the health of an individual; those who are less healthy are more susceptible to infection (Ortner 2003).

The loss of teeth while an individual is still alive is referred to as antemortem tooth loss (AMTL). The main causes of AMTL are caries, abscesses, and dental attrition (Mayes 2010; Mayes and Barber 2008). The physical indicator of AMTL is the absence of teeth, as well as the presence of healed bone remodeling the gap left in the corresponding alveolar bone (Ortner 2003) (Figure 17). If the hole left by tooth loss has a sharp and unhealed appearance then tooth loss occurred after the individual’s death (Buikstra and Ubelaker 1994).

**Methods**

Abscess formation was noted when resorbed bone with defined, circular, or curved margins within the alveolar bone were observed. These are the areas left behind as a result of bone resorbing to allow for the drainage of pus. The location of abscesses within the dental arcade was indicated by noting the correlating tooth/teeth number. Similarly, the occurrence of AMTL was noted by indicating what tooth/teeth number was absent.
Figure 16. Example of abscess formation in Individual 17862 from the Point Sal collection.

Figure 17. Example of AMTL in Individual 17861 from the Point Sal collection.
**Results**

Thirty-five out of the fifty-five individuals (67%) in the Point Sal collection have maxilla and mandibles available for adequate observation of abscesses and AMTL. Of this thirty-five, 23% (n=8) showed abscess formation, with 38% (n=3) having three or more teeth affected. AMTL was recorded for 31% (n=11) of individuals. Because of the amount of wear on all of the teeth with correlating abscesses, any caries that may have been the original cause of infection were wiped out.

**Discussion**

Several conclusions can be drawn from the presence of abscesses within the Point Sal collection. That the pulp cavity was exposed allowing for infection is clear, exactly how it was exposed is unclear. Since none of the teeth associated with abscesses seem to be broken, then abscess formation would have had to stem either from attrition or from caries. It is difficult to determine which because, while caries can expose the pulp cavity to infection, attrition can often remove evidence of prior caries formation as well as expose the pulp cavity. Given the extreme rate of both attrition as well as a presence of caries, it is plausible they may have had an equally influential role in abscess formation in the Point Sal collection.

The presence of three or more abscesses on an individual is evidence that the body was under a large amount of stress and experiencing systemic breakdown (Mayes and Barber 2008). Here, oral health is a reliable indicator of overall biological health. Since 38% of individuals with abscesses had three or more teeth affected, it is safe to conclude that portions of the population in the Point Sal collection were dealing with chronic bad health.

That more than a third of observable individuals show AMTL is not surprising when considering the amount of abscesses along with extreme dental attrition within the group. These poor dental conditions are indicators of chronic health problems within the group as a whole.

**LINEAR ENAMEL HYPOPLASIA**

Tooth development occurs inside the alveolar bone starting with the occlusal apex of each the crown and building downward toward the root (Hillson 1996). Any systemic metabolic disruption during childhood would suspend dental development (Goodman and Armelagos 1985). When the disruption has subsided, tooth development resumes leaving a
visible band or pitting across the enamel. This band is called Linear Enamel Hypoplasia (LEH) (Ortner 2003). Systemic metabolic disruption can occur due to two major factors, chronic illness or malnutrition (Goodman et al. 1984; Ortner 2003), and both lead to LEH similar in appearance. Therefore although the presence of LEH is a reliable indicator of childhood stress, often, the exact etiology cannot be determined (Goodman and Armelagos 1985). Still, patterns of LEH in a population are a reliable indicator of childhood health (Mayes and Barber 2008). While permanent teeth develop during early childhood, deciduous teeth grow in utero. When LEH occurs on deciduous teeth it means development was hindered while the individual was still in the womb (Hillson 1996). In this scenario LEH is no longer a signal of childhood stress, but rather an indicator that the mother was suffering from poor health during pregnancy (Goodman and Rose 1990; Mayes and Barber 2008).

Methods
Observations of LEH were made macroscopically and recorded as present or absent. Tooth number indicated the location of LEH and severity of LEH was discussed briefly.

Results
Out of fifty-five individuals, thirty-five had dentition available. Out of these individuals, 9% (n=3) showed LEH. When categorized by age, two of the individuals were between 6 and 24 months old and one of the individuals was over the age of fifty.

Discussion
LEH is an indicator of illness early in life, how early depends on the teeth affected. Deciduous dentition exhibiting LEH are an indicator that the individual was under stress while in utero and is a reflection of the mother’s health (Mayes and Barber 2008). If LEH is found on permanent dentition, it is evidence of illness in early childhood. Out of the three individuals for whom LEH was observable, only one individual was older than twenty-four months. This age distribution is probably due to the fact that the high amount of wear in most of the adults would have obliterated any evidence of LEH. If this is the case, incidences of childhood stress may have been higher in the collection. The other two individuals, both under two years of age, exhibit LEH on deciduous dentition (Figure 18), indicating poor health while in utero. Since the health of a fetus is contingent on the health of its mother, then
both individuals with LEH on deciduous teeth had mothers who were under severe biological stress during pregnancy. LEH found in this population is another indicator that this population endured long periods of poor health.
CHAPTER 11

STRESS MARKERS

OSTEOPHYTOSIS

Osteoarthritis is a degenerative process that causes the breakdown of protective cartilage in joints, which leads to bone on bone contact (Ortner 2003). This contact often triggers bone-building cells called osteoblasts to lay down new layers of bone on the affected area (Ortner 2003). Bone build-up that accumulates along joint margins is called osteophytes (Ortner 2003). Other indicators of joint degeneration are porosity, whether micro or macro; eburnation, which is the polishing of bone as a result of bone on bone contact; and bony build-up on the joint surface. Osteophytes are important indicators of osteoarthritis on the spine, therefore, osteoarthritis in the spine is referred to as osteophytosis (Larsen 1997) (Figure 19).

Figure 19. Individual 17752 exhibiting moderate osteophytosis from the Point Sal collection.
Although osteophytosis may be caused by injury or metabolic problems (Ortner 2003), mechanical stress and repetitive physical activities are the main reasons for the formation of osteophytosis (Larsen 1997; Ortner 1968). Recognizing patterning of osteophytosis within a population provides clues as to the daily activities of that population (Larsen 1997).

In a study conducted by Walker and Hollimon (1989), patterning of osteophytosis in a prehistoric Chumash population was used to make inferences about shifts in subsistence strategies. Osteophytosis found in the lower (lumbar) vertebrae was linked to activities associated with gathering, such as “using digging sticks and seed beaters, and carrying burden baskets…for grinding plant foods with stone tools” (Walker and Hollimon 1989:180). It should follow that analogous patterns of bone and joint involvement found in populations in the same region would indicate similar subsistence strategies.

**METHODS**

Osteophytosis was macroscopically observed and was noted using a scale adapted from the Smithsonian (Osteoware 2011). This scale uses the morphology of osteophytes to determine severity and is as follows: elevated rim was considered slight (SL); curved spicules were assigned as moderate (MR); and fusion of spicules as extreme (EX). If skeletal elements needed for observation were missing, the space was left blank and it was not included in the analysis. The severity of osteoarthritis was described separately and the osteophytes were measured in millimeters.

**RESULTS**

Within the Point Sal collection (n=55), twenty-one individuals had the skeletal elements necessary to observe osteophytosis. Of the individuals analyzed, 43% (n=9) had some degree of osteophytosis. Out of the individuals who had osteophytosis, 56% (n=5) were noted with EX and 44% (n=4) as MR and none with SL. All manifestations of osteophytosis were confined to the lumbar vertebrae.

**DISCUSSION**

In the populations Walker and Hollimon (1989) studied they attributed high rates of osteophytosis to gathering activities. Activities involving grinding, bending over, and
carrying heavy objects were prevalent enough to affect close to half of the observable population. Behaviors that could cause this include collecting shellfish, digging for roots and tubers, and using stone grinding tools in the preparation of foods (Walker and Hollimon 1989). It is my suggestion that osteophytosis present in the Point Sal collection was a result of such activities. Within this collection, patterns of osteophytosis are consistent with other skeletal indicators for similar foods, such as dental attrition, spina bifida, and porotic hyperostosis.
CHAPTER 12

DISCUSSION

INTRODUCTION

There have been dramatic environmental shifts in the Santa Barbara Channel region throughout the last few thousand years. The impact these changes have had on prehistoric Chumash living in the region have been studied by various researchers (Arnold 1992, 1993; Gamble 2005; Glassow 1996; Lambert and Walker 1991; Raab and Larson 1997; Walker and Lambert 1989; Walker and Thornton 2002). Environmental shifts, such as changes in sea surface temperatures (SST) and periods of drought, had an impact on the availability of food and water resources. The resulting shift in subsistence strategies and allocation of food resources is hypothesized to be the impetus for the rise of social complexity in the Chumash (Arnold 1991, 1992; Gamble 2005; Kennett and Kennett 2000). However, as Lambert and Walker (1991:964) point out, “there is disagreement about the timing and the tempo of the shift toward increasing social complexity.” Arnold (1992, 1993) argues for a more rapid change in environment leading to a change in political organization and the rise of complexity. While others consider a longer duration of environmental pressures, starting during the Middle Period, and carrying on to the Late Period, slowly leading to the rise of complexity (Gamble 2005; King 1990; Lambert and Walker 1991). Because human remains are such good indicators of environmental conditions, bioarchaeology/osteology has played an integral part in this discussion (Gamble et al. 2001; Lambert 2007; Lambert and Walker 1991; Walker 1986; Walker and Erlandson 1986; Walker and Hollimon 1989). The osteological analysis presented in this thesis is also a valuable contribution.

Two components make the skeletal analysis of the Point Sal collection an important contribution to understanding the prehistoric Chumash. One is the antiquity of the collection; radiocarbon dating places the individuals in the Point Sal collection between 1000 and 1500 BP (Bruwelheide et al. 2001). This time period in the Santa Barbara region is called the Middle Period (King 1990), which is a few hundred years earlier than the Late Period (Figure 1). The Late Period is associated with environmental stresses and the rise of complexity.
Therefor, conclusions regarding the Point Sal collection have the potential to contribute to a larger discussion regarding the tempo of change among the Chumash. Second, this population is from the mainland, and most research regarding environmental pressures, whether archaeological, paleoenvironmental, or bioarchaeological, have mainly focused on the Channel Islands.

**SUMMARY OF PALEOENVIRONMENTAL DATA**

Paleoenvironmental analysis of this time period (Figure 20) and region concludes SST slowly rose from 3000 until 1600 years BP, which is connected to a decrease in marine productivity (Kennett and Kennett 2000). After 1400 BP (AD 600) the region experienced a drop in SST and increase in marine productivity (Kennett and Kennett 2000). Shortly after, environmental data suggest a regional drought starting around 1200 BP and lasting through 700 BP (Davis 1992; Stine 1994). It was these drought conditions that some researchers have claimed put stresses on the Chumash as well as forcing greater population concentrations around limited water sources, triggering the rise of social complexity (Kennett and Kennett 2000; Lambert and Walker 1991; Raab and Larson 1997).

**SUMMARY OF PATHOLOGIES**

The Point Sal collection was exhumed in the 1930’s by George Carter, two and a half miles inland from Glassow’s (1991) Point Sal excavation. The skeletal analysis and results presented here allow for discussions regarding overall health of those interred at the Point Sal cemetery. This was done by observing patterns of several anomalies on the remains, which include evidence of porotic hyperostosis/cribra orbitalia, spina bifida, dental pathology, and osteophytosis.

Porotic hyperostosis and cribra orbitalia have been traditionally seen as metabolic disorders directly connected with iron deficiency anemia usually as a result of insufficient diet (Larsen 1997). New studies suggest that they may be a result of B12 and B9 vitamin deficiencies acting in concert with insufficient iron levels (Walker et al. 2009). Lack of these nutrients may be attributed to insufficient access to food. However, diarrheal diseases as a result of parasitic infections can also deplete the body of essential nutrients (Ortner 2003; Reinhard 1988; Walker 1986). Such infections have been found in the Santa Barbara region

(Walker 1986; Walker and Lambert 1989). Occurrences of PH and CO are an indicator of overall population health (Larsen 1997; Ortner 2003).

Forty-six percent (n=20) of the observed individuals in the Point Sal collection have porotic hyperostosis. Meaning either the population did not have adequate access to essential nutrients, or the nutrients they were consuming were being depleted rapidly. Archaeology in the Point Sal region shows evidence of marine food consumption (Glassow 1991, 1996). Further, abalone bowls as well as other shellfish deposits were found in the graves of the Point Sal individuals (Carter 1941). Shellfish, such as abalone, do contain B12, B6, and iron, all of which are important in the avoidance of porotic hyperostosis and cribra orbitalia. However, shellfish can also contain parasites known to have caused diarrheal diseases in other Chumash populations (Walker 1986). Paleoenvironmental conditions about this time
period not only support an increase in marine activity (Kennett and Kennett 2000), but also a period of drought and dry terrestrial conditions (Davis 1992; Kennett and Kennett 2000; Stine 1994; Raab and Larson 1997). Dry terrestrial conditions would not only have limited access to terrestrial food sources, but also decreased access to water sources. Raab and Larson (1997) as well a Kennett and Kennett (2000) believe that a decrease in water sources would have caused populations to crowd around one source, thereby increasing the chances of parasitic infection. Although the Point Sal collection’s antiquity overlaps drought conditions by only 200 years, the evidence presented in this study indicates that the combination of parasites from shellfish, as well as contaminated water, lead to diarrheal diseases in the Point Sal individuals. These diseases depleted individuals of enough essential nutrients as to create physiological conditions seen in porotic hyperostosis and cribra orbitalia. Dry terrestrial circumstances may have further contributed to lack of proper nutrition because of a reduction of available plant foods rich vitamins B9.

Several edible plants in the region have been identified, such as black sage, which provide edible seeds, or cattail, bulrush, and juncus that have edible roots (Glassow 1991). Further evidence that these plants were utilized as a food source are the metates and mortars, found at the site during Carter’s (1941) excavation of the Point Sal individuals. Metates and mortars are commonly used in the grinding of tough plant foods such as roots and tubers, as well as seeds (Walker and Erlandson 1986). The lack of sufficient amounts of vitamins B9 and B12 in these plant foods is consistent with findings of porotic hyperostosis in the Point Sal collection.

Also, found in the Point Sal collection, is the presence of cribra orbitalia, which has been attributed to a lack of iron (Larsen 1997). Cribra orbitalia in the Point Sal collection may also be a result of C deficiency (Ortner 2003; Walker et al. 2009). Vitamin C is found in a lot of fruits, mostly citrus. A deficiency in vitamin C would indicate inadequate fruit in the area. Lose of C can also be a result from diarrheal diseases (Walker 1986). Given the prevalence of porotic hyperostosis within the Point Sal collection, as well as evidence of diarrheal diseases elsewhere in the region it is most likely that diarrheal diseases stemming from food-borne parasites in combination with the consumption of foods lacking proper nutrients to be the primary contributing factor.
Spina bifida, found in 26% (n=7) of individuals observed in the Point Sal collection, provides further evidence for lack of essential nutrients. Although spina bifida has been connected to genetic factors (Van der Put et al. 1995), the lack of sufficient amounts of vitamin B9 (folic acid) is accepted as the primary etiological factor (Berry et al. 1999; Botto et al. 1999; Lemire and Beckwith 1984; Smithells et al. 1976). Vitamin B9 is dominant in leafy greens (Greenwood-Robinson 2008), therefore lack of sufficient amounts of leafy greens in one’s diet may result in vitamin B9 deficiency. Dry terrestrial conditions at this time (Davis 1992; Raab and Larson 1997; Stine 1994) may have reduced the regions available leafy greens. However, the lack of vitamin B9 may also be because of a depletion of, rather than, a lack of proper nutrition. Again, such depletion of nutrients would have been most likely a result of diarrheal diseases stemming from consumption of contaminated shellfish (Walker 1978a) or crowding around water sources (Kennett and Kennett 2000; Raab and Larson 1997).

Dental pathology is a good indicator of not only diet but also overall health. Four different categories of dental pathologies were observed in the Point Sal collection, they were: dental caries, abscess formation/antemortem tooth-loss, linear enamel hypoplasia (LEH) and dental attrition.

The presence of caries provides further evidence for the type of diet consumed as well as health of the population. Results showed that 21% (N=14) of individuals observed had caries on two or more teeth. Caries result from a diet rich in carbohydrates (Hillson 1996). Carbohydrates are found in tubers and roots (Walker and Erlandson 1986), which were likely used as a food sources for the Point Sal individuals. Along with carbohydrates, caries are prevalent when there is a reduction in general health (Mayes and Barber 2008). A reduction in health would be expected if, as evidenced by other pathologies in this collection, the Point Sal individuals were suffering from depletion in nutrients and prolonged periods of stress.

Linear enamel hypoplasia, which give evidence to stress during development, and abscess formation, which can take place throughout life, are further indications of diminished health within the Point Sal population. In the Point Sal collection 23% of observable individuals showed signs of abscessing, out of these, 38% (n=3) had three or more teeth affected, which is a sign of systemic health break-down (Mayes 2010). Linear enamel hypoplasia, an indicator of childhood stress, was found in 9% (n=3) of observable
individuals. The presence of LEH on deciduous teeth of two individuals shows that the mother suffered some biological insult while pregnant (Mayes et al. 2009). Dental attrition eradicated what may have been a greater number of individuals with LEH by wearing down the crown itself, additionally; it would have opened up the dentition to external assaults, and a potentially greater number of abscesses.

Another dental pathology that was observed in the Point Sal collection was dental attrition. One of the reasons for the attrition observed in the Point Sal collection is a tough and grit filled diet. Tough foods such as roots and tubers have been connected to higher wear rates in the Santa Barbara region (Walker and Erlandson 1986). However it is most likely the grit left behind from the preparation of these foods, which involves grinding with stone that contributed to wear on teeth (Walker 1978a; B. Wood 2013). Another reason for attrition in the Point Sal collection could be sand from the consumption of shellfish as well as the preparation of dried fish (Walker 1978a). It is likely that a combination of these factors led to dental attrition within the Point Sal population. Consumption of both of these foods is consistent with lack on adequate nutrition in the collection, as they have been connected with the presence of diarrheal diseases (Walker 1986).

Repetitive daily activities leave behind evidence on the skeleton in a discernable pattern (Larsen 1997). If predictions about the Point Sal collection regarding food types based on dental pathologies are correct, then the repetitive actions in acquiring these foods should show on the skeleton. Bending over to gather roots, tubers, and shellfish, as well as positioning the body on hands and knees in order to grind with a metate, are repetitive activities that engage the lower back, and would eventually result in osteophytosis (Larsen 1997; Walker and Hollimon 1989).

In the Point Sal collection, 43% (N=9) of observable individuals have osteophytosis, indicating that members of that population were engaged in activities associated with gathering (of shellfish), digging with a stick (for roots and tubers), as well as using stone grinding tools. A similar conclusion was reached when Walker and Hollimon (1989) observed the skeletal remains from several sites along the Santa Barbara Channel Island region.
**COMPARATIVE DATA**

PH has often been a reliable indicator of population health (Larsen 1997; Ortner 2003). Like PH, periostitis is a similar skeletal lesion and has also been used in previous studies (Lambert 1993; Kent and Dunn 1996; Walker and Lambert 1989; Weston 2008) as an indicator of population health. While no periostitis was observed in the current study, PH was documented in 46% (n=20) of individuals observed. A few osteological studies have been conducted in the Santa Barbara region looking at population health. Lambert (1993) observed frequencies of periostitis in two Island Chumash groups and found an increase in frequency during the Middle Period with a peak in the Late Middle Period. She concluded that exposure to infectious diseases might be the reason behind the findings. Lambert and Walker (1989) also looked at periostitis as an indicator of health on a mainland population from the Late Middle Period. Using increasing rates of periostitis, they concluded a decline in overall health for this time period, which they connected with poor environmental conditions as well as presence of disease. The Point Sal collection was compared to these collections in order to establish a better contextual relationship in the region. A two-sided chi-squared test of equal or given proportion was conducted comparing periostitis for two of Island Chumash groups (Lambert 1993), and a mainland population (Lambert and Walker 1989) to PH found in the Point Sal collection (Table 3). The results, although suggestive, but inconclusive, are that there was a significant difference between the proportions of PH and Periostitis between these populations (p =0.07). In order to pinpoint which populations were significantly different and which were not I then tested the Point Sal population against the Island Chumash, again with a two-sided chi-squared test of equal or given proportions, and found that there was not a significant difference (p =0.01901) between these two populations.

Given the above results, I tested the null hypothesis that the proportions of PH in the Point Sal collection are equal to the proportions of periostitis in Lambert and Walker’s (1989) mainland population, against the one-sided alternative that the Point Sal population has a greater occurrence. I was able to conclude that the occurrence of PH in the Point Sal collection is significantly greater than that of Lambert and Walker’s (1989) mainland population (p=0.009503).

The skeletal evidence in the Point Sal collection shows a decline in health during an earlier period (The Middle Period) than trends observed elsewhere, such as on the Channel
Table 3. SCRI-100 and SCRI-83, Ven-110, Point Sal from Present Study

<table>
<thead>
<tr>
<th>Site</th>
<th>Individuals Observed</th>
<th>Individuals With Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCRI-100</td>
<td>37</td>
<td>13</td>
</tr>
<tr>
<td>SCRI-83</td>
<td>45</td>
<td>16</td>
</tr>
<tr>
<td>Ven-110</td>
<td>92</td>
<td>22</td>
</tr>
<tr>
<td>Point Sal</td>
<td>44</td>
<td>20</td>
</tr>
</tbody>
</table>

Adapted from: SCRI-100 and SCRI-83 from Lambert 1993, Ven-110 from Walker and Lambert 1989.

Islands, (Lambert 1993) as well as the mainland (Lambert and Walker 1989), where declining health has been documented later (The Late Middle and Late Period). Further, evidence from the Point Sal collection indicates that not only was there a decline in health happening earlier on the mainland than previously documented, but it was occurring at a significantly higher rate.

Overlapping scenarios are viable here. First, comparisons of the three studies suggest, that the Point Sal group may have been affected by diminutive conditions before the other two study groups on the mainland and Chanel Islands. Second, It also may infer that the duration of environmental hardships causing a decline in health throughout the region has a longer temporal range than has been previously suggested. Such a finding would indicate that there was not a punctuated moment of environmental hardships during the Late Period, as suggested by some researchers (Arnold 1992, 1993; Kennett and Kennett 2000; Raab and Larson 1997). Instead, environmental hardships seem to have started as early as the Middle Period and remained through the Late Period. This would favor a longer and more moderate tempo in environmental hardship and a gradual shift to social complexity as suggested by King (1990) and Gamble (2005). Albeit, it is important to note that the findings in this thesis are a snapshot of a limited geographical region. Future research on different regions, as well as time periods, is needed if any conclusive arguments are to be made about the tempo of environmental hardship and the rise of Chumash complexity.
CONCLUSION

The presence of porotic hyperostosis, spina bifida, various dental pathologies, and osteophytosis in the Point Sal collection supports a conclusion that the Purisimeño who occupied the eastern end of the Point Sal region endured periods of poor health, probably as a result of parasite-borne diseases, which led to diarrheal diseases (Raab and Larson 1997; Walker 1986). Osteological evidence in the Point Sal collection also supports that they were consuming a diet consisting of tough plant foods such as roots, foods high in carbohydrates such as tubers, along with a lack of leafy greens. Paleoenvironmental conditions support dry conditions for the time period the Point Sal population lived (Davis 1992; Kennett and Kennett 2000; Raab and Larson 1997; Stine 1994). Glassow’s (1996) analysis of a site in Point Sal, closer to the coast, showed evidence of a decline in population until 1400 BP. This decline in population is connected to a decrease in resources (Glassow 1996). The sites Glassow (1991, 1996) excavated are only two miles apart from where the Point Sal collection was exhumed (Carter 1941). Not surprisingly, the time period which Glassow (1996) observed archaeological evidence for a decline in population, correlates with Point Sal’s bioarchaeological evidence for poor population health, and adverse environmental conditions.

My conclusion from skeletal analysis, showing the Purisimeño population experienced environmental stresses, and endured chronic health problems, supports the hypothesis that resource scarcity was the catalyst for the rise of social complexity amongst the Chumash (Arnold 1991, 1992; Kennett and Kennett 2000; Raab and Larson 1997). While this may be true, it is important to consider the majority of this population (Figure 6) made it into adulthood. Thus, surviving whatever environmental, and therefore biological, stressors existed during growth and development. In this situation, skeletal lesions “may be evidence of a fairly effective immune response (Ortner 2003:57),” and proof of a body enduring rather than surrendering to assaults on health (J. W. Wood et al. 1992). In considering this, an argument could be made that surviving such harsh conditions would mean this population has successfully negotiated environmental hardships.
CHAPTER 13

CONCLUSION

Bioarchaeology is an important tool in trying to understand the past. Often archaeological data is supported or debated using bioarchaeological analyses. One of the main tools of bioarchaeology is osteology, which allows the researcher to extract a wealth of information from human skeletal remains. The data presented in this thesis from an osteological analysis of Point Sal collection has added to the body of knowledge about prehistoric Chumash. By analyzing various markers in the skeletal remains of the Point Sal collection, it was shown that the Purisimeño Chumash population, exhumed by George Carter (1941), endured long periods of poor health and stress. Such stresses are indicative of adverse environmental conditions and have been connected to the rise of social complexity (Arnold 1992, 2001; Arnold and Graesh 1998; Kennett and Kennett 2000; Lambert and Walker 1991; Raab and Larson 1997; Walker and Thornton 2002; Walker and Lambert 1989). However, these environmental stresses are linked to the Late Period, and mostly on the Channel Islands. The Point Sal collection shows that such stresses existed on the mainland in the Middle Period, a few hundred years before. This could mean harsh environmental conditions hit the mainland before they hit the islands, or both the islands and the mainland experienced a longer duration of environmental hardships. Albeit, this is only one collection from one region and more populations of prehistoric Chumash need to be analyzed in order to gain a more conclusive picture.
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Stuiver, M., and P. J. Reimer

Ubelaker, Douglas H.


Vercellotti, G. D., V. Formicola Caramella, G. Fornaciari, and C. S. Larson

Walker Phillip L.

Walker, Phillip L., and Michael J. DeNiro
Walker, Phillip L., and Jon Erlandson

Walker, Phillip L., and S. E. Hollimon

Walker, Phillip L., and Travis D. Hudson

Walker, Phillip L., John R. Johnson, and Patricia M. Lambert

Walker, Phillip L., and Patricia Lambert

Walker, Phillip L., Rhonda R. Brathurst, Rebecca Richman, Thor Gjerdrum, Valerie A. Anrushko

Walker, Phillip L., and Russell Thornton

Weinberg, Eugene, and Judith Miklossy

Weston, Darlene

White, Tim D., and Pieter A. Folkens

White, Tim D., Michael T. Black, and Pieter A. Folkens

Wood, Bernard

APPENDIX A

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Sex Determination: p = pelvic morphology, s = skull morphology
Age Determination: p = pelvic morphology, s = suture closure, f = epiphyseal closure, d = dental development, r = rib end
APPENDIX B

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Sex Determination: p = pelvic morphology, s = skull morphology
Age Determination: p = pelvic morphology, s = suture closure, f = epiphyseal closure, d = dental development, r = rib end