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Susan Morley
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The Paleodemography of the Yukisma Site, CA-SCI-38:
A Prehistoric Cemetery
of the South San Francisco Bay

A Thesis Presented to
the Faculty of the Department of Social Science
San Jose State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

By
Susan Morley
August, 1997

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ABSTRACT

The Paleodemography of the Yukisma Site, CA-SCI-38 A Prehistoric Cemetery of the South San Francisco Bay

by Susan Morley

This thesis reports upon a demographic assessment of CA-SCI-38, a prehistoric cemetery excavated in Milpitas, California. Radiocarbon dating places deposition from A.D. 230 to AD. 1500. Of 252 individuals recovered, 231 were aged by seriation according to standard methods of epiphyseal fusion, dental eruption, and pubic symphyseal morphology, from 2 months to 60 years. Adult sex diagnosis was based upon the morphological assessment of the pelves and the posterior mandibular ramus. Analysis of variance resulted in little difference between age estimations utilized here: the auricular surface of the ilium, sternal rib end, and pubic symphysis methods. The mean estimated female age is 5.886 years higher than the mean estimated male age. Life table analysis yields an e'' of 31.6, a gross reproductive rate of 1.65, a mean family size of 2.38, generation length of 26.6. Differential burial practices are considered responsible for the under-representation of subadults and sex bias among adult individuals.

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I also thank Dr. Alison Galloway, a forensic anthropologist and professor of anthropology at the University of California at Santa Cruz. Dr. Galloway's stimulating conversation and thoughtful advice was always timely and she has added depth to my understanding of human skeletal biology especially as it relates to human evolutionary biology.

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The paleodemography of the Carlston-Annis site in west-central Kentucky, as reported upon by Dr. Robert Mensforth with the Cleveland State University Anthropology Department, greatly influenced my research. Dr. Mensforth provided me with the computer program that facilitated paleodemographic analysis. I am grateful for his quick replies to the many questions I presented him regarding the problems associated with life table analysis.

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I came to the study of anthropology through the archaeology program at Cabrillo College, a strong technical program with few rivals in California as directed by Rob Edwards. Rob was really the teacher who first turned my attention to Central California's natural history and caused me to begin to wonder about the people who inhabited this region for thousands of years. It is my good fortune to have had him as a teacher.

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CHAPTER ONE

INTRODUCTION

Conceptually, culture and population are subtle concepts, similar in several aspects. Both provide a common framework for viewing a universe of phenomenon comprising recognizable individual elements but concerned with group attributes such as number, composition, structure, distribution, and change; both have generic and specific uses. Each is superorganic and holistic, transcending social roles of the individual organism. Culture and population are everywhere and nowhere simultaneously. (Zubrow 1976:3)

Human population has risen dramatically over the last 10,000 years. Anthropological studies that regard the relationship of population and the development of technical knowledge as coeval have resulted in theories that cite major transitions in human population with the advent of agriculture (Carr-Saunders 1922, Childe 1951, Braidwood et al. 1957, Steward 1955, Braidwood et al. 1957, Boserup 1965, Willey 1966, Carneiro and Hilse 1966, Coe and Flannery 1967, Acsádi and Nemeskéri 1970, Baker and Sanders 1972, Cowgill 1975, Cohen 1977, Hassan 1981, Cohen and Armelagos 1984). Agriculture had been considered a “progressive” move toward better living from Childe (1936) until eventually Lee and Devore (1972) wrote convincingly that hunter-gatherer groups not only had a more diverse diet with better nutrition, but more leisure time as well. This view is still subject to dispute.

Childe was perhaps the first archaeologist to integrate theories of population change with economic development. The grand theory of the development of an “agricultural revolution” was put forth in *Man Makes Himself* (Childe 1936). Childe

believed that catastrophic climatic conditions in the Near East forced people to implement new strategies to ensure food supply with technologies of food production. With this new technology population growth rapidly expanded, characterizing the stages of the “advance” of human societies.

The traditional view (Childe 1936), still popularly held, argues that “the adoption of agricultural economies...resulted in the improvement of the quality and reliability of human food supplies, and the overall lessening of labor demands in the food quest” (Cohen 1984:1). It is now understood that agricultural technology does not necessarily afford better health than hunting and gathering adaptation (see Cohen and Armelagos 1984 for in-depth discussion; also Lee and DeVore 1972). Sedentary agricultural subsistence has now been determined to be frequently accompanied by increased rates of infection, disease, malnutrition, and most interestingly, a decline in the mean age-at death (Cassidy 1972, Goodman et al. 1984, Buikstra and Cook 1984).

A Malthusian point of view regards world food supply as the independent variable upon which the world population depends. Boserup (1965) helped change this long-held view by hypothesizing that sparse populations were the result of primitive subsistence technology. Boserup’s population pressure theory (1965) argued that intensive agricultural technology developed as a response to resource shortages leading to socio-cultural complexity as the technology increased. Therefore, population growth was theorized to bring about technological development so that populations no longer would need to rely on a hunter-gatherer subsistence. An important part of Boserup’s concept of

the agricultural revolution was that there was a diminishing return of product to labor. As Spooner has pointed out, modern economic theory developed by Boserup blames the “vicious circle of sparse population [on] primitive techniques” (Boserup 1965:70-76); her theories were “constructed precisely in order to bring out the difference between those primitive societies that are growing and successful and those that are non-growing and unsuccessful” (Spooner 1972:xvii). For decades Boserup’s thesis fundamentally influenced anthropological population subsistence theory, for better or worse (Steward 1955, Dumond 1965, Sanders and Price 1968, Spooner 1972, Cohen 1977, and others). It has more recently been acknowledged that “population growth instigated economic change” rather than being a result of technological change (Cohen and Armelagos 1984:585, see also Cohen 1977, Binford 1968).

This lack of improvement in the health of human groups with the advent of agriculture was underscored by osteological data presented at the Wenner-Gren Conference in 1982 and published in *Paleopathology at the Origins of Agriculture* (1984). In this symposium, sixteen studies support the theory that hunter-gatherers were more healthy than farmers. “Even if subadult mortality is discounted, preagricultural adults have the higher average age-at-death” (Cohen and Armelagos 1984:593). Skeletal evidence has demonstrated an increase in mortality in agricultural groups across many prehistoric populations studied including cases from Illinois, Georgia, the Lower Mississippi Valley, Kentucky, and India (Cohen and Armelagos 1984). It has been suggested that high fertility rate and reduced infant mortality were responsible for

increased human numbers as societies adapted to sedentism and not the assumed notion of reduced mortality overall (Roth 1994).

While agricultural adaptation was a phenomenon shared by both the New World and the Old World as groups increased in population densities, there were evidences to the effect that agriculture was not always present as a factor accompanying population increase (Roosevelt 1984:567). This is especially evident in prehistoric Central California where agricultural technology never developed *per se* (Dickle et al. 1984:439). The prehistoric populations of Central California have been classified as hunter-gatherers. This classification has been problematic since hunter-gatherer peoples are known typically to demonstrate sparse populations (Howell 1976, Lee 1972) and Central California's hunter-gatherers demonstrated dense populations (Kroeber 1939, Baumhoff 1963, Gould 1963, King 1970 & 1974, Bean 1974, Cook 1976, Doran 1980, Milliken 1983).

Paleodemographic Study

Any attempt to understand the development of human societies must consider the “demographic parameters such as population size, age and sex structure, mortality, and fertility” (Zubrow 1976:2). Paleodemography is founded upon the capacity for human skeletal analysis to supply this information about the history of the living organism. As methods for aging and sexing the human skeleton have developed, paleodemographic studies have expanded (Moore et al. 1975, Swedlund 1975, Lovejoy et al. 1977, Howell

1979, Doran 1980, Howell 1982, Buikstra et al. 1986 & 1985, Johansson and Horowitz 1986, Goodman and Armelagos 1988, Mensforth 1990, Storey 1992, and others).

The seminal work of Acsádi and Nemeskéri, *History of Human Life Span and Mortality*, was a turning point in paleodemographic analysis (1970). Acsádi and Nemeskéri applied life table analysis to prehistoric European samples. Contrary to the above discussion, Acsádi and Nemeskéri reported that there was a decrease in mortality with the transition to agriculture (1970:215). Acsádi and Nemeskéri concluded that hunter-gatherers lives were fraught with hardship and “brutally short” (Acsádi and Nemeskéri 1970; see also Childe 1951). Acsádi and Nemeskéri’s research utilized a multifactorial approach in the determination of vital rates in skeletal series including cranial suture closure, epiphyseal fusion of the proximal humerus and femur, dental wear, and Acsádi’s independently formulated pubic symphyseal method (Acsádi and Nemeskéri 1970:157).

Since that time, paleodemographic applications have exponentially increased, and rightly so. Most worthy of anthropological pursuit, “the fundamental demographic events of birth, marriage, migration, and death [are] imbued by all human societies with intense emotional and moral significance” (Hammel and Howell 1987:141). These events describe the research goals in the demographic assessment of prehistoric populations.

“When demographic research is extended beyond its descriptive level, it is concerned with the social and biological processes that relate to population change” (Swedlund and Armelagos 1976). This is not an attempt to entwine cultural evolution

with biological evolution, for these processes are not the same. They are only alike insofar as there is a chronological aspect inherent in the definition of the term. Historically, biological evolution has been considered divergent by nature whereas cultural evolution is diffusionist and convergent (Childe 1951), whether it is defined as unilinear, universal, or multilinear (Steward, 1955:14). Human evolution can be defined as our inherited biology but culture is, as Ralph Linton wrote, “our social heredity” (1936). However, as Storey pointed out in a recent paleodemographic study, *Life and Death in the Ancient City of Teotihuacan*, “cultural attributes and processes have demographic causes, influences, and results, and neither culture nor demography can be understood completely without reference to the other” (Storey 1992:1). “Humans survive not through biological adaptation nor through cultural adaptation, but through biocultural adaptation” (Blakeley 1977:1) calling for the holistic integration of anthropological studies. This integrative approach can be effectively implemented in mortuary analysis as archaeologists, skeletal biologists, and ethnographers, under the rubric of anthropology, join once disparate methodologies to investigate the past.

Human Osteology

Human osteologists are necessarily in the forefront of debate as to the applicability of alternative methods of aging and sexing the human skeleton and to the viability of applying these vital rates to demographic reconstruction. Because of the reported refinements in the estimation of vital rates, human osteologists were encouraged

to apply these methods for demographic reconstruction (Weiss 1973, Ward and Weiss 1976, Lovejoy et al. 1977, Howell 1982, Sattenspiel and Harpending 1983, Milner et al. 1989, Mensforth 1990, Storey 1992).

The foundation of this thesis is incumbent upon the accuracy of methods for estimating the age-at-death from human skeletal remains and also the determination of the sex of the individual. Adult age estimation, in particular, has proven to be a difficult task and two methods of age estimation were applied in this thesis, along with one recently developed sex determination method, to expand a multifactorial approach. When a skeletal series has been adequately aged and sexed, life tables may then be computed and illustrated graphically. Further, they can be used for comparison with other similar studies and to what demographers have come to expect for rates of mortality and fertility of human populations.

Overview of Paleodemographic Analysis

By following archaeological research, from excavation to report, there is an opportunity to integrate four different phases of the research: archaeology, osteology, demography, and ethnography. This thesis is based upon the integration of these four disciplines of paleodemography. The following outline, as presented by Johansson and Horowitz (1986:234), offers a consolidated general overview of paleodemographic research.

A vanished population whose demographic characteristics are unknown buried their dead over an unknown period of time according to unknown rules. This generates a skeletal population.

Phase 1: Archaeological excavation and analysis

Archaeologists recover and date the population. Non-skeletal evidence relevant to mode of subsistence, burial customs, settlement size, density, and the probable growth pattern is also recovered. The time period over which the skeletons were deposited is estimated.

Problems include the representative nature of the surviving skeletons. There may be age, sex and class biases that restrict the representative nature of the excavated skeletons.

Phase 2: Anatomical and paleopathological analysis: Age-at-death

The skeletons are sorted by sex, and the age-at-death of each one is estimated. The paleopathological analysis of each skeleton is undertaken.

Problems include the possibility that the margins of error involved in skeletal estimation are too large to permit meaningful estimates, especially when numbers are small. The accuracy of sex attribution is sometimes difficult. The relationship between signs of skeletal stress and other probable mortality outcomes are often unclear.

Phase 3: Demographic analysis: Mortality/fertility estimation

Assuming closure and stationarity, the observed distribution of deaths by age and its means are fitted to model life tables using various life table techniques. A set of mortality estimates results. The fertility estimate is a residual of the estimation of mortality.

Problems include the degree to which the derived estimates fit the once living population, especially if it cannot be independently established that it was once stable, stationary, and closed.

Phase 4: Historical reconstruction and theory building

Mortality and fertility estimates are used in conjunction with the data on the nature of the economy during the time of skeletal deposition to reconstruct the relationship between socioeconomic change and demographic change.

Research Focus

CA-SCI-38 is located in Milpitas, California on the grounds of the Elmwood Correctional Facility (see Maps 3.A and 3.B; also see Leventhal et. al 1993). When construction disturbed the prehistoric archaeological site, CA-SCI-38, an archaeological mitigation program recovered human remains that had been deposited there for a period of at least 1100 years.

Carefully controlled archaeological recovery, under the direction of Laura Jones at Stanford University and Alan Leventhal at San Jose State University was undertaken by Ohlone Families Consulting Service (OFCS), a tribally owned and operated archaeological consulting firm. OFCS and the Muwekma Ohlone Tribe represent the people who have direct lineal descent and are the cultural affiliated tribal group of this aboriginal region, the Santa Clara Valley. As a result, the Muwekma were responsible for the recovery of their ancestral remains. Because this site provided the opportunity to study the valuable Ohlone Indian prehistoric record through osteological analysis, this author requested permission from the Muwekma Tribal Council to implement a research design largely ignored in Central California, specifically paleodemographic analysis. Permission was granted by the Muwekma Tribe to study these human remains; this study reports upon the results of this research.

Map 3.A: Project Location Map for CA-SCI-38

Map 3.B: Site Location Map for CA-SCI-38

Osteological analysis of CA-SCI-38

When an archaeological recovery program is complete, the second and perhaps most difficult phase of paleodemographic analysis is conducted: age assessment of the skeletal remains. The osteologist becomes the census taker of the prehistoric cemetery, but rather than counting the number of the living, paleodemographers count and evaluate the dead.

Osteological analysis of CA-SCI-38 was undertaken in collaboration with the San Jose State University Osteology Laboratory and the San Jose State University Foundation. Dr. Robert Jurmain directed this analysis employing five osteologists: Dr. Lorna Pierce, Muriel Maverick, David Calleri, Sandy Weldon, and this author. Suzanne Rodriguez, tribal council woman to the Muwekma Ohlone Tribe, also assisted in the preparation of the osteological materials. These individuals were responsible for washing, then recording all human osteological elements as each individual came under review and for making initial assessment of age and sex. Drs. Robert Jurmain and Lorna Pierce were responsible for the final age and sex determination for each individual.

The first goal of this thesis was the reconstruction of the age and sex composition of CA-SCI-38. Adult age estimation, for the upper decades in particular, has proven to be a difficult task; accordingly, the addition of two other methods was applied specifically by this author for age estimates more applicable to paleodemographic study. Because

they have been reported to accurately assess adult ages in the upper decades, and because skeletal ages are reported in age intervals that allow for seriation of the sample, the auricular surface of the ilium (Lovejoy et al. 1985b) and the sternal rib end (İsçan et al. 1984) methods were utilized in this research. The results of these methods are reported both in Chapter Three, Materials and Methods, and in Appendices A, B, and C.

Sex determination is also a necessary consideration for human skeletal analysis. This skeletal series was sexed utilizing methods developed by Phenice (1969) and the comprehensive methods as described by Bass (1991). These methods were applied by the San Jose State University Osteology team. The most recent development of sex determination, utilizing the posterior ramus of the mandible (Loth 1996), was also applied by this author. Sex determination methods are also discussed in Chapter Three, Materials and Methods.

Paleodemographic goals

After vital rates were reconstructed the data were applied to life table analysis. The demographic characteristics of CA-SCL-38 are compared here in Chapter Five to CA-Ala-329, a well-studied mortuary complex 13 miles to the northwest sharing similar temporal components. CA-SCL-38 life table analysis is also compared to the only paleodemographic research conducted for a Central California skeletal series, Doran's *Paleodemography of the Plains Miwok Ethnolinguistic Area* (1980). To further add to the analytical value of this research, the Carlston Annis (Bt-5) Late Archaic Period site from

west-central Kentucky (Mensforth 1990) is also compared with CA-SCI-38 and CA-Ala-329.

Life tables are employed to estimate the demographic parameters of a population based upon how long an individual may be expected to survive after birth. It has been suggested that calculations of age-at-death by cohort is actually a death table, but it is really the measure of life that is of interest.

The life table, through a process of inference, is taken to represent the life processes of a local biological population and often forms the basis for further inference on the relationships between population and cultural processes. (Moore et al. 1975:57)

Construction of synthetic cohort life tables (Ward and Weiss 1976:4) constitutes the standard method by which the age-at-death of individuals born in the same year are tracked until all have died. A cohort life table records the mortality age of each individual and follows that cohort through time. Obviously, there is no way to identify a cohort in a skeletal series. An abridged life table, as applied in this research, is a current life table that “looks at a population at a given time, such as a year or five years, and records the mortality pattern seen for all ages” (Storey 1992:138). From the skeletal remains recovered through archaeological investigation, life tables may be computed to extrapolate the general mortality and fertility pattern for the population under investigation. Of necessity, this study addressed census errors that may be responsible for the biased recovery of subadult and female adult individuals in CA-SCI-38. Life table analysis of CA-SCI-38 is presented in Chapter Five, Results and Conclusions.

Limitations of Study

Sample bias

Any scientific study must concern itself with sample bias. Some problems in sample recovery bias have been addressed by Walker et al. (1988). Often the recovery of a skeletal series will include an unequal distribution of males and females. One of the most problematic biases for paleodemographic study is the under-representation of subadult individuals. Results of the Walker et al. study found preservation most often affects age bias rather than sex bias. Differential burial treatment may also affect the sample. This present study is confronted with both problems, as discussed in Chapter Five, Results and Conclusions.

Ethnographic Evidence

Ethnographic evidence is an important source of information in reconstructing population parameters for paleodemographic study. Migration and marriage patterns may be discerned in the ethnographic record, as well as the effects of migration on the growth of a given human population. These issues are further addressed in Chapter Two, Regional Background.

Summary

A large part of anthropological study consists of determining how differing socioeconomic adaptations may either benefit or detract from the quality of life in a given society. The fourth and final phase of paleodemography is the reconstruction of the

relationship between the established demography and socioeconomic change. In California, where the hunter-gatherer model has been applied, dense populations have developed. The rich natural habitat of the prehistoric Central California peoples, who are considered to be semi-sedentary with developed food-storage strategies, led to the dense populations reported for California at contact. How the unique situation of subsistence adaptation may apply to prehistoric Central California groups must then be considered because population densities comparable with sedentary agricultural regimes are being defined as hunter-gatherer regimes.

Contemporary paleodemographic research addresses three important questions: 1) Has the human life span increased? 2) Has life expectancy at birth increased? 3) How are demographics related to food production (Konigsberg and Frankenberg 1994)? Anthropological demographics of extant, preagricultural, tribal societies have contributed to theories of fertility and mortality, and these theories, so generated, may be applied to extinct societies as manifested in an archaeological skeletal sample. The life expectancy, mortality, and fertility estimations of the skeletal series from CA-SCI-38 are the main goals of this thesis. Were children subjected to high mortality? Which groups suffered the highest mortality? How long did the eldest survive? Were men and women living equally long lives? Can we make conjectures as to the nature of the role of fertility in that society? With the integration of small units of study, theories of culture for Central California may be regenerated.

CHAPTER TWO

REGIONAL BACKGROUND

At the time of European contact California demonstrated the most dense human populations in the New World north of Mexico (Kroeber 1939, Baumhoff 1963, Dobyns 1966, King 1970 & 1974, Bean 1974, Cook 1976). The most heavily concentrated area of population was geographically centered in the San Francisco Bay/Sacramento Delta region (Ibid.) in Central or “Alta” California. With the advent of missionization this population was decimated by several complicating conditions: introduced disease, warfare, slavery, and loss of the subsistence resources of their land base (Walker et al. 1989). The missionization of Alta California was so swift and all consuming that “[b]y the year 1810, only forty years later, the tribal territories in all but the most northerly reaches of the San Francisco Bay region were empty” (Milliken 1996:1). Gleaning the mission records has provided a window into the aspects of native cultures of these contact societies (Merriam 1967, Cook 1976, Milliken 1983, 1996), but far less is understood about the demographic aspects of the pre-contact tribes from this region.

With human population growth and agriculture, highly stratified states evolved, fortified by stone walls and militia (see Fagan 1995:342-360 for an overview of the development of agriculture). The ephemeral nature of California’s cultural subsistence pattern did not present a picture of “progress” to 19th Century anthropologists. Not until the mid-twentieth century did anthropological scholars begin realize the implications of

the unique subsistence adaptation evidenced in California. Adaptive strategies such as burning the land to induce vegetation growth (Lewis 1973) rather than the more traditional horticultural or agriculture technologies, the use of baskets rather than ceramics, shell and stone ornaments rather than metal all were interpreted as a lack of technological advance. The supposed lack of a technology-based subsistence regime in California, such as agriculture or pastoralism, was then suggested as the reason that highly stratified society had never developed in Central California.

Until the mid-twentieth century, the problem of “why agriculture did not become established in California was never dealt with except in terms of aboriginal lassitude or deficient intelligence” (Bean and Lawton 1973:26). California regional scholars now realize that potent land management techniques had been established in place of agriculture (Blackburn and Anderson 1993). Designating precontact California societies as hunter-gatherer has indirectly implied less complex cultural organization, as Bean and Blackburn realized when they wrote:

The idea that highly stratified society had to be accompanied by agriculture is inadequate, simplistic, and dangerously misleading. Instead human adaptive systems increasingly are being seen as occurring along a complex gradient...expanding capacity to modify or transform natural ecosystems" (Harris and Roth 1987). All human societies have therefore been involved over many millennia in an ongoing process of domesticating the environment; effective techniques ranging from simple pruning of vegetation to the use of genetically-altered and human-dependent species of plants or animals, to gain a greater or lesser degree of control over the world environment around them...California's various, rich, diverse, and carefully managed habitats supported (through the medium of exceptionally effective extractive and storage technology) the highest population densities, as well as some of the largest population concentrations, in all of North America; in fact, it now appears that the population levels present in California prior to European contact may possibly have been the most complex to have ever characterized societies without a well-developed and relatively intensive agricultural subsistence base. (Blackburn and Anderson 1993:16)

A survey of the numerous mortuary complexes in Central California has now inferred that highly stratified societies were established and had been evolving for several thousand years (Bean and Lawton 1973, Leventhal 1993).

Anthropologists have agreed that substantially dense populations cannot remain integrated enough to prosper without evolving a complex society (Sanders 1984). There is a recent body of literature which maintains that in Central California agriculture was in a 'proto' or 'quasi' state (see Blackburn and Anderson 1993, Bean and Lawton 1976). Central California aboriginal groups then have been classified as semi-sedentary proto-agricultural "tribelets" (Kroeber 1954). The designation of "tribelets" may not be justified. A tribe is a cluster of bands organized by clans (Fagan 1995:30). Chiefdoms are kin-based but are considered more hierarchical (Ibid.). "Mississippian chiefdoms of the

Midwest and South flourished during the early second millennium A.D., maintain[ing] extensive trade networks and ritual contacts over long distances" (Ibid.:31). As previously stated, substantially dense populations cannot remain integrated enough to prosper without evolving a complex society (Sanders 1984). For the classification of hunter-gatherers to hold true for Central California, less complex groups demonstrating sparse population should be manifest. The applicability of the term "tribelet" may, in this case, be inaccurate. It has been suggested that California tribes had "advanced" to the stage of chiefdoms (Bean and Blackburn 1976:7). The term "tribelet" suggests a society even less complexly organized than a tribal society. Widmer (1988) has studied the Calusa of Southeastern Florida and suggested that early Floridian non-agriculturally adaptive tribes had advanced to an intensively military-oriented society that could be defined as sedentary chiefdoms.

A redefinition may need to be applied to the state of development for prehistoric Central California societies. It is widely held that prehistoric societies in Central California exhibited characteristic traits of hunter-gatherer groups lacking intensive food production techniques; however, these aboriginal societies maintained dense populations (Blackburn and Anderson 1993). It is now obvious that Central California's unique situation does not allow for modeling based upon the strictly agricultural versus hunter/gather regimes. Further,

California societies bear a more striking resemblance to Melanesian chiefdoms than they do Australian or African bands- a fact that has justifiably called into question some of the standard clichés and overly simplistic generalizations regarding hunters and gatherers that have been anthropological dogma for so long. (Bean and Blackburn 1976:7)

Central California Archaeology

One of the first archaeological investigations of the San Francisco Bay region was conducted at the Emeryville mound (Uhle 1907). Uhle identified ten stratigraphic levels as evidence for culture change. Nelson's Ellis Landing monograph (1910) and Schenck's study at the Emeryville mound (1929) reported no evidence for archaeological stratification representative of culture change in Central California. Kroeber also denied evidence for culture change through time around the San Francisco Bayshore, based upon linguistic studies (1923). Rogers (1929) and Olson (1930) reported distinct cultural changes in the Santa Barbara Channel areas. Eventually, the Central California Taxonomic System (CCTS) was proposed by Lillard, Heizer, and Fenenga (1939) based upon their research in the Lower Sacramento Valley. It was estimated that the Early Horizon began at 2500 B.C., the Middle Horizon at 1500 B.C., and the Late Horizon at 500 A.D. This classification was based on seriation of artifacts from multicomponent sites. Beardsley subsequently included the San Francisco Bay region into the CCTS in 1948 and Meighan finally demonstrated cultural elaboration in Central California to be as complex as early agricultural societies (1959).

The Early Horizon is considered to have been reliant upon a hunter-gather subsistence adaptation. Due to the paucity of sites representing the Early Horizon, population is considered to have been sparse as is reported for other hunter-gatherer groups. The Middle Horizon was considered reliant on an acorn-fish adaptation with increased population densities. The Late Horizon was considered similar to the Middle Horizon (Doran 1989).

Subsequent challenges to the CCTS (Gerow 1968, Bennyhoff 1969, Fredrickson 1973) have stirred the taxonomic stew by questioning the usefulness of such a simple classificatory system. The obvious limitations of three huge temporal periods as applied to the entire prehistory of Central California provoked refinement or replacement of temporal frames (Bennyhoff 1969, Fredrickson 1974, Leventhal 1993). These issues continue to be debated.

Instead of agriculture, California theorists proposed an adaptation to "acorn technology" (Heizer and Baumhoff 1956, Baumhoff 1963, Schultz 1981, Dickle et al. 1984). Just when the "acorn technology" developed and whether it was diffused from another population became a basis for contention in California anthropological theory (Heizer and Fenenga 1939, Baumhoff 1963, Gerow 1968).

Prehistoric California's Disregard for Agriculture

In Central California, where the hunter-gatherer model of subsistence has been applied, dense populations have developed prehistorically. Population densities

comparable with sedentary agricultural regimes existed in the unique California subsistence adaptation. California culture's unique adaptive technology, which was resistant to agricultural strategies into the protohistoric period, thus may not be modeled specifically upon the either/or of agriculture versus hunter-gatherer strategies of subsistence. How the unique situation of subsistence adaptation may apply to prehistoric Central California society must then be considered.

Dickle et al. reported that as the indigenous people of the Central Valley came to rely more and more on acorns their technology advanced and their population increased (1984). Considering the reasonably healthy condition of the skeletal samples (Brues 1966), it may be questionable as to whether an economic subsistence strategy, based mostly upon a carbohydrate/fat staple such as acorns, could account for such a healthy society.

The reliance upon the starchy food of the acorn is often compared to the domestication of grain in the early Levant (Roosevelt 1984). The reliance upon acorns in the diet has been recently demonstrated to be overemphasized (Blackburn and Anderson 1992). This over-emphasis on an "acorn economy" has also lent a false simplicity to subsistence strategies as

California's native economy was far more complex in terms of energy extraction processes than can be comprehended by a primary focus on such features as the acorn-salmon industries with the assumption that all other hunting and collecting activities were supplementary. (Ibid.:45)

The bountiful nature of California's subsistence resources underscores the ignorance of famine by these people (Kroeber 1925:41). That the aboriginal people did not realize the bounty and relied upon "third food choices" was questioned by Shipek when she wrote that

[t]he most damaging misconception that Europeans brought with them to California--as well as to the rest of the continent--was the belief that they were entering a "natural wilderness. (Shipek 1993:388)

Skeletal Studies of Prehistoric Central California

There have been many archaeological recovery programs carried out in Central California over the past century. Archaeological studies have increased exponentially with the implementation of CEQA, the California Environmental Quality Act, in 1972. Academic institutions and cultural resource management firms, having the privilege of studying Central California's prehistoric human skeletal remains, most often have focused on pathological or metric/non-metric trait analysis. From these skeletal studies much has been discovered about the aboriginal peoples who lived in Central California during the past 10,000 years and most especially the past 3000 years which includes the temporal period pertinent to this report.

Central California Paleodemography

A variety of scholarship has attempted to estimate the population parameters of prehistoric Central California. These studies have been based upon dietary subsistence analysis (Schultz 1981, Nelson 1910), burial density in cemetery sites (Wedel 1941), and

ethnographic accounts (Kroeber 1923, Cook 1957, Baumhoff 1963, Merriam 1967, Milliken 1983).

In the Central Valley of California populations are reported as “quite dense at contact” (Dickle et al. 1984:450). As a biological anthropologist trained at Berkeley, Cook relied upon historical data (Mission Records) to address the impact of European intrusion on aboriginal populations (1943, 1950, 1957, 1976). Most authors of California prehistoric studies apply Cook’s estimates. The Central Valley was determined by Cook to have a population density of 3.36 persons/km² (1976). Baumhoff based the existence of high population density in California upon what was termed an “acorn-fish-game adaptation”(1963:225), utilizing what had been defined by Cook (1976) as an ecological approach to paleodemography. Baumhoff reported population densities for the Central Valley as 4.4 persons/km² and population density of California hunter-gatherers as 3.9 persons/km² (1963).

A paleodemographic approach to the study of skeletal series has been largely overlooked in Central California, perhaps due to the recent development of paleodemographic methods. Three studies from this region include Doran’s paleodemography of the Plains Miwok (1980), a subsistence model by Schulz (1981), and Gillett’s masters thesis, which compared the differential success of certain osteological aging methods (1987).

Doran’s *Paleodemography of the Plains Miwok Ethnolinguistic Area* (1980), reporting on the culture group neighboring this present study sample in the northeast, is

one of the only systematic paleodemographic undertakings for Central California. Doran's research was based upon twelve sites from the Plains Miwok area. Doran's dissertation took a wide view of population growth in that region from what the CCTS defines as Early, Middle, and Late Horizon sites. Age estimation methods applied by Doran included the McKern/Stewart pubic symphyseal method, now considered outdated for use in archaeological studies (Lovejoy et al 1985b, Katz and Suchey 1986). Doran understood the limitations of age estimation utilizing the McKern/Stewart pubic symphyseal method, but his work was undertaken before the widely-utilized Suchey-Brooks pubic symphyseal, the auricular surface of the ilium, or the sternal rib end methods were available; although it continues to be useful in forensic analysis (Galloway, personal communication, 1997).

Through intersite comparison, Doran's research suggested that according to the distribution of subadult individuals in these three different horizons, population "growth was occurring, and the rate of growth was lowest in the Early Horizon, intermediate in the Middle Horizon, and highest in the Late Horizon" (Doran 1980:110). The use of the term "horizon" is based upon the tripartite division employed at the time of the study--the Central California Taxonomic System. The broad temporal frames Doran applied may be of little use in defining Central California's enduring prehistory. Doran was limited by available methods of osteology and Central California's developing taxonomic framework. Situations where early analyses prove unreliable are unfortunate. Moreover, a regional approach is important, for an integration of small studies leads to a broader view.

Doran's Plains Miwok study was based upon stable population theory and concluded that, although population growth was advancing over time, these were "younger populations." Subadult survival outpaced adult mortality in Doran's study area. Also, adult female mortality was higher in the Late Horizon, leading Doran to conclude that female mortality increased over time, perhaps due to death at childbirth. Doran's research led Dickle et al. to report that "all three complexes had an accelerating population growth rate" (Dickle et al. 1984:454). This conclusion holds important implications for paleodemographic study. There are no such studies to verify that the growth rate in Central California's San Francisco Bay region were analogous to the Central Valley; however, the analogy would seem to hold true based upon ethnographic accounts and site density.

Although Doran's dissertation (1980) reported a rapid rise in Central California population by the Middle Horizon, it was suggested that the increased population density was not accompanied by better health (Dickle et al. 1984). "Acorn specialization was viewed as a progressive move similar to the adoption of agriculture elsewhere, and directed toward the stabilization of food availability" (Dickle et al. 1984:443). Dickle et al. further state that "[d]uring the winter months, when hunting and fishing were difficult and fresh vegetal foods unavailable, consumption of stored acorn products may have exceeded that of all other foods" (Dickle et al. 1984:440). Therefore, it was concluded that "it is hardly an exaggeration to categorize native economies of this area as balenophageous (acorn eating), or, in view of the dense populations associated with them,

to consider this adaptation as paralleling in importance the development of agriculture in other areas” (Ibid.).

Game animals and vegetable increase can be easily perceived in Central California winters. As already mentioned, Kroeber reported that there were no words for famine in the native languages of Central California (Kroeber 1925). If climatic change is considered, it may perhaps hold true that the aboriginal groups of California had a difficult time hunting and finding food during certain periods. More recently Walker has conducted research that does suggest that there were periods of severe drought around 500 to 1100 AD in California, leading to increased violence as people struggled over declining resources (1989).

Archaeological evidence indicates that the level of physical violence in California Indian society varied significantly through time. Periods of increased violence appear to be correlated with competition over resources brought about by unstable environmental conditions. Around A.D. 500, for example, the comparatively favorable climate in California began to shift toward unstable conditions, marked by several repeated episodes of severe drought. These conditions persisted until around A.D. 1100 (Walker et al, 1989:359).

This has implications for the present study sample because of the high mortality rates reported (as presented here in Chapter Five) for male individuals aged 25-40 at CA-SCI-38.

Schultz (1981) described an increase of population in the Central Valley of California based upon the increasing number of site components through time. Differential survival rate with reduction of “Early Horizon” site survival may be

responsible in part for the results of Schultz's research, an explanation originally proposed by Dumond in his study of prehistoric Alaskan sites (Dumond 1972). Schultz reported a rise in population from the "Early Horizon" (4500-3000 B.P.) into the "Middle Horizon" (3000-1000 B.P.). Late Horizon/Phase One sites (1000-500 B.P.) did not demonstrate the rapid increase found from the "Early" to the "Middle Horizon." Schultz reported that the greatest population growth attributable to the Central Valley occurred from the Early to Middle Horizons; however, Schultz's research came at the same time the CCTS was coming under evaluation. Schultz's conclusions support Doran's dissertation (1980); nevertheless, interpretation of the results of various studies is constrained by the changing taxonomic frameworks and refinements in age estimation methods for the human skeleton.

CA-Ala-329 is a well-known archaeological site from the San Francisco Bay region. Gillett's master's thesis investigated age estimation methods based upon CA-Ala-329, a mortuary complex neighboring CA-SCI-38 (1987). Gillett compared the Todd Ten Phase pubic symphyseal method with the Suchey-Brook pubic symphyseal method and concluded that the Suchey-Brooks method was more applicable, especially to a male sample.

CA-Ala-329 is an exceptionally well preserved skeletal series, meeting the criteria for paleodemographic investigation. From Gillett's research it was concluded that the Suchey-Brooks method provided a population curve more closely resembling the model life table curves developed by Weiss for the upper decades. Gillett also calculated life

tables utilizing age-estimation of adults based upon the Suchey-Brooks pubic symphyseal method. Gillett concluded that there are “limitations when application of the Suchey-Brooks method is considered for use in prehistoric populations” (Gillett 1987:46). The Suchey-Brooks method, like the Todd method, is based upon a male sample, and should only be considered accurate when applied to males (Katz and Suchey 1986). When applying the method to females it is very likely that the resulting ages will be skewed in the upper decades giving an impression of longer life, and therefore should be considered with caution” (Gillett 1987: 46). After 1987 a set of female standards was developed by Suchey et al. (1988) and Gillett then applied the female criteria to the CA-Ala-329 sample. No interpretive conclusions, however, were attempted from the life table computations resulting from Gillett’s study.

The auricular surface of the ilium and the sternal rib end methods of age estimation were not considered by Gillett when aging the CA-Ala-329 sample. Interestingly enough, it is the *underaging* of adult individuals which has been the most persistent problem in paleodemographic studies and the auricular surface is utilized here to help alleviate this problem. Gillett did not apply the sternal rib end method, noting that this was because the authors could not guarantee its success in aging any sample other than European since the method was developed from a European sample.

Research Focus

Site location

CA-SCI-38 is a prehistoric Indian cemetery approximately five miles from the San Francisco Bay Shore. On the Milpitas, California 7.5 minute quadrangle topographic map from the United States Geological Survey. CA-SCI-38 is located in Township 6S, Range 1E. The site is located in Zone 10 at coordinates 596550 m. Easting/4141700 m. Northing. The site is situated on a flat plain at the edge of the Lower Penetencia Creek and interfaces several microenvironments where grass lands adjoin a riverine environment and fresh water marshes. For the last 4000 years this ecological habitat of the region has remained relatively the same as it exists today (Elsasser 1986:6). Known also as the Alms House Mound, CA-SCI-38 is located 13.25 miles from CA-Ala-329, another well-researched archaeological site of the region discussed in this study.

Archaeological Recovery Program

In 1992, CA-SCI-38 was disturbed by construction and an archaeological recovery program was undertaken by Ohlone Families Consulting Service (Leventhal et. al 1993). A concerted effort went into burial charcoal recovery resulting in 38 radiocarbon dates. Radiocarbon dates derived from burial associated charcoal place the temporal range of deposition from the Middle/Late Transition component to a Late Phase 2 component, prior to European contact, A.D. 1769 (based upon chronological Scheme B in Bennyhoff and Hughes 1987). Radiocarbon dating was conducted by the Washington

State University Radiocarbon Dating Laboratory at Pullman. This important archaeological site is determined to have been used as a cemetery for a period of 1500 to 2000 years, but the bulk of the dates fall between 1500 B.P. to 230 B.P. when the site was intensively used as a burial ground.

The artifact assemblage recovered in association with the burials at CA-SCI-38 fall mostly in the Late Phase Period. There are 34 cremations. Cremations are a feature of the Late Period (Bennyhoff 1977; also see Leventhal 1993). Burials interred in the extended position, as opposed to flexed, tend to be indicative of the Early, archaic period (Schultz 1981). However, there are no fully extended burials in this sample.

Results on obsidian hydration studies are based almost exclusively on Napa obsidian (Bellifemine 1997). The hydration readings range between 1.5 and 2.3 microns. These results coincide with the radiocarbon dates reported for CA-SCI-38, reflecting Late to Middle Late Transition temporal periods (see Bennyhoff and Hughes 1987). Most of the *Olivella* beads recovered are also typical of the Late Phase periods, consisting largely of types M1 and M2 *Olivella* beads. There are 19 *Haliotis* Kuksu (“banjo”) pendants associated with the burials. Trade objects include obsidian from Napa, magnesite beads from the Clear Lake region, *Haliotis* and *Olivella* shell ornaments from the coast, Monterey banded chert (also from the coast and most likely from Año Nuevo), and an unusual red andesite mortar sourced as native to Mt. Diablo.

The complete recovery of all individuals is the first goal in paleodemographic analysis. CA-SCI-38 fulfills this requirement, as it was excavated with carefully planned

methodological control. A field recovery program employed systematic control in the excavation and recovery of all archaeological material remains. Once a mound reported to be about 5 feet in height (Meighan 1952), over the past 140 years CA-SCI-38 has been leveled by agricultural development. It is assumed that, within the upper portion of the mound (the latest depositional area), the latest burials were disinterred and removed during agricultural plowing. Therefore, the remnants of the middle and lower portions of the cemetery have been recovered.

When the field recovery phase of the project was completed, all excavated materials were moved to San Jose State University's Anthropology Laboratory. Osteological analysis proved the archaeological recovery methods were so thorough at CA-SCI-38 that even the smallest elements of the human skeletal remains were regularly identified during the inventory phase (i.e., hyoid bones, distal phalanges, subadult and neonatal elements). The excellent preservation at this site permitted the osteological research team to age and sex the individuals as each individual came under review.

Paleodemographic requirements as applied to CA-SCI-38

This thesis subscribes to a normative paleodemographic analysis of the CA-SCI-38, the prehistoric cemetery under consideration here. The normative model assumes that CA-SCI-38 was a cemetery used for approximately 1100 years by a tribe or series of neighboring tribes. The long depositional history fulfills a fundamental paleodemographic requirement. In order for paleodemography to be undertaken, the

sample must exhibit a stationary state (i.e., migration-free with an equal birth and death rate). “[A]s Weiss and Smouse have pointed out, if skeletal populations extend over several centuries, their living counterparts may have in fact closely approximated the stationary state” (Johansson and Horowitz 1986:237). Accepting this theory, CA-SCI-38 fulfills this requirement. Within what is thought to be the center of the cemetery, nearly 100% recovery has been achieved.

The archaeological literature of Central California has usually not recognized sites as cemeteries, but often interprets burials grounds as villages. Recently, the existence of discrete cemeteries is being recognized more and more by scholars of California prehistory (T. King 1974, Meighan 1987, Leventhal 1993). There are no residential features (i.e., house pits or hearths) at CA-SCI-38. Activities inferred by *in situ* observations at the site suggest CA-SCI-38 was indeed a cemetery site as evidenced by vitrified clay platforms, most probably the residue of cremation ceremonies (see Leventhal 1993 for in depth discussion).

Assumption of unbiased recovery

A further assumption in paleodemography expects that the population interred in the cemetery represents a normative cross-section of the village population, from neonates to elderly adults. Mensforth has suggested that the ratio of subadults to adults should “comprise 40 to 50% of all individual deaths” (Mensforth, personal communication, 1997). The normative model was found lacking in that there was a

limited representation of neonates at CA-SCI-38. This is not an unusual problem for paleodemographic research and requires adjusting the demographic interpretation. It is not only subadult samples that suffer from differential burial practices--the female/male adult sex ratio at CA-SCI-38, 1.56, is also biased yielding 100 males and 64 females.

Assumption of stable populations

“If an independent, usually archaeologically derived, estimate of the growth or decline rate of the population can be made...stable-population models can be used with the mean age-at-death to estimate approximate life expectancy and analyze what kinds of mortality rates could have produced the pattern found” (Storey 1994:150). The slow growth rate of preindustrial populations is one of the assumptions that allows for application of life table analysis to this sample.

Assumption of little or no migration

A population with little or no migration is one of the assumptions of stationarity (Weiss 1973). Suchey's dissertation (1979) is one study found to back up this assumption of little or no migration at the regional level. Suchey studied non-metric traits from several Central California samples and found little evidence for migration (1979). Suchey tried to determine heterogeneity between Coastal groups and Interior groups based on non-metric skeletal analysis (1979) of Sacramento Delta, Marin, and Alameda County sites. In Suchey's introduction it is noted that Brooks, “in an unpublished demography paper including an analysis of the distribution of eight metric traits in 14 skeletal samples,

[found] differing frequencies [and thus] she interpreted the prehistoric settlements to have been endogamous” (Suchey 1979:11). Suchey also reported conclusions similar to those of Brooks (Ibid.). The determination of migration patterns in paleodemographic analysis relies upon research of this kind.

Summary

In order to apply paleodemographic methods to life table analyses the most important objective for the human osteologist is the accurate assessment of age and sex for the sample population. The focus of this thesis is the application of osteological age estimation methods that may allow for consistency in aging older individuals. For this reason, the adult sample was subjected to several recently-developed age estimation methods and one new sex determination method. The application of these techniques is the topic of Chapter Three, Materials and Methods.

CHAPTER THREE

MATERIALS AND METHODS

A Brief History of Osteological Age Estimation

The nature of human osteology is empirical and methodological. Human osteologists over the past century have laid the foundation for contemporary studies in paleodemography with the refinement of methods to determine the age and sex of human skeletons (Todd 1920 & 1921, Todd and Lyons 1924, Brooks 1955, McKern 1956, McKern and Stewart 1957, Johnston 1962, Gilbert and McKern 1973, Hanihara and Suzuki 1978, Levy 1982, Isçan et al. 1984, Lovejoy et al. 1985a & 1985b, Katz and Suchey 1986). These researchers all subscribe to the fundamental theory that the age of an individual at the time of death can be determined or estimated by the morphological and/or metric expression of specific areas of maturational processes, particularly at articulated joints

In the treatment of a paleo-skeletal series, the sex and age of individuals is the fundamental aspect. "These two basic characteristic features are the subject of paleodemography, and should be estimated invariably when individual skeletal finds as well as series are evaluated" (Acsádi and Nemeskéri 1970). The paleodemographer must turn to the human skeletal biologist to determine these vital rates.

Age estimation for subadult individuals is well founded in the biological development of tooth eruption (Ubelaker 1989, 1978) which accurately assesses the age of an individual up to age fifteen, when the dentition becomes fully developed. Age-estimation for adult individuals suffers from dissimilar complications, and accordingly aging the adult human skeleton has proven to be a much more difficult task.

Human osteologists readily admit to the difficulties of aging the adult skeleton. Every study based upon skeletal aging techniques reintroduces the inherent difficulties (Gilbert and McKern 1973, Meindl et al. 1983, Milner et al. 1989, Storey 1992, Russell 1993, Lovejoy et al. nd, Konigsberg and Frankenberg 1994, Loth 1995). Once the developmental or growth processes of the skeleton are complete, the variability of age-estimation in the maintenance phase and the degenerative phase becomes stochastic. Yet these techniques lay the foundation for paleodemographic research. One of the most important objectives in age-estimation is understanding human longevity. Because age-estimation for older individuals is considered less reliable, development of more accurate methods is imperative. The sternal rib end (İşcan, et al. 1984, 1985, 1986, 1987) and the auricular surface of the ilium (Lovejoy et al. 1985b) have both been demonstrated to increase the accuracy of age estimation in the upper decades.

Once it was believed that estimation of age could be reliably assessed from the cranium through one of the longest standing methods of age-estimation, basilar suture closure (Dwight 1890, Todd and Lyons 1924). Because of the differential preservation of

the cranium in archaeological contexts, the basilar suture was relied upon for age-estimation in many early skeletal studies. Reflective of the difficulty of developing a reliable methodology for adult age-estimation, many researchers now consider the method of basilar suture aging inaccurate (Brooks 1955, McKern and Stewart 1957), and now rely upon newer methods that have been determined to be more reliable. Todd's life work, however, did lead to the development of adult age-estimation based on the morphological characteristics of the pubic symphysis (Todd 1920 and 1921).

Pubic symphyseal method of age-estimation

Age-estimation by the pubic symphyseal method was first developed by Todd based upon what is now known as the Hamann-Todd Collection, housed at the Cleveland Museum of Natural History (1920 and 1921). Todd developed a ten-phase system based upon analysis of 306 male individuals. It has been demonstrated by Brooks (1955), Katz and Suchey (1986), and Angel et al. (1986) that there is a propensity to overage an individual using the Todd Ten Phase method. This is thought to be true because the sample was developed from an older male sample and lacks adequate representation of females and younger individuals. Osteologists have reported that the accuracy of the ages utilized by Todd are not dependable, as even Todd realized (Todd 1920:314). This method continued to be refined by Suchey and colleagues (Katz and Suchey 1986, Brooks and Suchey 1990) and is now known to osteologists as the Suchey-Brooks Method.

Brooks was inspired to improve upon Todd's Ten Phase method because the mean age-at-death of California's prehistoric skeletal series never exceeded age 30 (Brooks 1955). By applying Todd's Ten Phase method and cranial suture closure to the University of California Museum of Anthropology's native California skeletal sample, Brooks concluded that the Todd cranial suture method is susceptible to over-aging and the pubic symphysis to under-aging (Brooks 1955:588).

After the Korean War, Stewart was asked to analyze unknown American soldiers as they were to be returned to the United States (McKern and Stewart 1957). A three components, six stage scoring system was developed based upon these data. The McKern-Stewart study has been found to suffer from age and sex bias as the study was based upon young males. It has been concluded that this method is not accurate and should be avoided (Angel et al. 1986).

As the McKern-Stewart method was not applicable to females (based upon an all male sample), Gilbert and McKern developed a three component system of five phases (Gilbert and McKern 1957) based upon a female sample. Suchey later concluded (1979) that the Gilbert/McKern method suffers from interobserver error, when 23 physical anthropologists, attending the American Association of Physical Anthropology's 55th Annual Meeting in New Mexico, only achieved 51% accuracy from a set of casts made available at those meetings.

Because the foundation of this thesis is based upon the accuracy with which a sample skeletal series may be aged and sexed, every available method was applied to the skeletal series under consideration here. The pubic symphyseal method of age estimation is often considered the most accurate method by which to age adults, especially in the upper decades (Katz and Suchey 1986, Suchey and Brooks 1990). The San Jose State University Osteology team relied upon the Suchey-Brooks pubic symphyseal method for aging the adult sample. In order to add confidence to those estimated ages, this author also applied the auricular surface of the ilium and the sternal rib end methods, as previously discussed.

Age estimation achieved by the pubic symphysis is reported in wide age-ranges. For example, the Suchey-Brooks adult female Phase II ages the female individual as 19 - 40 years with a mean of 25.0 years $\pm$ 4.9 (Brooks and Suchey 1990:235). Suchey-Brooks pubic symphyseal method applies age ranges with “wide 95% confidence intervals, most of which range from 30 to 50 years per phase” (Isçan 1989:117). This makes the Suchey-Brooks method difficult to compare with methods utilizing intervals. Applying the methods of pubic symphyseal age estimation guarantees accuracy in the 95% range; no other method can claim this confidence interval. For this reason it may be more appropriately applied to individual forensic cases. However, the auricular “is buttressed by the thick plate of the posterior ilium and thus its post-mortem preservation of 65%-80% far exceeds that of the os pubis (30% - 45% preservation in most cases)...[t]he auricular surface, although harder to learn, represents the site within the skeleton that is

better represented relative to all other age criteria, with the exception of the dentition” (Mensforth, personal communication, 1997).

Sternal Rib End Method of Age Estimation

Standards for male age estimation based upon the sternal rib end were developed by Isçan et al. (1984). In the following year a similar method was developed for females (Isçan et al. 1985). Such a process of scientific refinement is parallel to the development of the pubic symphyseal methods (Todd 1920, 1921, McKern and Stewart 1957, Gilbert and McKern 1973, Katz and Suchey 1986). Male criteria were developed first and found to be inapplicable to the female sample, calling for the development of specific female standards.

The sternal rib end method is reported to track regular biomorphological change into the seventh decade (Isçan et al. 1984:853). The sternal rib end method is utilized here because this method has been cited as accurate by researchers other than the original developers of the method (Angel et al. 1986, Russell et al. 1993, Dudar 1993). Loth recently has used the sternal rib end to assess the Spitalfields Cemetery sample (1995) and reported, most importantly here, that the "rib can be considered a reliable site for age estimations in archaeological populations" (Loth 1995:465).

Isçan et al.'s initial paper, reporting the development of the sternal rib end age estimation method, cautioned that its application should be only applied to a European sample because it was developed on a European sample. (Isçan 1989:132). Russell et al.

independently tested the sternal rib end method (1993). Whereas Isçan et al “predicted that blacks would show a tendency toward accelerated rib changes compared to whites, especially after the early 30s” (Russell et al. 1993:53), Russell et al. reported disagreement and not only “found that the 4th rib shows characteristic changes in morphology with age and can be included in multifactorial age estimates” but further concluded that “Americans of African descent (black) showed a non-significant trend for the rib changes to be delayed compared to Americans of European descent” (Loth, personal communication, 1997).

This cautionary advice should be considered when applying the sternal rib end method to an Amerind sample. Even though Loth has not formally assessed an Amerind sample, she suggests that Amerind ribs seem to follow the white standards more closely than blacks standards (Loth, personal communication, 1997).

The Auricular Surface of the Ilium Method of Age Estimation

The auricular surface of the ilium method of age estimation was developed by Lovejoy et al. (1985b). The surface of the auricular is varied and unique in its individual morphology. The articulation of the sacrum with the ilium forms a synovial joint. Each of these surfaces has a distinctive cartilaginous nature (Lovejoy 1985b). The sacral cartilage is hyaline. The surface cells are arranged in compact, parallel layers. The iliac cartilage is fibrous "with occasional islands of hyaline cartilage" (Ibid.:16). As age increases, the surface becomes “roughened, furred and frayed” (Ibid.). Sashin (1930) attributed this

process to an age-related increase in the proportion of fibrocartilage in the joint. Schunke (1938) took issue with this observation, attributing it instead to the more typical process of degeneration seen in other moveable joints with synovial cavities (Ibid.). Changes recognized in the joint surfaces in the third decade are recognizable in the grain and texture of the bone in autopsy and, as Lovejoy has concluded, in archaeological specimens. The surface bone is smooth and fine-grained with what is defined as transverse organization or “billowing.” Billowing is a morphological term denoting undulations of the surface and is also seen in epiphyseal fusion. Degeneration of this transverse organization is a major indication of the aging process. Transverse lines or billows are replaced by “striae” after age interval 25-30. Definitions of each phase are presented in Appendix C. It is suggested by Lovejoy that, as the primary source for age-estimation, the photographs are to be used in conjunction with the phase descriptions to illustrate the terminology and highlight the particular morphological changes.

Previous attempts by this author to estimate age-at-death from an analogous archaeological sample, CA-Ala-329, had proven the auricular surface method difficult to learn. The changes manifest in the auricular surface are difficult to interpret because there is no delayed epiphyseal stage and because the surface is complex. The fluid progression of morphological changes, combined with this most irregular auricular surface, necessitate long term study to acquire the precise understanding of each phase.

Age-estimations obtained by this method in analysis (previously conducted by this author) of CA-Ala-329 materials were found to be within the range of previously

estimated osteological techniques in 29 out of 34 individuals in the sample. The auricular age estimates were found to correlate 85% of the time with original age estimations. Because of this strong correlation found for the CA-Ala-329 sample, this method was applied to CA-SCI-38. The auricular surface age estimation data are presented in Appendix C.

Methodological Considerations

The multifactorial approach

It is important to integrate all known reliable methods of age estimation and apply the methods to each individual as it comes under study in the sample. A “multifactorial approach” developed by Lovejoy et al. (1985b), illustrates the advantage of utilizing all reliable sites and then averaging the achieved results. The multifactorial method of age estimation applies age information for each skeleton from as many age indicators as are present.

Lovejoy et al. developed a multifactorial approach to estimate age-at-death that includes the pubic symphyseal method as revised from Todd’s original method (Lovejoy et al 1985a). Katz and Suchey criticized Lovejoy et al.’s efforts to age older individuals with the Todd Ten Phase system because of the deletion of “problematic specimens” (Katz and Suchey, 1986). In a rebuttal to Katz/Suchey’s criticism of their deletion of individuals that they considered problematic specimens, Lovejoy et al. pointed out that all research is based on Todd’s original research and it is not a “difference in sample which

best accounts for the low mean error of chronological age estimation” (Meindl et al. 1990:356). What they insist upon is that there needs to be a

consistent biological assessment and that “[t]ypological categorization is only useful for truly discrete events [as] this practice restricts age estimation to a single, dominant feature of each specimen, despite the unquestionable existence of numerous other age-related changes which regularly occur in the symphysis. (Meindl et al. 1990:356)

Lovejoy et al. utilized five indicators in a multifactorial approach: femoral cortical index, auricular surface, pubic symphysis, medial clavicle fusion, and dental wear. Each indicator was then weighted using principal component analysis to derive the most reliable age (Lovejoy et al. 1985a). Jackes has pointed out that “multiple techniques can be applied in a controlled way only in sites with complete skeletons and excellent preservation (Jackes 1992:198). All five skeletal indicators are rarely present in archaeological samples and CA-SCI-38 is no exception. “Under the circumstances obtaining for most archaeological skeletal collections, published ages will have been assessed by a variety of techniques. Skeletal preservation, age and sex-dependent though it may be, will be controlling our techniques of age assessment” (Ibid.:199).

Seriation of skeletal samples

Seriation (Lovejoy et al. 1985a) of a skeletal series is based upon biological chronology. It is necessary to obtain an integrated analysis in a skeletal series by placing each individual age within acceptable age intervals, thereby permitting life table analysis. All elements presenting age indicator data for an age estimation method (i.e., all pelves or

all sternal rib ends) are set out in separate phases, usually five year intervals. Then in each phase, the indicator is compared to other elements that have been assigned to a particular phase and each age indicator can be further studied and arranged according to where the indicator falls in each separate phase. Seriation facilitates aging large samples, also decreasing systematic interobserver error. Simply ranking the age indicators offers less precision than seriating the sample.

In order not to project invalid accuracy, age assessments are usually made within five-year categories (e.g., 50-55 years). This results in the further loss of data, since a specimen that the observer believes to be on the borderline between 45 and 50 is, on the available evidence, probably younger than one the observer believes to be between 55 and 60. Yet the two specimens might be lumped into the same age category. (Lovejoy et al. 1985b:3)

Seriation also allows one population's morphological characteristics to be considered rather than basing the estimation by directly comparing the phase characteristics to a twentieth century sample upon which these three methods (above) have been developed (Ibid.). Once there is a biological distribution of ages, estimating as accurately as possible the entire range of the sample, these ages may be utilized to determine the rates of fertility and mortality that are the residual (derived) estimates of any life table. Graphic reproduction can then be generated to illustrate the distribution of ages from the database.

Areas of Contention

Certain scholars have questioned the usefulness of paleodemography. Not all researchers agree with the capacity of paleodemography to offer insight into the social status of the deceased as observed through a mortuary analysis. Piggott believed that there are too many emotional and religious ties to try to derive evidence of past cultural practice (Piggott 1969). Angel wrote that life tables, based upon osteological age-estimation, present three "false assumptions:" (1) that the cemetery "represents a single generation cohort," (2) "that death rates are even at all ages after infancy and hence directly reflected in cemetery age frequencies," and (3) the sample is stable both biologically and culturally (1969:428).

Bocquet-Appel and Masset offer perhaps the most outright criticism of paleodemographic research in a paper entitled "Farewell to Paleodemography" (Bocquet-Appel and Masset, 1982). This critique argued that the contrast between creating a life table from historical demography such as birth records and marriages could offer a "picture of life"; however, it did not seem possible that such pictures of social context could be constructed from a graveyard population. It also was their position that sexes must be considered separately for any useful analysis to occur. They suggested that poor preservation of infant bones skews analysis. In their estimation, paleodemographers could not use the comparative parameters of modern populations in prehistoric analysis from skeletal remains. The shortsightedness of bidding farewell to paleodemography would preempt archaeological investigation and cut out the heart of the database. Bocquet-Appel

and Masset may have "Bid Farewell to Paleodemography" (1982), but their farewell seems to have been premature.

Five points were presented in Boquet-Appell and Masset's thesis (1982) to demonstrate that age estimation methods are a primary deterrent to any paleodemographic analysis. They suggested that: (1) age estimation methods are biased toward the modern skeletal series upon which they are developed, (2) skeletal age distributions from archaeological prehistoric samples do not vary from "the reference samples used to generate them," (3) absence of infant bones skews analysis, (4) these same osteological methods are developed with unequal representation of age ranges, and (5) "information conveyed by the age ranges is so poor that the age distributions thus available can hardly reflect anything but random fluctuations and errors of method" (Bouquet-Appel and Masset 1982:321-332).

Van Gerven and Armelagos denied that age estimations are biased by modern skeletal series pointing out that their Nubian study did reflect a significant difference in age distribution ($p < 0.01$) from the Hamann-Todd series upon which their research was based (1983). Buikstra and Konigsburg rebutted all five specific criticisms in a point-by-point examination: (1) Bouquet-Appel and Masset compared their criticism of the invariance of reference samples to the wrong standards, (2) age standards developed upon cranial suture closure are no longer considered reliable by osteologists, (3) age estimation standards are found to be reliable across populations, (4) by smoothing the data from 26

well documented archaeological samples, age distributions did not appear to “randomly fluctuate,” (5) “age indicators are modestly biased indicators of real age”(1987:323).

Criticism thus fostered a defense of paleodemographic methods serving to strengthen the field and leading to a resurgence in paleodemographic research. Such positive response may only be possible when there is a strong foundation in a discipline regardless of the shortcomings in the present state of development.

Osteological Analyses of CA-SCI-38

Criteria for adult age estimation

Because multiple age criteria have been found to improve the accuracy of age estimation (Acsádi and Nemeskéri 1970, Meindl 1983, Lovejoy et al. 1985a), all available age indicators were considered for each individual. All individuals had been aged by the San Jose State University Osteological team according to standard methods of epiphyseal fusion (Bass 1987), medial clavicle fusion (Webb and Suchey 1985), dental eruption (Ubelaker 1978), and pubic symphyseal morphology (Katz and Suchey 1986).

When there are two or more indicators available, the mean of these two indicators is averaged. For example, Burial 4 has a pubic symphysis indicator, a rib indicator, and an auricular indicator. The pubic symphysis and epiphyseal fusion placed this individual in the 40-50 age range. The mean of the range is 45. Burial 4 also has a rib indicator, seriated to age 42, and an auricular indicator, seriated to age 49. The mean age equals 45. This averaging process was continued until all individuals were included.

Dental wear has been highly regarded by some authors, but its role in age determination has frequently been secondary because of suspected problems in correcting wear rates for specific populations (Lovejoy et al. 1985a). This is especially problematic as the population of aboriginal Californians demonstrate dental wear patterns radically affected by the infusion of bits of granite and volcanic mortar surface residue into ground seeds that made up a large portion of the diet of these people (Jurmain 1990a). Femoral cortical index was not available for aging the adult sample of CA-SCI-38.

Adult Sex Determination

Sex determination is most often determined from the morphological characteristics of the os coxa. All individuals recovered from CA-SCI-38 were sexed by the San Jose State University Osteology team based upon Phenice's morphological characteristics of the pelvis (Bass 1991, Ubelaker 1989, Phenice 1969). Criteria utilized for sex determination included the sub-pubic concavity, the ventral arc, the medial aspect of the ischiopubic ramus, and the length of the pubis. During the inventory process, Muriel Maverick conducted extensive metric assessment of all available elements, including craniometrics. Although it was tempting to apply this metric data to sex determination, no studies have been reported to accurately assess metric data for California aboriginal samples; therefore, the metric data were not utilized for sex determination. Research based upon metric data of this kind for California skeletal studies would prove a valuable osteological tool.

Subadult methods for age and sex determination

Subadults individuals in this sample were aged according to the pattern of dental eruption (Ubelaker 1989) and epiphyseal fusion (Hunt and Gleiser 1955, McKern and Stewart 1957, Webb and Suchey 1985). Subadult sex determination is not usually considered accurate due to the fact that the morphological characteristics are still in the development phase. There are several studies that have considered sex estimation for immature individuals (Kosá 1989, Ubelaker 1989); however, no attempt was made to sex immature individuals (aged less than 16.0 years) in this study.

Sternal Rib End Analysis

The sternal rib end method is sex specific and, as all individuals had been previously sexed in the initial analysis, this sex classification data was maintained. Burials with at least one complete rib, as recorded in the skeletal inventory records, were examined. In cases where many fragmentary rib elements were reported in the record, the burial was also examined in the event that rib reconstruction would be possible. Elmer's White Glue was used to reconstruct the elements. Once the ribs of an individual were reconstructed as completely as possible, they were arranged on a tray and labeled to protect the provenience. Reconstruction of as many rib fragments as possible allowed the maximum recovery of the central or mid-ribs in efforts to improve sample size. Many tedious hours of intensive concentration were required to match and repair rib elements before identification could be made.

Rib identification

The characteristic morphology of the sternal rib end in central ribs is distinctive. The articular end is large and widely oval. Mann points out concern with correct identification of ribs four through ten (1992). The third, fourth, and fifth sternal rib ends have the largest articular area of all the ribs. This is, in part, why more analytical information is found in these ribs. The first rib in this sample always displayed the morphology of an older rib. Rib ten and the floating ribs, eleven and twelve, are not subjected to the physiological stresses found in the central ribs.

Rib four was the target rib, based upon Isçan et al.'s methodology. Although rib four was the target rib, central ribs two through seven may be utilized in the aging process. For this study only ribs three and five were considered if rib four was not available. Studies have shown that ribs three and five are most often within the same phase as the fourth rib and in no instances more than one phase apart" (Isçan 1989:118). It has been "cautioned that non-fourth ribs deviate from the phase assigned to rib four by 36% to 50%; however, deviations are within one phase 87.6% of the time" (Dudar 1993:797).

After reconstruction of the ribs from the burials of CA-SCI-38 was completed, the ribs were laid out inside each other, upside-down, with the first rib in the center and the eighth and ninth ribs to the outside. Tenth, eleventh, and twelfth ribs were useful to help place ribs in proper order. The first rib is easily identified as it is "the shortest of all the ribs [and] the head usually has only one articular facet" (Bass, 1987:134). The second rib

is also easily identified, not only because it conforms specifically outside the first, but because it also has a defining morphology. The third rib fits closely outside the fourth and this is repeated to the twelfth rib. In this way a neat, heart-shaped pattern is formed that aids in the determination of the third, fourth, and fifth ribs.

Mann (1992) suggests that the ribs be laid out, rightside-up, side by side on a table top. In this way, he suggests that one can determine rib-sequence by the pattern of the head position. Mann's methods for rib sequence determination may be more of an aid to those not formally schooled in human osteology. This osteologist found that the ribs conform very well to each other when the elements are placed upside-down on the table, making the task of identification less complex than suggested. Bass does report that "[i]t is difficult to tell the exact number of the rib without a comparative skeleton"(Ibid.), but if there are enough elements present, which can be reconstructed (with patience), the correct rib number may be determined in many cases.

After initial determination of rib number, the vertebral column was articulated. By placing the rib, determined to be the third, fourth, or fifth, against the costal and transverse articulations of the vertebrae (the costochondral junction), the identification of the correct rib can be verified. This also is helpful when determining ribs that have been reconstructed solo. If the sternal end is broadly ovoid, rather than flat and narrow, it is more likely to be rib three through seven. When the rib element is complete, and if there are identifiable vertebrae for articulation, the correct sequence may be assured.

Because this is a sex-specific method, when reconstruction of the ribs and identification was complete, the female sample ($n = 28$) was separated from the male sample ($n = 55$). Each rib was labeled with tape and placed in a plastic bag to protect the provenience. Sex was recorded, both on the bag and on the element with a small piece of masking tape. Even though this author had searched the CA-SCI-38 burial records for presence of elements, so as not to become too familiar with the previously determined statistics, Muriel Maverick read the record and the information as noted.

“There is no differentiation between sides” (Isçan 1989:118). Whether a right or left rib was present, the element was included and noted as such. Loth has also reported that “this method can be applied to Neanderthals because they exhibit the same pattern of age-related changes” (1995:465); however, the phase descriptions are still titled as to race. These phase descriptions are presented in Appendix B along with the descriptions of the rib morphology.

The interval phases were decided and each rib sample was set out in its respective phase for seriation. In each phase, ribs demonstrating characteristics exactly as described were placed in the center of the distribution. See Appendix B for a complete description of sternal rib end phases.

Auricular Surface of the Ilium Analysis

The sample chosen for the auricular surface of the ilium study at CA-SCI-38 included all adults presenting at least one auricular surface. Individual burials were

screened for adult age and sex, condition of the os coxae, and consideration as to the completeness of the auricular surface and presence of both right and left elements. All grossly pathological elements were eliminated.

It is important to train the eye to be able to discern the textures of the auricular surface. In previous analysis of CA-Ala-329 materials fusion of the ilium may have prejudiced estimation but also aided in discerning the varying aspects of the grain, thus initially helping to distinguish between fine, smooth bone (youthful) and bone that had been subject to compaction (older). With more familiarity and practice, the gross morphological structures became more discernible.

These elements were then studied according to the methods described in the article by Lovejoy et al. (1985b) and from the photographic series later developed at Kent State University from the Hamann-Todd collection. The seriation of the auricular sample was applied in exactly the same way as the sternal rib ends seriation (explained above). The auricular study results are presented in Appendix C.

Discussion of the CA-SCI-38 female sample

Some individual cases of interest are now considered here. The burials from CA-SCI-38 were in good to excellent preservation; however, there were no cases of bony projections on sternal rib ends as marked as those depicted in Iscan's article (Iscan, 1989:116, fig. 5.7). Bony projections define Phases VII and VIII (i.e., 60+). Only one

female was assigned to Phase VII. Burial 81 had the most marked bony projections in this sample, located on the inferior rim, Phase VII. This element was also very light and porous. It was noted that these projections are not on the articular surface but the rim. In any case, Burial 81 had the most irregular morphology and was assigned the oldest age. No female ribs from this sample were found to have bony projections in the pit. As previously stated, because of the excellent preservation of the elements at this site some bony projections from the interior of the pit should have been maintained. It is interesting to note that 68% of the rib sample were aged 30+. The ribs from older individuals seem to be relatively well-preserved at this site.

Sternal rib end Phases V and VI are defined as having “plaque-like” deposits in the pit floor (Isçan 1989:112). This was difficult to ascertain. Any accretion on the pit surface was defined as plaque. Burial 68 had a waxy articular surface surrounded by a porous, pitted rim. Because of the waxy coating, which differed from others in the sample, it was defined as plaque.

Burials 4 and 145 displayed ridges and shallow pits characteristic of sternal rib end Phases I and II. Because of the porosity and plaque in the pit, they were assigned to higher phases. Burials 43, 55, 183, and 232 were assigned to Phase V, even though they had scallops remaining. Burial 32 had scallops and a deep porous pit. Because of the presence of the scallops and the central arc, Burial 32 was assigned to Phase IV. Burial 221 had a very short central arc on the anterior rim, almost unnoticeable, and was

assigned to Phase IV. There were no scallops, no porosity or "plaque-like" linings. This rib was difficult to estimate for phase because of its amorphous morphology.

Burial 35 was female aged 25+ on the basis of a fragment of the left pubis (Suchey-Brooks Phase IV, $36.8 \pm \text{SD } 9.6$). Two sternal rib ends, a left and a right, were located and studied. The pit was deep and porotic, the walls thin, with no central arc. There were no scallops remaining on the rim. This is Phase VI, 43-58. Burial 35 was seriated to at least 43 years of age on the basis of the rib. After assigning phases, each phase was set out separately and seriated in ascending order.

Discussion of male sample

Consideration of several interesting cases for the male sample is further discussed. The ribs of Burial 33 were characteristic of Phase II (Isçan 1989) as the 4th left rib was wavy with scallops developing. The pit depth varied in that the inferior half demonstrated some depth but the superior half displayed only initial indentation. The walls were thick. Previous age estimation had placed this individual at age 32. The auricular age assigned by this author is 33. The rib estimate came close to these previous estimates. Bony projections, expected in later phases (VII and VIII), were never as marked as samples pictured in the original paper (Isçan 1989, Reichs 1986). The rims break down in later phases but the pits did not demonstrate any depth in this sample. Burials 161, 26, and 10 had projections in a porous pit, but there was also remnant scalloping and no projections along the rim. These characteristics apply to separate phases according to the method as

described. The 4th left rib of Burial 10 had a regular rounded rim with diminished scallops, illustrative of Phase IV. The walls were short, thus the pit was shallow. The pit was the most porous of the sample and appeared ready to "dissolve." Light could be seen from the exterior to the interior when held to incandescent light. Even when holding it to inferior fluorescent light, small holes let light through. This individual was assigned last place in the entire male series, Phase VI, age 47. Burial 211 was indeterminate and initially aged at 25+ by fusion of the medial clavicle. The ribs were studied and three central sternal rib ends were located. The largest and most likely to be 3, 4, or 5 displayed worn scallops on a still rounded rim. The pit was widely u-shaped but not at great depth. This individual was assigned to Phase IV, 26-32, seriated at age 28. As discussed above, a complete table for the sternal rib age estimates is presented in Appendix B.

General discussion

Pit depth was not as extreme in this sample as described by Iscan et al. (1989). Scallops remained even when the pit displayed bony growth or porosity. Perhaps these central morphological developments are occurring in younger individuals and should have been assigned to Phase III. Are bony growths strictly age-dependent or are they stress factors? From Iscan we are led to believe they are related to age. Given these considerations, those individuals displaying bony growth were assigned to the later phase.

Of 252 individuals in this skeletal series, 50 adults were initially classified as indeterminate sex. Indeterminately-sexed adult individuals pose one of the most difficult

problems in this study. Therefore, a more recently developed method for determining sex, based upon the posterior ramus of the mandible (Loth 1996), was applied to this series. As a result nine individuals were further reclassified according to sex.

Loth's Posterior Ramus of the Mandible Sex Determination Method

The posterior ramus of the mandible has demonstrated morphological features that present the human osteologist with a new sex determination indicator (Loth 1996). As the human individual develops there are differentiating aspects of the skeleton that are dimorphic. At the occlusal plane of the mandible, flexure (or the lack thereof) along the posterior mandibular ramus has been determined to be dimorphic in nature (Ibid.) When flexure is present at the occlusal plane the individual may be classified as male and conversely, when flexure is absent, the individual may be classified as female. The cut-off point for utilization of this method of sex determination is confined to fully developed, mature individuals. Younger individuals may be mistakenly determined to be female as the flexure has not become developed.

Table 3.1: This table reports on the individuals from CA-SCI-38 sexed according to the Loth Mandibular Ramus Method.

burial	burial	sex	loth		finalsex
30	30a	i	f	1	F
31	31a	i	f	1	F
35	35a	i	f	1	F
72	72a	i	f	1	F
94	94a	i	m	1	M
187	187a	m?	f	1	F
227	227a	i	f	1	F
228	228a	i	m	1	M
234	234a	i	f	1	F
				9.00	

Loth's mandibular ramus method for sex determination was applied to nine cases in this study. Eight cases had been classified as indeterminate and one case had been sexed as male. Of the eight individuals classified as indeterminate, seven were reclassified according to the mandibular morphology as provided by Loth (see Table 3.1). Only once was there a case for reverse sex determination. This case was Burial 187, which was at first classified as questionably male on the basis of metric data. Epiphyseal fusion placed Burial 187 in the adult category. The lack of flexure in the mandible of this individual was cause to reclassify this individual as female. In the case of Burial 227, the results may be questioned. The mandible of burial 227 demonstrated no flexure at the occlusal plane; however, this individual was aged as 17 years and not fully mature. Loth has pointed out that the individual must be fully mature for consideration. A male individual, not fully adult, may be more reliably sexed by this method because, as a result of male hormonal effects of developmental growth, the development of flexure as opposed to lack of flexure demonstrates male development (Loth, personal communication, 1997).

Subadult sampling problems

Of the 252 individuals recovered at CA-SCI-38, 47 were determined to be subadult or less than 16.0 years. Osteological elements representing extra subadult individuals interred with the primary burial were noticed in eight cases: Burials 61, 76, 90, 205, 223, 229, 230, and 238. Because subadult bones may have been relocated due to

croatavenial activity or other possible taphonomic situations, it then became necessary to determine if these individuals were really separate burials. To determine whether these individuals were really separate subadult individuals the burial site map was consulted. The burial site map was prepared by Bellifemina (1997). A scatter plot using a coordinate system allowed for pinpointing each burial location. This map was used to determine the geographical relationship of each burial.

When no other subadult individual was located within a 5 meter radius of one of these eight cases, it was assumed that these were indeed separate individuals and a burial number was assigned to them. Provenience of these eight cases supports evidence that these individuals were individual primary inhumations. Eventually these subadult individuals were assigned to the burial “a” category. These eight individuals were inventoried as Burials 61a, 76a, 90a, 205a, 223a, 229a, 230a, and 238a. An estimate of ages for these eight subadult individuals was then entered into the main data base.

Table 3.2: Neonate Sample additionally included to the skeletal inventory of CA-SCI-38

burial	finalsex	age criteria	age
61a	I	occip. condyle (0 - 4mos.), 1 cervical vert, 1 cranial frag.	0.20
76a	I	neonate occipital condyle, unfused verts, and MT5	0.50
90a	I	neonate occipital condyle, immature spineous process	4.00
205a	I	unfused pubis and ischium (5-10)	7.00
223a	I	maxilla with deciduous teeth = 18 mos.	0.75
229a	I	fragmentary neonate mandible	0.20
230a	I	neonate right ulna	0.50
238a	I	vertebral body of neonate	0.50

Age estimation methods resulted in insubstantial differences in age estimation techniques as applied in this sample. The statistical analysis of comparison between age

indicator results is presented in graphical form in Chapter 5. For a complete list of the age estimation methods as assessed in this previous chapter see Appendix A. For the description of the morphological characteristics of the individuals in the sternal rib end sample, see Appendix B, the Sternal Rib End Data. Appendix C presents the tabularized form of the auricular surface data. To begin to understand how these ages are applied to paleodemographic reconstruction, the theoretical implications of life table analysis must be clarified. Life tables and demographic reconstruction are the topics of Chapter Four, Theoretical Implications of Paleodemography.

CHAPTER FOUR

THEORETICAL IMPLICATIONS FOR PALEODEMOGRAPHY

Paleodemography is a subject which is simultaneously intensely interesting and devilishly difficult. It is intensely interesting because its subject matter is the life and death of our ancestors. We cannot have a clear idea of the history of our species without knowing quite a lot about the risks of mortality to which they were subject, and about their ability to bear children to keep the groups alive. The subject is difficult because of the nearly complete loss of the data needed for the analysis. (Howell 1976:25)

Paleodemographers seek to understand cultural adaptation through the determination of biological aspects of vital rates, i.e., the age and sex of individuals determined through osteological methods. It has become obvious that fertility rates, as well as mortality rates in a human group, have import for understanding the nature of subsistence strategies and cultural adaptation (Weiss 1973, Sattenspiel and Harpending 1983, Hammel and Howell 1987, Johansson and Horowitz 1987, Milner et al. 1990).

The theoretical implications of paleodemography have been elusive (Caldwell et al. 1987, Hammel and Howell 1987). Hammel and Howell's pointed attempt to "place the development of human demography and coevolved culture squarely within the framework of biological evolutionary theory--evolutionary theory as modern biologists know it, not as some remember or imagine it" (Ibid.:142) demonstrates the fundamental development of recent paleodemographic theory.

To the extent that we can explain some principle, or a very economical number of principles, and a very large amount of cultural behavior - to that extent we have progressed. This is a legitimate scientific objective. When we have made our explanation in terms of one (or more) selected principles, the next stage is to introduce auxiliary hypotheses and make modifications in order to explain the residue that is not covered in the first explanation. Gradually the first explanation will be superseded. Such is the dialectical process of scientific explanation. (Carneiro, as paraphrased in Spooner 1972:xxvi)

The scope of paleodemographic study may extend from the application of one age-estimation technique, based upon one skeletal individual from an isolated context (Wilde and Tasa 1991), to the comprehensive review of an entire series of skeletons analyzed and studied through synthetic abridged life tables (Acsádi and Nemeskéri 1970, Weiss 1973, Swedlund 1975, Lovejoy et al. 1977, Mensforth 1990). When life tables are constructed from a population sample, the biological aspects of a population, as represented by the descriptive statistics of age and sex, may be compared with the cultural adaptation of the group to measure the success of the expressed adaptive strategy.

To demonstrate the advance of research methods in skeletal biology, an early study may provide insight into the objectives once held central to the discipline. A premier paleodemographic study of North American osteological research was conducted by Hooton and reported in *The Indians of Pecos Pueblo: a study of their skeletal remains* (1930). This study employed estimated skeletal age-at-death methods to determine mortality rates from the sample; however, the focus of study was cranial metrics, indicative of a typological approach common to archaeological study of the day. Hooton correlated cranial morphology with stratigraphical assemblages utilizing statistical

analysis to determine the degree of homogeneity present in the sample. Basically, this analysis argued that the presence of a certain type of pottery in provenience with a certain type of cranial morphology would add to the understanding of the temporal components at the site and thus allow for differentiation of groups. Age and sex estimates were important, but only in so far as application to determinations of type. Also, there was little interest in subadult remains. "After all necessary elimination of fragmentary material, immature skeletons, and those of doubtful sex or unknown archaeological date had been made, there remained no more than 250 skeletons in good condition for study" (Hooton 1930:18).

It has become evident that there is more to learn from the skeletal remains of prehistoric societies than a typological approach may offer. The processual approach to archaeological study now demands information of social import. This intellectual development is underscored by the multitude of contemporary paleodemographic studies that seek to relate anthropological demographic theories to explain the characteristics of prehistoric populations (Ubelaker 1974, Moore 1975, Zubrow 1976, Swedlund 1976, Blakely 1977, Lovejoy et al. 1977, Chapman and Randsborg 1981, Howell 1982, Milner 1988, Conner 1990, Mensforth 1990, Storey 1992).

Archaeological Methods of Paleodemography

Archaeologist's growing interest in population studies led to the "crystallization of a demographic paradigm" (Hassan 1975:9). Leading archaeological scholars, circa the

mid-twentieth century, sought evidence to explain the human demographic explosion that seemed to go hand-in-hand with the human capacity to produce food (Childe 1936, Braidwood 1957, Sanders 1968, Dumond 1965, Sanders 1968, Braidwood 1983). Archaeological methods have been applied to prehistoric assemblages to derive information on demographic patterns (see Hassan 1975 and Zubrow 1976 for overviews) as “[i]mportant evidence that can be employed to calculate the absolute number of persons in a population may be drawn from the results of field observation and excavation” (Cook 1972:1). Cook defined this approach as the archaeological method. Sanders’ paleodemographic study of Teotihuacan was based upon artifact scatter in a settlement pattern analysis in order to estimate population densities (1965). Dumond’s *Prehistoric Population Growth in Eskimo Alaska* utilized cultural ecology models of settlement patterns based upon the number of sites (1972). Here Dumond pointed out that “the relatively higher visibility of later over earlier aboriginal occupation is familiar to archaeologists in many areas and may imply nothing regarding population density” (1972:322).

Food residue analysis was applied to studies of the Khorramabad Valley region of southwestern Iran by Hole et al. (1967). Subsistence analysis, based upon butchering techniques of bison bones in ratio to house numbers, was applied by White in South Dakota (1953), and habitation space was estimated by Kidder at the Grasshopper Pueblo (1976). Cook defined these approaches as ecological methods. All the above studies

demonstrate the import archaeologists attach to demographic studies (Spooner 1972, Zubrow 1976, and Hassan 1981).

Earlier skeletal studies, focusing upon demographic interpretation in an archaeological context, have been founded on proportional calculations utilizing ratios of skeletal remains to infer parameters of populations from Egypt (O'Connor 1972), California (Cook 1976) and relative populations based on cemetery density from Madisonville, Ohio (Hooton 1920), Lower Nubia (Trigger 1965), and at Pecos Pueblo (Kidder 1958). These are but a few examples of differing methods that have been used to extrapolate demographic data from archaeological assemblages. The significance of demographic research is thus underscored by widely diverse anthropological investigations. However, these early studies were not able to address more thoroughly the age structure, mortality, and fertility of the various samples investigated and could only roughly address population parameters "yield[ing] indirect evidence of total population size and hence allowing for speculation about rates of growth through time [but] adding little to our understanding of demographic processes" (Ward and Weiss 1976:5). That is not to suggest that these studies be "rejected out of hand" (Ibid.) as any correlation of archaeological population reconstruction with skeletal data would be potentially important corroborative evidence.

Typological Skeletal Studies

Craniometrics characterized physical anthropology in the early twentieth century. Skeletal biology was at this time in its nascent period and the typological approach to skeletal biology was reflective of the archaeological paradigm of the period. With the shift to New Archaeology, anthropologists expected to be able to use archaeological analyses for hypothesis testing of social import (Binford 1989). Binford, a seminal proponent of New Archaeology, called vital rates, the sex, age, status, and conditions at death of the individuals examined, *social personae* (Ibid.). Hooton's analysis of the skeletal series recovered at Pecos focused sharply upon cranial morphology but also applied Todd's pubic symphyseal age estimation method (1920, 1921). Hooton's application of Todd's age estimation methods in the Pecos Pueblo sample was confined to chronological differentiation of groups, mortality and population estimates (Hooton 1930).

Anthropological Demography

This use of simpler societies as mirrors for our modern complex ones is in the tradition of anthropology and seems to me inevitable (Kluckhohn '49) if we are to build up the thought-pictures necessary to understand demographic statistics today and not just let modern statistics breed more of the same meaninglessness. (Angel 1969)

Anthropological demography researches the characteristics of extant preindustrial populations to understand how the relationship of vital rates and reproductive methods may affect a society. Field studies, based upon ethnographic research and approached

from a demographic perspective, have offered insight as to whether or not a society attempted to consciously control population growth. Ethnographic methods accounting for infanticide and abortion, spacing of births due to prolonged lactation or nutrition or sexual abstinence, endogamy versus exogamy, and other patterns of reproductive control are factors directly influencing the character of a human population (see Handwerker 1986, for overview). These field studies have been applied, most extensively, to the !Kung peoples (Lee and DeVore 1972, Howell 1979, Pennington 1996), the Inuit (Steiger and Schrier 1974, Binford 1976), and Yanomamo (Neel and Chagnon 1968, Chagnon 1970) peoples who are considered to represent most closely the prehistoric cultures for which there is little or no ethnographic account.

Paleodemographers integrate this type of anthropological research with life table analyses to study how prehistoric populations may compare to modern ethnographic research (Howell 1979, Milner et al. 1990). In order to explain biological evolutionary changes in human populations, certain information must be methodologically ascertained: "(1) the age distribution of death, (2) the age distribution of fertility, (3) the size and density of a population, (4) the spatial distribution of subpopulations, (5) interaction between individuals within and between populations with respect to mating, (6) the regulation of population growth, and (7) the modification of natural selection by cultural evolution" (Ward and Weiss 1976:2). A common denominator of paleodemographic research then lies "in defining the course of human evolution" (Buikstra and Konigsberg 1985). This broad statement refers to the advance of human populations both

synchronously and diachronically. "To fully understand the evolution of our species we must understand how the demographic structure of hominid populations has changed through time, since the demographic structure provides the milieu within which agents of genetic change (selection, drift, migration and mutation) can operate." (Ward and Weiss 1976:2)

It can be pointed out that although, "we have a closer understanding of the action of demographic parameters than other natural populations...this opportunity is lessened by the fact that demographic processes that operated during the bulk of our species evolutionary history are not well understood—far less than the demographic processes in operation today, because they fall outside the purview of classical demography" (Ward and Weiss 1976:2). More recently, Storey suggested that "it is not at all certain that the potential errors [of paleodemographic methods] are really less critical in the demographic conclusions made on these anthropological populations" (1994:146). She cites three reasons why modern anthropological demography may not be any more accurate than skeletal paleodemography: (1) "In many of these living populations, people are not aware of their chronological age and the researcher must very often make estimates, even for children. In situations where people do have an idea of their age, how can the researcher be certain that individuals are not under or over-aging themselves?" (2) "living people do not necessarily remember, or tell the researcher, about all the children who have been born or do not necessarily recall the age at which they died" (Ibid.). Whether

contemporary demographic studies can be more accurate than paleodemographic studies then becomes an issue.

Demographic Life Table Analysis

Uniformitarian theory

The uniformitarian theory of natural processes, whether geological or biological, is founded upon theories that maintain that these processes have remained the same over the duration of time.

A uniformitarian position in paleodemography implies that the human animal has not basically changed in its direct biological response to the environmental in processes of ovulation, spermatogenesis, length of pregnancy, degree of helplessness of the young and rates of maturation and senility over time. (Howell 1976:26)

Howell limits uniformitarian assumptions in the developmental processes of *Homo sapiens sapiens* proper to some 40,000+ years. Simpson wrote that the ontology of the human life span has only changed in so far as medicine has alleviated disease. "All of the great strides of medicine do not seem to have raised the potential life span of man by one minute; they have only made it possible for more men to come nearer to realizing their potential spans without being cut off earlier by diseases or by avoidable rapid degeneration" (1949:71). Moreover, women's lives have evolved alongside their male counterparts, and are, in addition, the well spring of fertility. It is an estimation of fertility along with mortality that underlies the importance of paleodemographic analysis.

Stable population theory

A seminal study of contemporary paleodemography is based upon the assumption that the population under examination is stable or stationary (Acsádi and Nemeskéri 1970). Stationary populations demonstrate unchanging mortality and fertility rates and the birth and death rates are in equilibrium, so that no growth occurs (Weiss 1973). The stability of a population is difficult to estimate and is usually based upon the fact that preindustrial populations demonstrate little growth (Weiss 1973, Howell 1979). The criteria for stability in a population require that a population “forgets” the past so that only present conditions ultimately determine age structure. “Even if conditions are changing, there is still an aspect of “forgetfulness” in populations; any two populations, no matter how different to begin with will approach the same population structure if both are subjected to the same changing vital rates” (Weiss 1973:10).

Mortality or death rates are calculated based on the proportion of those living to those dead. Obviously, a skeletal series allows for no such comparison. This is where much of the reluctance to accept paleodemographic analysis may lie; however, the nature of prehistoric societies has been considered stable or at least stationary (Weiss 1973). Little or no migration, coupled with unchanging mortality and birth rates, leave the same population parameters over time.

Just how long must a stationary population remain stationary in order to calculate reliable lifetables? Johansson and Horowitz have suggested that “if a recovered skeletal population was deposited over a period greater than, for example 300 to 500 years, the

assumption of stationarity may be justified” (1986:237) as “short term populations become invisible in the long term” (Pennington 1996:261). When prehistoric populations are not considered subject to high rates of growth, paleodemographic analysis may be applied.

Life Tables

Life tables are employed to estimate the demographic structure of a population based upon how long an individual may be expected to survive from birth. A current life table “looks at a population at a given time, such as a year or five years, and records the mortality pattern seen for all ages; it does not follow the same cohort through time” (Storey 1992:138). Individuals recovered through archaeological investigation may have been interred over hundreds of years, and the life table extrapolates a general mortality pattern for the population under investigation. Life tables should be employed with caution, because we cannot know the chronological age of a population but only infer it from the biological age estimates.

Acsádi and Nemeskéri presented the first and most comprehensive use of life tables in their analysis of prehistoric European skeletal samples, *The History of Human Life Span and Human Mortality* (1970). This research presented demographic data based upon modern European samples as compared with prehistoric European samples to determine how mortality rates had changed through time. They were first to employ a multifactorial approach in age estimation. The average ages of the various skeletal

samples could then be utilized to calculate life tables. From this method, life tables “serve mainly for showing how many of those born reach their first, second, third, etc. birthday, and how many of those of a given age live to their next birthday. The fundamental data of the life tables determine the number (l_x) of survivors at given ages” (1970:28). Acsádi and Nemeskéri found that the human life span in the Paleolithic was a brutally short 20 years and that, with the advent of agriculture, human life span increased to between 30 and 40 years.

Model life tables

Weiss first developed model life tables based upon preindustrial anthropological populations in order to compare their demographic parameters (1973) with archaeological skeletal samples. Although Weiss’ tables are no longer utilized by anthropologists because “the data on which they are based are too flawed to yield useful models” (Storey 1994:3), Weiss’s efforts were responsible for the contemporary development of synthetic model life tables.

Mortality and fertility

The descriptive statistics of life tables analysis generate mortality rates, life expectancy rates, survivorship rates, and fertility rates as a residual of the estimation of mortality (Horowitz and Johansson 1992). Fertility rates must be determined first in order to calculate other rates in a population sample, and fertility cannot be quantified from the human skeleton--although some have tried (Angel 1969, Putschar 1976, Holt 1978,

Kelley 1979). Human females bear children after they have achieved sexual maturity and the reproductive capacity to bear children eventually ends with menopause, not with their lives. A limit of maximum childbirth can be estimated, but cultural constructs and environmental constraints are factors that determine how many children a woman can bring to term and raise successfully. To begin to understand prehistoric fertility regimes, ethnographic studies may be consulted and models constructed for comparative purposes.

Fertility has been assumed, in a biological sense, to be dependent on duration of lactation (Menken 1975). Prolonged lactation has been considered as a suppressant to ovulation. In hunting-gathering societies prolonged lactation is considered to have evolved because of the need for a mother to nurse for longer periods of time; whereas, in sedentary agricultural societies weanling gruel allowed for the relaxation of nursing and thus more closely spaced birth intervals and higher fertility. Frisch first proposed that body fat also was responsible for variation in birth rates (1973) as “low calorie intake relative to a high level of activity -- expressed, for example, as a low percentage of body fat (Frisch and McArthur 1974) -- may have an endocrinological effect which, among other things, diminished fertility by suppressing ovulation” (Harris and Roth 1987). Rather than accept one or the other of these hypotheses, “these two factors may be another example of a synergism, as described for nutrition and infection” (Caldwell and Caldwell 1987:181).

Combined with mortality and fertility, the balance of births and deaths delimits the rate of growth or lack thereof. Cultural adaptation, in any case, affects the fertility rate

in human societies. The Caldwells insist that much more anthropological field work, accomplished by anthropologists with demographic training, is necessary to dispel many of the myths circulating about fertility control in preindustrial populations (1987).

Alongside the uniformitarian assumptions of human longevity and fertility, models of extant hunter-gatherer societies may be constructed to estimate the population parameters of distinctive societies. Milner et al. (1989) applied models based upon two modern traditional societies to gain insight into the paleodemography of a late prehistoric Oneota skeletal sample from Midwest North America. Based upon !Kung hunter-gatherer and Yanomamo horticulturist fertility and mortality schedules, the Oneota sample showed a “close correspondence” with the Yanomamo age-at-death distributions and led them to hypothesize that these two societies compared favorably in their cultural makeup. Another aspect of the study and a more fundamental one, upheld Sattenspiel and Harpending’s theory “that fertility has more of an effect than mortality on the overall configuration of the age-at-death distributions of stable populations”(1989:49).

Most recently, survival in early childhood has demonstrated an important implication for demography. !Kung children, born into a hunter-gatherer subsistence regime, demonstrated reduced mortality when they were raised by neighboring Herero pastoralists (Pennington 1996). Pennington found that “small changes in early childhood mortality are enough to account for very large changes in population growth” (Ibid.:273).

The construction of life tables calculated to represent a sample with high infant under-enumeration was objected to by Weiss (1973). “He thought the publication of

obviously erroneous data would lead to several problems. This may be so; however, it is our position that the actual unsmoothed data deserve to be presented in the literature” (Moore et al. 1975:59). Moore et al. constructed “experimental life tables” where the “raw death counts” of the infant age interval were systematically varied. The study was based on one in which the problem of infant-underenumeration was assumed, “with 10 infants out of roughly 250 individuals, or about 4% of the total population. The infant raw count was increased in steps of 10 until the infants totaled 40% of the sample. This would represent 160 infant burials out of a total of 400. The raw counts in other age intervals were not changed. The former situation is analogous to one of infant burial exclusion” (Ibid.:59). “The greatest impact of enumeration errors exists in the survivorship values” and “(t)he probability of dying and the life expectancy show little change outside the infant bracket”; therefore, “[t]hese investigations are a strong indication that the effects of infant under-enumeration error are negligible outside the infant category, except for a very strong effect upon the survivorship curve” (Ibid.:60).

Birth rates and the mean age-at-death

Calculation of the birth rate as the inverse of the mean age-at-death in any given osteological sample was first proposed by Sattenspiel and Harpending (1983). This idea initiated a second major reassessment of paleodemographic methods (the first major reassessment occurred in the osteological aging methods as questioned by Boquet-Appel and Masset, see Chapter Three) by questioning assumptions of stable population theory

based upon the use of life tables which up until then had been generally accepted to calculate estimates of mortality (1983). Their work focused upon the difficult considerations of fertility rate estimation from life table calculations of mean age-at-death by demonstrating that what had been considered the mortality rate, or mean age-at-death, was really related to fertility. It was found that fertility rates, not an estimate of mortality, could be calculated as the inverse of mean age-at-death. This study challenged the utilization of mortality rates to calculate the average length of life (e^0). “[T]he crude birth rate, $1/e^0$ [expectancy of life at birth] has been used to show mortality trends through time (Sattenspeil and Harpending 1983). The high mortality level model life tables constructed by Coale and Demeny (1966) show that $1/e^0$ will provide an accurate crude birth rate only in populations that are either near zero growth rate or in decline. In populations with growth, $1/e^0$ will be higher than the birth rate” (Jackes 1992:214).

Sattenspeil and Harpending (1983) further demonstrated that when we discover more young individuals than older (in a prehistoric skeletal sample) this may not mean the young were dying at greater rates. They suggest that what is really happening is that there are just more young people available to die. Just the presence of a larger cohort of younger age classes may suggest an increase in fertility and the presence of a larger cohort of children reduces the calculation of the estimation of life expectancy even though there may be no decrease in life expectancy at all. Jackes advises that fertility rates “must not be misconstrued to suggest that sites should be compared by using life table fertility rates [because] infant under-representation and adult age estimation errors

inflate the age classes between 15 and 45 [and] result in erroneous fertility rates”(Jackes 1992:215). This very problem is confronted in Chapter 5.

Dependency ratios

Dependency ratios are also an important consideration in paleodemographic study. Children and elderly individuals have been considered dependent because they must rely on active adults for sustenance and care, although this may not prove true for all anthropological populations. It is the reproductive effort demanded for survival of the population by reproductively mature individuals that is of interest here. Mensforth writes that “[w]hen estimating the total number of subadults one would expect to find in a premodern non-technologically advanced small anthropological population, we generally expect subadults to comprise anywhere from 40-50% of all individual deaths. Thus, the life table descriptive statistic l^{15} (small case “L” and superscript 15), or survivorship at age 15, has intuitive meaning and inferential value. The fewer number of individuals that survive to adulthood, the greater the effort reproductive aged individuals must accomplish in order to replace themselves and their mates in succeeding generations” (Mensforth, personal communication, 1997). Howell identified dependent ages as under 15 and over 50 (1979). Howell’s consideration of dependency ratios resulted in illustrating that the Libben sample (Lovejoy et al. 1977) described “an extremely young population, in which many of the children would be orphans, in which the adults would have had to work hard

and effectively to support the group, and almost none of whom would have lived long enough to become grandparents (Howell 1979:262).

CHAPTER FIVE

RESULTS AND CONCLUSIONS OF OSTEOLOGICAL ANALYSIS

Limitations of Study

Taphonomic problems

Poorly preserved bone is difficult or impossible to assess for age; therefore, the survival rate of osteological elements has direct implications for the usefulness of any method. Adult age estimation based upon the pubic symphysis and the sternal rib end may be restrictive due to the fragile nature of the bone. The auricular surface of the ilium, on the other hand, is buttressed by the thick plate of the posterior ilium. Because of this robust nature and the fact that the auricular surface is less exposed, it may be considered to better withstand taphonomic conditions. In Pfeiffer's sample of over 400 adult skeletons from the Kleinberg Ossuary, only 12.5% could be aged by the pubic symphyseal method (Jackes 1992). CA-SCI-38 has 128 of a possible 183 adult pubic bones, or a 70% survival rate for the pubic bone. CA-SCI-38 yielded 138 utilizable auriculars of 183 adult individuals, or a 75% survival rate. The sternal rib end is less well represented than either of the pelvic sites. In CA-SCI-38 only 84 sternal rib ends were available, or 45%. The auricular surface of the ilium is the most well-preserved age indicator implemented in this analysis, but only exceeds the pubic symphysis by 5%. The preservation of the more fragile pubic bone, with cortical bone preserved for age estimation, further underscores the excellent preservation and archaeological recovery methods at CA-SCI-38.

The final ages were calculated by adding the three separately determined age estimates (the rib, auricular, and composite age) and dividing. In cases where there are only two indicators available, the means was calculated in the same way. If there was only one indicator available, this age estimate was used.

Statistical Analyses of Age Indicators

To compare the ages achieved for adult females and adult males a two sample t-test was run in the SYSTAT program.

Table 5.1: There is significant difference found between female age and male age estimates ($p = .00025$). The mean estimated female age is 5.88687 years higher than the mean estimated male age.

The descriptive statistics for Female Age versus Male Age					
	Female		Male		
N	64		100		
Minimum	16		16		
Maximum	60		50		
Range	44		34		
Median	40.5		31.5		
Mean	37.296		31.4		
Std. Error	1.463		0.841		
Std. Dev.	11.71		8.411		
Variance	137.132		70.749		
Two-sample t-test on AGE grouped by SEX					
Group	N		MEAN		SD
F	64		37.2968		11.71037
M	100		31.41		8.41127
Separate Variance t = 3.48697	DF = 104.2		P = 0.0072		
Difference in Means = 5.88687	95% Confidence Interval = 2.53910 - 9.43265				
Pooled Variance t = 3.74234	DF = 162		p = 0.00025		
Dif. in Means = 5.8868	95% Confidence Interval = 2.78055 - 8.99320				

Next, 3 paired t-tests were run to determine if there was significant difference in the estimates of adult age for each respective indicator between two indicators.

Table 5.2: There is no significant difference between the age estimates as achieved by the sternal rib end and the composite age, $p(0.05) = 0.327$.

The descriptive statistics for Sternal Rib Age estimates versus Composite Age					
		Rib age		Composite age	
N		85		85	
Minimum		14		17	
Maximum		60		55	
Range		46		38	
Median		32		35	
Mean		33.09142		34.76417	
Std. Error		1.195		1.04	
Std Dev		11.02446		9.59371	
Variance		121.5387		92.03922	
Two-sample t-test on Age grouped by Rib age versus Composite age					
Group	N		Mean		SD
composite age	85		34.76471		9.59371
rib age	85		33.20238		11.04512
Separate Variance t = 0.98123			DF = 163	P = 0.32793	
Difference in Means = 1.56232			95% CI - -*1.58166 - 4.71631		
Pooled Variance t = 0.98205			DF = 167		p = 0.32750
Difference in Means = 1.56232			95% CI = -1.57851 - 4.70316		

Table 5.3: There is a significant difference between the ages achieved by the Auricular Surface Age and Composite Age, $p(0.05) = 0.00037$.

Auricular Age estimates versus Composite Age					
to the Composite Age estimates					
	Auricular age		Composite age		
<i>N</i>	138		138		
Minimum	18		16		
Maximum	60		58		
Range	42		42		
Median	37		35.5		
Mean	36.15942		34.97826		
Std. Error	0.8263		0.8679		
Std. Dev..	9.70683		10.19551		
Variance	94.22257		103.9484		
Two-sample t-test on Age grouped by Auricular and Composite age					
Group	<i>N</i>		Mean		SD
Composite	138		34.978		10.19551
Auricular	138		36.159		9.73683
Mean dif. = -1.18116	DF = 137	95%CI = -1.82084 to - 0.54147			
SD dif. = 3.80018	t = -3.65127			$p = 0.00037$	

As reported here, the only significant difference between age estimators was found for the auricular surface of the ilium age and composite age. The mean auricular age estimate is 1.5 years greater than the mean composite age estimates. The auricular surface age estimates may also be compared with the sternal rib end age estimates as reported in Table 5.4 on page 86.

Table 5.4: There is no significant difference between the ages estimates for the sternal rib end and the ages estimated for the auricular surface of the ilium.

The Auricular Age estimates versus Sternal Rib End estimates				
	Rib		Auricular	
<i>N</i>	77		77	
Minimum	14		18	
Maximum	60		55	
Range	46		37	
Median	32		37	
Mean	33.62238		36.01299	
Std. Error	1.121852		1.09127	
Std. DEV.	10.9557		9.57587	
Variance	120.0273		91.6972	
Two-sample t-test on Age grouped by RIB and Auricular age				
Group	<i>N</i>		Mean	SD
Auricular	77		36.01299	9.57587
Rib	77		33.62338	10.9557
Separate variance $t = 1.44108$			DF = 149.3	$p = 0.15166$
Mean difference = 2.38961	2.38961			
Pooled Variance $t = 1.44108$	DF = 152			0.15162
Mean difference = 2.38961			95% C I = -0.88651 - 5.66573	

There were 77 individuals with all three age indicators available: the pubic bone, representing composite age, the auricular surface of the ilium, and the sternal rib end. To determine how these methods compared, all data was entered into a SYSTAT file which encompassed individual age estimates for these 77 individuals with all three indicators. The average age of all three age estimates was compared using SYSTAT's ANOVA program. The ANOVA table is reprinted in Table 5.5 on page 87.

Table 5.5: There is no statistical difference between the ages achieved utilizing the three age indicators ($p = 0.23204$).

Analysis of Variance for Three Indicators							
Source		Sum of Squares	DF	Mean-Square	F-Ratio	P	
Var (3)		303.1255	2	151.5628	1.47024	0.23204	
Error		23503.87		228	103.0872		
Least squares means		LS means		SE		N	
VAR = auricular		36.12988		1.15706		77	
VAR = composite		34.97403		1.15706		77	
VAR = rib		33.33766		1.15706		77	
Using model MSE of 103.087 with 228 DF, a Matrix of pairwise mean diffs.							
		1	2	3			
1		0					
2		-1.15584	0				
3		-2.79221	-1.63636	0		$P= 0.2320$	

Because the sternal rib end method is sex-specific, two t-tests were run for each sample grouped by sex for rib age and composite age as reported in Table 5.6 on page 88.

Table 5.6: The hypothesis for the t-test is: The female rib age is not significantly different from the composite age. The hypothesis is accepted for $p(0.775) > 0.05$. There is a no significant difference between female rib age and female composite age. When the male rib age was compared to the composite age, no significant difference between the age estimates was found for $p(0.217) > 0.05$.

Descriptive statistics for total observations, 28 female ribs					
		ribage		composite age	
<i>N</i> of cases	28			28	
Minimum	14			18	
Maximum	55			58	
Range	44			37	
Mean	34.786			34.25	
Variance	169.138			115.824	
<i>SD</i>	13.005			10.762	
Descriptive statistics for total observations, 55 male ribs					
		ribage		composite age	
<i>N</i> of cases	55			55	
Minimum	17			17	
Maximum	60			45	
Range	43			28	
Mean	31.109			30	
Variance	88.803			63.185	
<i>SD</i>	9.424			7.749	

Distribution of Individuals by Age and Sex

Of 252 individuals recovered from CA-SCI-38, 231 were able to be aged with enough accuracy to be applied to life table analysis for dependency ratios and total sample size. Only 211 individuals were both aged and sexed accurately enough for life table analysis to assess mortality and fertility ratios. There were 64 adult individuals assigned to the female category and 100 adult individuals assigned to the male category.

There were 47 subadult individuals. For these 47 subadults no attempt was made to determine sex. There were 20 indeterminately sexed adult individuals able to be aged and applied to life table analysis. There were 21 indeterminate adult individuals placed into the adult categories of 16+, 17+, 18+, 25+, and 35+ for a total of 41 indeterminate adults ($n = 252$) which were not utilized for life table analysis as age could not be estimated more precisely than adult. Three individuals (of these 21 individuals) were of indeterminate age and sex. The following tables and charts presented here are based upon the dx coefficients as reported in Table 5.1. Dx is the distribution of individuals in age class x (i.e., 20 - 25, 30 - 35 etc.).

Table 5.7: The number of individuals for subadults (jdx), adult males (mdx) and females (fdx), and indeterminately sexed individuals (idx) at CA-SCI-38 ($n = 252$).

x	jdx	fdx	mdx	idx	$iidx$
0	11				16+etc
1	2				
2	1				
3	4				
4	3				
5	4				
10	12				
15	10				
20		7	13	9	
25		8	15	4	
30		4	15	1	
35		5	24	2	
40		5	18	1	
45		15	11	3	
50		14	4		
55		3			
60		3			
	47	64	100	20	21

Figure 5.1: The distribution of all individuals assessed for age at CA-SCI-38. This distribution is based upon the dx coefficients reported in Table 5.7. There are 47 subadults (jdx), 64 females (fdx), 100 males (mdx), and 20 indeterminately sexed but aged individuals (idx) [$n = 231$]. There are 21 indeterminate adult individuals ($iidx$) not assigned to specific age intervals [$n = 252$]. These 21 indeterminate adults are not included in Figures 5.1 and 5.2.

Figure 5.2: CA-SCI-38 age distributions when including subadults and adults both aged and sexed ($n = 211$, female $n = 64$, male $n = 100$, subadult $n = 47$).

Calculation of Life Tables

All data were recorded utilizing the EXCEL spreadsheet program. All graphs and tables were also created with EXCEL. Mensforth has described each category of the life table in *Demostat Software Package: Demographic Methods for the Anthropologists* (1988). These methods are described in detail by Weiss (1973), based upon demographic calculations developed by Lotka (1956), Coale (1972), Keyfitz 1968), and Shyrock and

Seigel (1971). The *Demostat Software Package* facilitates the computation of life tables, simulating different estimates of growth rate in a skeletal series with the option of smoothing the ages. Life tables were calculated with a hand calculator and with Mensforth's DEMOSTAT. The DEMOSTAT program allowed for precision in the computation of life tables for CA-SCI-38 and is reprinted in APPENDIX D.

Table 5.8: This synthetic abridged life table reports the ages for all individuals both aged and sexed, in the CA-SCI-38 sample plus 20 indeterminately sexed adults ($n = 231$).

x	dx	l'_x	l_x	L_x	T_x	E_x	Q_x	C_x	L'_x	K_x	ML'_x	FB_x	$FB_x \cdot t$	$FB_x \cdot C_x$	$FB_x \cdot L'_x$
0	11	231	1000	976	31617	31.6	0.048	0.031	0.976						*mn
1	2	220	952	948	30641	32.2	0.009	0.030	0.948						
2	1	218	944	942	29693	31.5	0.005	0.030	0.942						
3	4	217	939	931	28751	30.6	0.018	0.029	0.931						
4	3	213	922	916	27820	30.2	0.014	0.029	0.916						
5	4	210	909	4502	26905	29.6	0.019	0.142	4.502						
10	12	206	892	4329	22403	25.1	0.058	0.137	4.329						
15	10	194	840	4091	18074	21.5	0.052	0.129	4.091	0.642	2.626	0.031	0.156	0.004	2.237
20	29	184	797	3669	13983	17.6	0.158	0.116	3.669	1.739	6.380	0.085	0.423	0.010	6.987
25	27	155	671	3063	10314	15.4	0.174	0.097	3.063	1.741	5.332	0.085	0.424	0.008	7.137
30	20	128	554	2554	7251	13.1	0.156	0.081	2.554	1.410	3.601	0.069	0.343	0.006	5.696
35	31	108	468	2002	4697	10	0.287	0.063	2.002	0.981	1.964	0.048	0.239	0.003	3.585
40	24	77	333	1407	2695	8.1	0.312	0.044	1.407	0.407	0.573	0.020	0.099	0.001	1.184
45	29	53	229	833	1288	5.6	0.547	0.026	0.083						
50	18	24	104	325	455	4.4	0.75	0.010	0.0325						
55	3	6	26	97	130	5.0	0.500	0.003	0.097						
60	3	3	13	32	32	2.5	1.000	0.001	0.032						
	231			31617							20.547		1.704	0.03	26.99
										B		GRR	CBR	T	

As discussed in previous chapters, the data computed rely on the assumption of stationarity. The assumption of stationarity at CA-SCI-38 is based upon Suchey's non-metric evidence for no apparent significant migration in the Central California region (1979), and the more general assumption that prehistoric populations displayed minimal

growth (as addressed in previous chapters). All life tables computed in this study are based on a growth rate of zero (0), the stationary rate.

For CA-SCI-38 (when $n = 231$), the gross reproductive rate (GRR) is 1.70. The crude birth rate (CBR) is 31.6 (per 1,000 per year). Mean family size (MFS) is 2.38 and total completed family size ($TCFS$) is 3.41. Life expectancy at birth (E^0) is 31.6, and for individuals reaching age 15 (E^{15}) is 21.5. The percentage of individuals under age 15 is 16.0. The percentage of individuals 15 - 50 is 73.6. The percentage over 50 is 10.4. The mean age is 31.6. The dependency ratio is 0.36.

Table 5.9: Life table results of actual ages estimated for all subadults and adult individuals also able to be sexed, $n = 211$.

x	dx	l'_x	l_x	L_x	T_x	E_x	Q_x	C_x	L'_x	K_x	ML'_x	FB_x	$FB_x \cdot f$	$FB_x \cdot C_x$	$FB_x \cdot L'_x$
0	11	221	1000	974	31746	31.7	0.052	0.031	0.974						*mn
1	2	200	948	943	30773	32.5	0.010	0.030	0.943						
2	1	198	938	936	29829	31.8	0.005	0.029	0.936						
3	4	197	934	924	28893	30.9	0.020	0.029	0.924						
4	3	193	915	908	27969	30.6	0.016	0.029	0.908						
5	4	190	900	4455	27062	30.1	0.021	0.140	4.455						
10	12	186	882	4265	22607	25.6	0.065	0.134	4.265						
15	10	174	825	4005	18341	22.2	0.057	0.126	4.005	0.642	2.257	0.031	0.154	0.004	2.162
20	20	164	777	3649	14336	18.4	0.122	0.115	3.649	1.739	6.346	0.084	0.418	0.010	6.862
25	23	144	682	3140	10687	15.7	0.160	0.099	3.140	1.741	5.466	0.084	0.418	0.008	7.224
30	19	121	573	2642	7547	13.2	0.157	0.083	2.642	1.410	3.725	0.068	0.339	0.006	5.818
35	29	102	483	2073	4905	10.1	0.284	0.065	2.173	0.981	2.034	0.047	0.236	0.003	3.665
40	23	73	346	1457	2832	8.2	0.315	0.046	1.457	0.407	0.593	0.02	0.098	0.001	1.211
45	26	50	237	877	1374	5.8	0.520	0.028	0.877	0.084	0.074	0.004	0.02	0.000	0.168
50	18	24	114	355	498	4.4	0.750	0.011	0.355						
55	3	6	28	107	142	5.0	0.500	0.003	0.107						
60	3	3	14	36	36	2.5	1.000	0.001	0.036						
	211			31746							20.81		1.683	0.031	27.11
										B		GRR	CBR	T	

When considering only individuals, both aged and in the adult case also sexed ($n = 211$), as compared with the sample when $n = 231$ the difference in derived rates is

minimal: the E^0 is 31.7, and E^{15} is 22.2, Mean Family Size is 2.43, and Total Completed Family Size increased to 3.37 with a DR of 0.41. Because of these minimal differences, the life table, as reported in Table 5.10, will continue to be utilized for graphic illustration. The individuals reported in this life table have been both aged and sexed, allowing for comparison with other sites presented here. The minimal differences reported for the life tables, whether all individuals are included (raw data $n = 231$) or only those both aged and sexed ($n = 211$) are illustrated in the following graphs (Figures 5.3, 5.4, and 5.5).

Figure 5.3: CA-SCI-38 Survivorship Curve comparing the life table (Table 5.8) including subadults and indeterminate adults ($lx\ n = 231$) with life table calculations (Table 5.9) where only subadults and adults both aged and sexed ($lx\ n = 211$) are included. Lx is the number of survivors to age x out of a radix of 1,000.

Figure 5.4: Mortality Curve comparing life table, Table 5.8, including subadults and indeterminate adults ($Q_x n = 231$) to life table calculations (Table 5.9) where only subadults and adults both aged and sexed ($Q_x n = 211$) are included. Q_x is the probability of dying for those reaching age class x .

The mortality curves as compared in Figure 5.4 demonstrate a similar curve whether the data includes indeterminately sexed adults or not.

Figure 5.5: Ex is life expectancy at age x . These Life Expectancy Curves for CA-SCI-38 compare two different data sets: $Ex\ n = 211$ includes only subadults and adults both aged and sexed, $Ex\ n = 231$ includes 21 indeterminately sexed adults.

Subadult Recovery Problems

As the loss of subadults was the most difficult problem in the sample, it is addressed first. Subadults are particularly under-represented at this site. Individuals are considered dependent, as children and elderly people rely on active adults for sustenance and care. Individuals between the ages of 15 and 50 are the producers upon whom the elderly and children are dependent. The idea that older individuals are totally dependent upon the middle-aged adults may be questioned; however, this thesis will subscribe to Weiss' s definition for dependency. Dependency ratios more importantly address the capacity for a sample population to reproduce itself. As previously stated, Weiss

identified dependency ages as under 15 and over 50 (1973). Howell identified dependent ages as under 15 and over 60 (1979). The life table analysis of CA-SCI-38 is based upon the Weiss model, especially as there are no individuals aged over 60 years at this site. Mensforth has suggested that an expected dependency ratio for a small preindustrial population should be at least 0.50 (Mensforth, personal communication, 1997).

In order to consider how an additional hypothetical number of subadults affect the dependency ratio, a life table was computed by adding 52 hypothetical subadults to the sample. Twenty-two (22) individuals were added to age class 0 (neonates) and 30 individuals were added to age class 1 (one year olds). For CA-SCI-38 there are 47 subadults and 164 sexed adults ($n = 211$) yielding a *DR* of 0.41. The 52+ subadult model ($n = 263$) produces a *DR* of 0.74, a figure “most demographers would accept as being a more probable condition for pre-modern small anthropological populations” (Ibid.). To see how this applies to other rates in the life table analysis, a hypothetical life table is presented including the “missing” hypothetical subadults (see Moore, et al. 1975:59 for discussion). The αx values for the 52+ subadult hypothetical model are presented on the following page in Table 5.10.

Table 5.10: The distribution of individuals at CA-SCI-38 including 52 hypothetical subadults ($n = 263$). Dx Values Utilized for the CA-SCI-38 52+ Hypothetical Model

x	$j \ dx$	$f \ dx$	$m \ dx$
0	33		
1	36		
2	1		
3	5		
4	3		
5	2		
6.0-10	10		
11.0-15	9		
16-20		7	13
21-25		8	15
26-30		4	15
31-35		5	24
36-40		5	18
41-45		15	11
46-50		14	4
51-55		3	
56-60		3	
60-65	99	64	100
	263		

Table 5.11: The abridged life table for CA-SCI-38 based upon the hypothetical addition of 52 subadults ($n = 263$).

x	dx	l'_x	l_x	L_x	T_x	E_x	Q_x	C_x	L'_x	K_x	ML'_x	FB_x	$FB_x \cdot 5$	$FB_x \cdot C_x$	$FB_x \cdot L'_x$
0	33	263	1000	937	25196	25.2	0.125	0.037	0.937						*mn
1	36	230	875	806	24259	27.7	0.157	0.032	0.806						
2	1	194	738	736	23452	31.8	0.005	0.029	0.736						
3	5	193	734	724	22717	31.0	0.026	0.029	0.736						
4	3	188	715	709	21992	30.8	0.016	0.028	0.734						
5	2	185	703	3498	21283	30.3	0.011	0.139	0.709						
10	10	183	696	3384	17785	25.6	0.055	0.134	3.498						
15	9	173	658	3203	14401	21.9	0.052	0.127	3.384	0.642	2.057	0.039	0.196	0.005	2.193
20	21	164	624	2918	11198	18.0	0.128	0.116	2.918	1.739	5.075	0.106	0.530	0.012	6.957
25	26	143	544	2471	8279	15.2	0.182	0.098	2.417	1.741	4.303	0.106	0.530	0.01	7.209
30	18	117	554	2053	5808	13.1	0.154	0.081	2.053	1.410	2.895	0.086	0.43	0.007	5.733
35	29	99	376	1606	3755	10.0	0.293	0.064	1.606	0.981	1.576	0.06	0.299	0.004	3.601
40	23	70	266	1112	2148	8.1	0.329	0.044	1.112	0.407	0.453	0.025	0.124	0.001	1.172
45	25	47	179	656	1036	5.8	0.532	0.026	0.656						
50	16	22	84	266	380	4.5	0.727	0.011	0.266						
55	3	6	23	86	114	5.0	0.500	0.003	0.086						
60	3	3	11	29	29	2.5	1.000	0.001	0.029						
	263										16.413		2.134	0.04	27.02
											$\bar{B}$		GRR	CBR	T

Figure 5.6: The Survivorship Curve is strongly affected by the inclusion of 52+ hypothetical subadults ($lx n = 52+$ or 263) when compared with the actual distribution of CA-SCI-38 ($lx n = 211$).

Figure 5.7: The Mortality Curves for CA-SCI-38 comparing individuals both aged and sexed ($Q_x n = 211$), and the hypothetical 52+ subadult model ($Q_x n = 263$).

As reported by Moore et al. (1976:60), there is little change in the mortality curves with the inclusion of hypothetical subadults except as seen for the survivorship curve (lx , Figure 5.6). However, based on the hypothetical model life table from Table 5.11, the dependency (DR) ratio for CA-SCI-38 is now 0.74, a more acceptable figure for this pre-modern series. With this in mind, it is possible to also see how the addition of subadults has changed other *derived rates*. The Crude Birth Rate is 39.7 in the hypothetical model and 30.9 when applying actual data. The Gross Reproductive Rate is now 2.13. The Mean Family Size is 3.04. The Total Completed Family Size of 4.27 is almost 1.00 higher than the non-transformed data which yielded a $TCFS$ of 3.37. The Crude Death Rate is 39.7 in the hypothetical model compared to 31.5 in actual data ($n =$

211). E^0 is 25.2 in the hypothetical model, compared with 32.3 when applying actual data. The expectation of life at birth is eight years lower in the hypothetical model, reflecting how fertility rates affect mortality rates in demographic analysis.

E^{15} is now 21.9 in the 52+ hypothetical model. The fertility rate is increased and the mortality rate decreased when applying the hypothetical model of 52 additional subadults. Therefore, even though the mortality and life expectancy curves report little differences (in the sample of actual data [$n = 211$] versus the 52+ subadults model [$n = 263$]); the derived rates reflect quite different mortality and life expectancy rates.

Figure 5.8: This graph shows that the Life Expectancy Curves for CA-SCI-38 including individuals both aged and sexed ($Ex\ n = 211$) and the hypothetical model with 52 + subadults ($Ex\ n = 263$) differ only in the subadult category. All other age intervals report a very similar curve for life expectancy (ex).

Intersite Comparison of the Dependency Ratio

Intersite comparison of the dependency ratios from regional sites is presented below including data from seven regional sites for the southern San Francisco Bay area for comparison with CA-SCI-38.

Table 5.12: This table reports the Dependency Ratios of neighboring sites from the Guadalupe Corridor (Jurmain 1993). CA-SCI-38* is the *DR* when actual data when $n = 211$. CA-SCI-38** is the *DR* for transformed data including the 52+ hypothetical subadults ($n = 263$).

Site	<i>DR</i>	<i>n</i>
CA-SCI-68	0.75	14
CA-SCI-137	0.82	69
CA-SCI-690	1.08	52
CA-SCI-6W	0.94	93
CA-Ala-329	1.17	167
CA-Ala-342	1.75	41
CA-Ala-343	0.64	41
CA-SCI-38*	0.41	211
CA-SCI-38**	0.76	263

The above table (Table 5.12) of intersite comparison for dependency ratio further illustrates the under-representation of subadult burials at CA-SCI-38. CA-SCI-38 has the lowest dependency ratio of seven regional sites reported by Jurmain (1993:82). The last two entries in Table 5.12 for the CA-SCI-38 *DR* are results of this present research.

Angel concluded that in life table analysis, infant under-enumeration results in errors in other life table values (1969). Weiss also objected to the presentation of life tables where the chance of infant under-enumeration is high (1973). Moore et al. have pointed this out and concluded that "it is our position that the actual unsmoothed data need to be presented in the literature, and that methods of presentation are available that

compensate for many of the recognized deficiencies of the data” (Moore et al. 1976:59). It has been demonstrated here that the inclusion of 52 hypothetical subadults into the sample does not significantly distort the life table ratios, excepting the survivorship curve. As discussed above, it is the derived rates that differ when the hypothetical model is employed, even though the mortality and life expectancy curves remain similar.

Modeling Life Tables

CA-Ala-329

CA-Ala-329 is a mortuary complex located 13 miles from CA-SCI-38 that has undergone extensive analysis (Coberly 1973, Bizjak and Repke 1986, Gillett 1987, Jurmain 1990 and 1991, Leventhal 1993, Wilson 1993, and others). The descriptive paleodemographic statistics have been reported (Gillett 1987) and are utilized here for comparative purposes.

Both CA-SCI-38 and CA-Ala-329 may be considered to be “sister sites.” Both are mortuary sites and earth mounds demonstrating contemporary temporal components. The site formation and cultural processes that created these two sites as burial sites are very similar in that they are not formed as a residue of villages (although, in CA-Ala-329 this is subject to debate; see Leventhal 1993). There are different sampling considerations for CA-SCI-38 and CA-Ala-329. At CA-SCI-38 there is almost complete recovery within what is considered to be the heart of the mound. At CA-Ala-329 there is only a sample of the mound. Archaeological studies are limited by sampling strategies and interpretive statements can only be made to a limited degree. Accepting these conditions, this thesis

follows the assumption that the majority of the burials derived from CA-Ala-329 and CA-SCI-38 demonstrate Late Period components and are thus amenable to comparison. For this reason, the life table analysis for CA-Ala-329 has been included in this study for further comparison with CA-SCI-38.

The ages are originally reported in a smoothed life table for CA-Ala-329 (Gillett 1987) with no age table presented. The methods for computing life tables for CA-Ala-329 were not reported by Gillett. Therefore the CA-Ala-329 master list of the burial inventory report (archived at the San Jose State University Anthropology Laboratory) was re-tabulated to compute the age distributions (Δx) so a life table could be computed to present the data in graphical form. In order to compare the age distributions between sites, the data must be entered in consistent format. The total Δx for the results of Gillett's research are presented (Table 5.13). Only individuals that could be assigned an age and sex were included in this life table analysis.

Table 5.13: Age distribution from CA-Ala-329 based on Gillett's pubic symphysis age data ($n = 298$).

x	jdx	fdx	mdx
0	34		
1	18		
2	15		
3	0		
4	2		
5	3		
10	10		
15	2		
20		5	12
25		10	14
30		5	14
35		4	4
40		16	26
45		3	7
50		26	0
55		26	9
60		5	0
65		12	4
70			
75			

Table 5.14: CA-Ala-329 abridged life table ($n = 298$) based upon the mean of the age ranges assessed by the Suchey-Brooks pubic symphyseal method reported in Table 5.13 (after Gillett 1987).

x	dx	l'_x	l_x	L_x	T_x	E_x	Q_{x329}	C_x	L'_x	K_x	ML'_x	FB_x	FB_x^5	$FB_x \cdot C_x$	$FB_x \cdot L'_x$
0	34	298	1000	943	31789	31.8	0.114	0.030	0.943						*mn
1	18	264	886	856	30846	34.8	0.068	0.027	0.856						
2	15	246	826	1601	29990	36.3	0.061	0.050	0.800						
3	0	231	775	772	29190	37.7	0.000	0.024	0.775						
4	2	231	775	772	28414	36.7	0.009	0.024	0.772						
5	3	229	768	3817	27643	36.0	0.013	0.120	3.817						
10	10	226	758	3708	23826	31.4	0.044	0.117	3.708						
15	14	216	725	3507	20117	27.8	0.065	0.110	3.507	0.642	2.251	0.033	0.163	0.004	2.000
20	17	202	678	3247	16611	24.5	0.084	0.102	3.247	1.739	5.646	0.088	0.441	0.009	6.448
25	24	185	621	2903	13364	21.5	0.130	0.091	2.903	1.741	5.054	0.088	0.442	0.008	7.054
30	19	161	540	2542	10461	19.4	0.118	0.080	2.542	1.410	3.584	0.072	0.358	0.006	5.913
35	8	142	477	2315	7919	16.6	0.056	0.073	2.315	0.981	2.271	0.050	0.249	0.004	4.324
40	42	134	450	1896	5604	12.5	0.313	0.060	1.896	0.407	0.772	0.021	0.103	0.001	1.665
45	10	92	309	1460	3708	12.0	0.109	0.046	1.460	0.084	0.123	0.004	0.021	0	0.296
50	26	82	275	1158	2248	8.2	0.317	0.036	1.158						
55	35	56	188	646	1091	5.8	0.625	0.020	0.646						
60	5	21	70	310	445	6.3	0.238	0.010	0.310						
65	16	16	54	134	134	2.5	1.000	0.004	0.134						
	298										19.701		1.778	0.031	27.7
											B		GRR	CBR	T

Figure 5.9: Actual age distribution (dx) of all aged and sexed adult individuals at CA-Ala-329 based on Gillett's record for pubic symphysis age estimation ($n = 298$). The age distributions are based on data from Table 5.13.

Figure 5.10: Age distribution of CA-Ala-329 ($n = 298$) as compared to CA-SCI-38 ($n = 211$), including subadults (jdx), male adults (mdx), and female adults (fdx).

Figure 5.11: The comparison of total age distributions for all individuals is based on Gillett (1987) for CA-Ala-329 subadults (*jdx329*), males (*mdx329*), CA-Ala-329 females (*fdx329*). CA-SCI-38 subadults (*jdx38*), males (*mdx38*), and females (*fdx38*) are based upon the age estimation as determined in this.

Figure 5.12: Another view of the distribution of individuals at both CA-Ala-329 (when $n = 298$) and CA-SCI-38 (when $n = 211$), including subadults (jdx), male adults (mdx), and female adults (fdx).

In Figures 5.10 and 5.12 the under-representation of subadults in CA-SCI-38 is apparent as compared with CA-Ala-329, especially for infant mortality. Also there are more older adults at CA-Ala-329 as compared to the study group, CA-SCI-38. This may be explained by a large number of individuals at CA-Ala-329 being assigned to age classes with wide age ranges (i.e., $dx_{40} = 42$, $dx_{45} = 10$, $dx_{60} = 5$, $dx_{65} = 16$; see Table 5.13). The female adult sample for CA-Ala-329 shows that 46.4% of all females were estimated to be between 50 and 55. Accordingly, at CA-SCI-38 23.5% of all adult

females were estimated to be between 50 and 55. For CA-SCI-38 there are 21.9 females aged 45 and at CA-Ala-329 there are only 2.7 females aged 45. The differential reporting of older females is most likely associated with the different methods of age estimation applied to the different samples. The benefit of a method utilizing age intervals (i.e., the sternal rib end of the auricular surface) is that there is less clumping of ages into broad age ranges.

The sternal rib end method and the auricular age estimation methods have been reported as better able to address age estimation in older adult individuals; however, this research does not indicate older adults in the CA-SCI-38 sample. In fact, no individuals in the sample were aged over 60 years. There were no individuals aged over 63 in the CA-Ala-329 sample. For both CA-SCI-38 and CA-Ala-329 life expectancy does not exceed ~60 years.

Expectation of life at birth in CA-Ala-329 (E^0) is 31.8 and 31.7 for CA-SCI-38. Expectation of life at age 15 (E^{15}) at CA-Ala-329 is 27.8, and at CA-SCI-38 E^{15} is 22.2. The proportion of individuals under age 15 at CA-Ala-329 is 27.5, and for CA-SCI-38, 17.5. The proportion of individuals from 15-50 is 45.0 at CA-Ala-329, and for CA-SCI-38, 71.1. The proportion of individuals over 50 at CA-Ala-329 is 27.5, and for CA-SCI-38 it is 11.4. CA-Ala-329 has an acceptable *DR* (1.22) as compared with CA-SCI-38 (0.41) which required an adjustment in the total subadult sample to approach an acceptable *DR* (acceptable meaning a population that would live to reproduce itself). The *CBR* for CA-Ala-329 is 31.4, the *MFS* is 2.76, and the *TCFS* is 3.56. CA-Ala-329 also

has a more unbiased distribution of adult males to adult females than is found at CA-SCI-38.

Adult sex bias

Under-representation of subadults is not the only problem concerning biased samples for the CA-SCI-38 materials. The ratio of adult females to adult males also suggests differential burial recovery. Table 5.15 reports female and male age distributions for both CA-SCI-38 and CA-Ala-329.

Table 5.15: Adult male and female age distributions for CA-SCI-38 and CA-Ala-329.

CA-SCI-38 adult male and female age distribution								
<i>x</i>	<i>mdx</i>	<i>m%</i>	<i>mlx</i>	<i>fdx</i>	<i>f%</i>	<i>flx</i>	<i>sex ratio</i>	
20	13	13	100	7	10.9	100	1.9	
25	15	15	87	8	12.5	89.1	1.9	
30	15	15	72	4	6.3	76.6	3.8	
35	24	24	57	5	7.8	70.3	4.8	
40	18	18	33	5	7.8	62.5	3.6	
45	11	11	15	15	23.4	54.7	0.7	
50	4	4	4	14	21.9	31.3	0.3	
55	0	0	0	3	4.7	9.4	0	
60	0	0	0	3	4.7	4.7	0	
CA-Ala-329 adult male and female age distribution								
<i>x</i>	<i>mdx</i>	<i>m%</i>	<i>mlx</i>	<i>fdx</i>	<i>f%</i>	<i>flx</i>	<i>sex ratio</i>	
20	12	13.3	100	5	4.5	100	2.4	
25	14	15.6	86.7	10	8.9	95.5	1.4	
30	14	15.6	71.1	5	4.5	86.6	2.8	
35	4	4.4	55.6	4	3.6	82.1	1	
40	26	28.9	51.1	16	14.3	78.6	1.6	
45	7	7.8	22.2	3	2.7	64.3	2.3	
50	0	0	14.4	26	23.2	61.6	0	
55	9	10	14.4	26	23.2	38.4	0.4	
60	0	0	4.4	5	4.5	15.2	0	
65	4	4.4	4.4	12	10.7	10.7	0.3	

CA-SCI-38 and CA-Ala-329 Adult Male and Female Age Distributions

Figure 5.13: Adult age distributions for CA-SCI-38 and CA-Ala-329. Symbols indicate CA-SCI-38 female distribution (*fdx38*), CA-SCI-38 male distribution (*mdx38*), CA-Ala-329 female distribution (*fdx329*), and CA-Ala-329 male distribution (*mdx329*).

Figure 5.14: Survivorship Curves for CA-Ala-329 ($lx_{329} n = 298$) and CA-SCI-38 ($lx_{38} n = 211$) compared.

Figure 5.15: The difference between Mortality Curves at CA-SCI-38 ($n = 211$) and CA-Ala-329 ($n = 298$) may reflect a difference in the age estimation methods utilized for each sample.

Figure 5.16: Life expectancy for CA-SCI-38 is almost consistently 5 years lower than CA-Ala-329.

The number of male adult individuals at CA-SCI-38, aged 20 to 40 years, is almost double that of female adults in the same age categories. This is an age group that would be expected to have lower mortality rates, but the inverse seems to be true in this sample. Adult male deaths in this age group may be due to conflict or warfare, but differential burial practices must also be considered. Adult females at CA-SCI-38 only exceed adult males after age 40. By age 50 there are three times as many female adults. For females at CA-SCI-38 there are low mortality rates in the reproductive years. The survivorship of females in the child-bearing years may mean that women were well cared for and supported during their pregnancy by the group and may not have suffered high mortality at child birth. At the same time, it cannot be ruled out that younger adult

females were not buried at this site. The lack of subadults also may indicate that infants and young children were not interred here, subject to differential burial practices.

Also of interest is the average age-at-death for adult females and adult males at CA-SCI-38. The question was asked in the form of the null hypothesis: "Is the average estimated age-at-death for the female sample of CA-SCI-38 equal to the average age at death for the male sample?" An independent t-test was computed based upon male and female ages (see statistics at the beginning of chapter for AGE grouped by SEX on page 80). The p value (0.000250) calculated by SYSTAT is cause for rejection. The null hypothesis is rejected and the conclusion is drawn that the average age at death is not equal between the male and female age estimations at CA-SCI-38. In studying the descriptive statistics, we can see that the mean age at death for females is 37.296 and for males, 31.410. Females in this sample outlived the males by ~6 years. This fact is biased, however, by the unequal distribution of adult males and females in the CA-SCI-38 sample as demonstrated in the following tables and graphs. Because there appears to be an under-representation of adult females at CA-SCI-38, this directly affects the mean age-at-death as there are fewer female ages to add to the average total age.

Adult female and male age distributions are based on the actual αx values reported for each site. Males from the CA-SCI-38 sample show the highest mortality in the 30-40 age class, whereas in CA-Ala-329 the highest male mortality is in the 35-45 age class. Differing age estimation methods may explain the shift in high mortality rate in these two age classes for males between the differing sites. In any case, at both sites male mortality

is highest between ages 30 and 45. Likewise, female adults at both samples demonstrate higher mortality rates later in life than males (see Figures 5.18 and 5.19, 5.20, and 5.21).

Figure 5.17: Survivorship Curves for adults at both CA-Ala-329 and CA-SCI-38. Symbols indicate survivorship distributions for CA-SCI-38 females (*f38 lx*), CA-SCI-38 males (*m38 lx*), CA-Ala-329 females (*f329 lx*), and CA-Ala-329 males (*m329 lx*).

Figure 5.18: Female Mortality Curves (q_x) for CA-Ala-329 ($f_{329} q_x$) and CA-SCI-38 ($f_{38} q_x$).

Figure 5.19: Male Mortality Curves (q_x) for CA-Ala-329 ($m_{329} q_x$) and CA-SCI-38 ($m_{38} q_x$).

Figure 5.20: Adult male life expectancy (*ex*) for CA-Ala-329 (*m329 ex*) as compared to CA-SCI-38 (*m38 ex*).

Figure 5.21: Adult female life expectancy (*ex*) for CA-Ala-329 (*f329 ex*) as compared to CA-SCI-38 (*f38 ex*).

Figure 5.22: CA-SCI-38 male ($dx\ m38$) and female age distribution ($dx\ f38$).

Figure 5.23: CA-Ala-329 male ($dx\ m329$) and female age distribution ($dx\ f329$).

Differential Burial Treatment

Differential burial treatment, poor sample size, and taphonomic degradation are variables responsible for incompleteness in the osteological sample. Archaeological preservation is, of course, an important issue in paleodemographic analysis. There are several problems associated with the reliability of skeletal data “due to differential exhumation, differential preservation, biases inherent in the original processes of burial, etc.” (Ward and Weiss 1976:4). Walker et al. (1988) addressed this problem by comparing skeletal remains to mission records at La Purisima Mission Cemetery and CA-Ven-110, a mission period cemetery, for evidence of age and sex bias (1988). Results of the Walker et al. study found preservation most often affects age bias rather than sex bias. “At both sites, the remains of young adults were better preserved than those of children or elderly adults, and the completeness of male and female skeletons was comparable” (Walker et al. 1988:183). In the case of CA-SCI-38, 21% of the adult female sample is age 41-45 and 18% are 46-50. Male adult individuals accordingly are reported as 11% in age class 41-45 and only 4% are 46-50. There is a disproportionate number of females in the 41-45 age class as reported in Table 5.10. In CA-SCI-38 there is age and sex bias. Because of the excellent preservation of osteological material in CA-SCI-38, differential burial practices may be given consideration as an explanation for the skewed distribution of adults versus subadults; although these ratios may reflect actual conditions. The high mortality rate for males in age class 35-40, as compared with the high mortality for

females over 45, may reflect differential burial treatment or high male mortality may be the result of conflict, as addressed in the summary at the end of this chapter.

Modeling survivorship, mortality and life expectancy rates

Because of the problematic biased distribution of the CA-SCI-38 sample (both subadults and female are under-represented), the fertility and mortality rates derived from CA-Ala-329 may be more useful when comparing Central California prehistoric samples with other regional studies, and is included here along with CA-SCI-38 to illustrate how both sites compare with Doran's research (1980) and Mensforth's study of the Carlton Annis (Bt-5) site (1990).

Doran's Plains Miwok study

Doran's data for the Early, Middle, and Late Horizons of the Plains Miwok ethnolinguistic area (1980, introduced in the body of this text) is also presented here for modeling life tables. In this way the estimates of mortality and fertility, and survivorship rates for CA-SCI-38 and CA-Ala-329 may reflect similarities with one of these temporal periods.

As discussed in the preceding chapter, Doran based a paleodemographic analysis of the Plains Miwok on the intersite comparison of twelve sites (1980). Doran reported that "growth was occurring, and the rate of growth was lowest in the Early Horizon, intermediate in the Middle Horizon, and highest in the Late Horizon" (Doran 1980:110). Doran's study, based upon stable population theory, concluded that although population

growth was advancing over time, these were younger populations where subadult survival outpaced adult mortality. Also, adult female mortality was higher in the Late Horizon, leading Doran to conclude that female mortality increased over time, perhaps due to death at child birth. Because Doran did not report the descriptive statistics as sex specific, there is no way to make comparisons of male and female age distributions. The total distribution, survivorship, mortality, and life expectancy curves for Doran's Early, Middle, and Late Horizons are shown in the following graphs (Figures 5.16, 5.17, and 5.18) as compared to CA-SCI-38 and CA-Ala-329.

Figure 5.24: The Survivorship Curves for CA-SCI-38 (38 lx $n = 211$), CA-Ala-329 (329 lx $n = 298$), Doran's Early Horizon (lx early $n = 294$), Middle Horizon (lx mid $n = 589$), and Late Horizon ($late\ lx$ $n = 343$).

Figure 5.25: The Mortality Curves for CA-SCI-38 ($qx_{38} n = 211$), CA-Ala-329 ($qx_{329} n = 298$), Doran's Early Horizon ($qx_{early} n = 294$), Middle Horizon ($qx_{mid} n = 589$), and Late Horizon ($qx_{late} n = 343$).

Figure 5.26: Life Expectancy Curves compare the California samples: CA-SCI-38 ($Ex_{38} n = 211$), CA-Ala-329 ($ex_{329} n = 298$), Doran's Early Horizon ($Ex_{early\ pd} n = 294$), Middle Horizon ($Ex_{Mid\ pd} n = 589$), and Late Horizon ($Ex_{late\ pd} n = 343$).

When comparing CA-SCI-38 and CA-Ala-329 survivorship curves (lx) with Doran's tripartite periods, the lines are similar, with CA-SCI-38 demonstrating a life expectancy curve consistently five years lower than all other California samples. Both sites show lower survivorship at age class 60 than the Early, Middle, or Late Horizons. Mortality rates in the five different samples follow a similar curve with a slight rise of mortality in the CA-SCI-38 sample at age 55. Life expectancy curves for CA-SCI-38 and CA-Ala-329 are also similar, but CA-SCI-38 displays life expectancy five years lower than CA-Ala-329 along the entire curve. Doran reported life expectancy in all Horizons to extend into the eighth decade, whereas in CA-SCI-38 and CA-Ala-329 individuals are not reported to have achieved age seventy. This may be due to that fact that Doran employed the McKern-Stewart pubic symphysis age estimation method which has been found to consistently overage adult individuals. The lx values (Figure 5.19) for CA-SCI-38 and CA-Ala-329 both report reduced subadult survivorship as compared to Doran's Early, Middle, and Late Horizons.

The Carlton Annis (Bt-5) Late Archaic Site

To continue comparative assessment by modeling different sites, an Eastern Woodland Late Archaic hunter-gatherer sample population is also presented here. The Carlton Annis site is located in the Green River in west-central Kentucky. Mensforth reported the paleodemography of 390 individuals recovered from this site (1990). Occupied for over 2,500 years (as based on radiocarbon dating), the Carlton Annis site

(Bt-5) was seasonally occupied in the summer and fall. The Carlston Annis (Bt-5) site represents the people living in west-central Kentucky from 3000 to 4000 Y.B.P., 2000 years before the CA-Ala-329/CA-SCI-38 temporal period.

“The Bt-5 people were a seasonally mobile, semisedentary group of hunter-gatherers. They placed heavy reliance on local dietary resources. Mussels, fish, hickory nuts and acorns were harvested in abundance. On the basis of ethnographic analogy, it has been estimated that the site was occupied by 30 - 40 individuals per year and that such groups returned to the site annually for a period of approximately 1,500 years”. (Mensforth 1990:83)

Figure 5.27: The Survivorship Curves for CA-SCI-38 (*lx 38*), CA-Ala-329 (*lx 329*), and Mensforth's Carlston Annis Late Archaic site (Bt-5) (*lx Bt-5*) are compared. The CA-Ala-329 sample demonstrates a higher mortality rate overall and especially in the 30 - 55 age intervals.

Mortality rates from 0 to age class 25 as reported for CA-SCI-38 and CA-Ala-329 are similar to the Carlston Annis site (Figure 5.29 pg. 130) sample with variation occurring at age class 35. These variations may be due to age estimation methods and the high

mortality rates reported for ages 45-50 and 60-65 at CA-SCI-38 may also be due to differential burial practices. Survivorship rates are consistently higher for the California samples as compared with the Carlton Annis sample, and CA-SCI-38 falls between CA-Ala-329 and Bt-5, eventually matching the curve for Bt-5 at age 50.

Figure 5.28: A closer look at the Life Expectancy Curves for CA-Ala-329 (*Ex 329*), CA-SCI-38 (*Ex 38*) and the Carlton Annis Late Archaic site (*Ex Bt-5*) demonstrated similarly life expectancy curves for CA-SCI-38 and the Carlton Annis site.

Demographic parameters at Carlston Annis

All formulas for the derivation of the rates reported here are listed in Appendix D. The gross reproductive rate is defined as the average number of daughters born to women who reach 50 years of age [$GRR = \sum Fb_x(5)$]. The GRR at Carlston Annis (Bt-5) is 2.7

and 1.82 at CA-Ala-329. GRR^* is twice the GRR to account for birth of both sexes (Weiss 1973:69). This computes as an average of 5.4 children born to women who reach 50 years of age at Bt-5 and an average of 3.4 children at CA-SCL-38 and CA-Ala-329. Mean family size is 3.3 at Bt-5, 2.76 at CA-Ala-329, and 2.43 at CA-SCL-38. The total completed family size (*TCFS*) at the Bt-5 sample is 5.33 and ~3.5 for the two Central California samples. Based upon the derived data the Late Archaic hunter-gathering group (Bt-5) reports larger *MFS* and *GRR* than CA-Ala-329 or CA-SCL-38. The mean age at Bt-5 is 21.9. The inverse of the mean age has been demonstrated by Sattenspiel and Harpending (1983) to be the birth rate. The inverse of the mean age = 0.45. The crude birth rate (*CBR*) and the crude death rate (*CDR*) at Bt-5 is 45.0, whereas at CA-SCL-38 and at CA-Ala-329, the *CBR:CDR* is ~ 31.5.

Life expectancy at birth for the Carlston Annis sample is 22.4, for CA-Ala-329 it is 31.8, and for CA-SCL-38, 31.7. Life expectancy at age 15 for the Bt-5 sample is 19.4, at CA-Ala-329 it is 27.8, and 22.5 at CA-SCL-38. Mean age is 23.2 for Bt-5, 32.1 for CA-Ala-329, and 31.7 at CA-SCL-38. This would suggest that the people at CA-Ala-329 were outliving the archaic group of hunter-gatherers by almost a decade.

Figure 5.29: The Mortality Curves for CA-SCI-38 ($qx\ 38\ n = 211$), CA-Ala-329 ($qx329\ n = 298$) are compared to the Carlston Annis (Bt-5) ($qx\ Bt-5$) Late Archaic site ($n = 354$) from west-central Kentucky. Both mortality rates follow a similar line with a higher mortality experienced for individuals aged 45-50 and 60-65 at CA-SCI-38.

Table 5.16 The demographic parameters for mortality, life expectancy, and fertility for CA-SCI-38, CA-Ala-329, Doran's Early, Middle, and Late Horizon sites, and the Carlton Annis (Bt-5) Late Archaic site are reported to facilitate comparison

	CA-SCI-38	CA-SCI-38	CA-SCI-38	CA-Ala-329	Early	Middle	Late	Bt-5
<i>n</i>	211	263	231	298	341	584	341	218
Adult sex ratio	1.56	1.56	1.56	1.33				98
Fertility								
<i>CBR</i> (crude birth rate)	31.5	39.7	31.6	31.4	28.6	28.3	32	45
<i>GRR</i> (completed family size)	1.68	1.65	1.70	1.78	1.61	1.56	1.91	2.7
<i>MFS</i> (mean family size)	2.43	3.04	2.38	2.76	2.44	2.27	2.43	3.3
<i>TCFS</i>	3.37	4.27	3.41	3.56	3.23	3.12	3.82	2.7
generation length <i>T</i>	27.1	27.02	26.99	27.7	27.6	27.2	26.9	26.6
Mortality								
<i>CDR</i> (crude death rate)	31.5	39.7	31.6	31.4	28.6	28.3	32	45
<i>E⁰</i>	31.7	25.2	31.6	31.8	34.9	35.4	31.2	22.4
<i>E15</i>	22.2	21.9	21.5	27.8	26.1	24.2	21.6	19.4
<i>I15</i>	82.5	65.8	84.0	72.5	81.8	88	82.4	61.6
Proportion under 15 years	17.5	34.2	16.0	27.5	18.2	12	17.6	38.4
Proportion 15-50	71.1	57.4	73.6	45	59.2	68.5	65.4	52.8
Proportion over 50	11.4	8.4	10.4	27.5	22.6	19.5	17	8.8
Dependency Ratio	0.41	0.74	.036	1.22	0.69	0.46	0.53	0.89

Discussion of Fertility

Today, the female sex enjoys a longer life span in general than their male counterparts; however, “[i]n the course of history was not biological differences between the sexes that underwent modification, but rather the respective status of the sexes, and mortality conditions changed accordingly. In countries where adult women are practically engrossed with pregnancy, childbirth, suckling and in addition have to do all the work that falls on them by ancestral division of labor, often more exacting and wearing than the men's work, female mortality continues to be higher even today” (Acsádi and Nemeskéri

1970:186). Doran found that adult female mortality was higher in the Late Horizon of the Central Valley than in either the Early or Middle Horizons, leading him to conclude that death at childbirth may have been the cause. It is much more difficult to address paleodemographic fertility rates and the best reason to take a conservative view of these numbers is that the methodologies rely upon reliable age estimates for adult females. Female mortality in CA-SCI-38 is very low in the age classes between ages 15 and 40, the female reproductive years. In a skeletal series it may be that the underaging of the female sample plays a role in raising computed female mortality rates.

Fertility rates compared

In order to compare fertility rates, Weiss developed an archetypal fertility schedule from thirteen anthropological populations (Weiss 1973:33). The value “K” corresponds to seven fertile five year age (15-45) intervals derived from these 13 anthropological populations. This is interpreted as each female producing an estimated average number of children while in that age class. For “anthropological samples” (prehistoric), one archetypal data set is used to compute fertility curves and is used in this thesis to compare different site sample population fertility rates.

Table 5.17: The $M'x$ value is based upon archetypal data as developed by Weiss (1973:33) for anthropological populations. This table reports the $M'x$ for CA-SCI-38, CA-Ala-329, Doran's Early, Middle, and Late Horizons (1980), and the Carlston Annis (Bt-5) Late Archaic site (Mensforth (1990).

x	$M'x_{329}$	$M'x_{38(211)}$	$M'x_{early}$	$M'x_{middle}$	$M'x_{late}$	$M'x_{Bt-5}$
10	0	0	0	0	0	0
15	2.325	2.571	2.528	2.279	2.476	1.854
20	5.646	6.346	6.268	6.737	5.699	4.262
25	5.054	5.466	5.605	5.880	4.735	3.418
30	3.584	3.725	4.032	4.038	3.143	2.121
35	2.271	2.034	2.419	2.251	1.690	1.108
40	0.772	0.593	0.753	0.683	0.522	0.339
45	0.123	0.074	0.109	0.099	0.082	0.047
50	0	0	0	0	0	0
55	0	0	0	0	0	0

The highest fertility rates are generated for Doran's Early, Middle, and Late Horizon sites; however, the fertility rates do not differ substantially from ages 15-40. The Late Archaic Carlton Annis data reports the lowest fertility rates over all samples (Figure 5.30).

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Figure 5.30: Carlton Annis data (Bt-5) reports the lowest estimation for fertility of all sites compared. CA-SCI-38 data reports the lowest fertility for all California samples. This is probably due to the under-representation of subadults in CA-SCI-38. The CA-Ala-329 fertility curve most closely approximates Doran's Late Horizon.

Figure 5.31: The CA-SCI-38 Fertility Curve most closely approaches the Fertility Curve for Doran's Early Horizon and falls below CA-Ala-329 and Doran's three temporal periods.

Figure 5.32: The Fertility Curves for CA-SCI-38, CA-Ala-329 and the Late Horizon (after Doran 1980).

Comparison of Derived Rates to Anthropological Populations

Milner et al. “suggest that demographic statistics derived from adequately documented, traditional societies represent an efficient initial means of assessing the age structure of a skeletal series” (Milner et al. 1989:50). Milner et al. have compared the Yanomamo and !Kung mortality and fertility ratios to an Oneota skeletal sample dating ca. A.D. 1300 from the Central Illinois River Valley (1989). In the Milner et al. study the !Kung fertility rate ($GRR = 2.0$) and mortality ($E^0 = 33$) was interchanged with the Yanomamo fertility rate ($GRR = 3.25$) and mortality rate ($E^0 = 20$) in order to compare the Oneota sample to contemporary hunter-gatherer groups and contemporary horticulturalist samples (Ibid.:51).

To compare demographic rates of mortality and fertility as reported by Milner et al. (1989) to a Central California sample, CA-Ala-329 was selected rather than utilizing the CA-SCI-38 data, due to the fact CA-Ala-329 was less subject to selective bias (although CA-SCI-38 is also included). The GRR for CA-Ala-329 (1.78) and CA-SCI-38 (1.70) compares more closely to !Kung fertility, but falls short by 0.22. It may be considered that the continued under-representation of subadults in prehistoric skeletal samples from Central California is reflected in this low fertility rate when considering the dense populations reported there. This is pointed out even though the CA-Ala-329 sample reflects a reasonable DR as compared to CA-SCI-38 ($n = 231$).

The mortality for CA-Ala-329 (E^0) was 31.8 while !Kung mortality (E^0) was 33.0 and for the Yanomamo E^0 was 20.0. The mortality rate for CA-Ala-329 more closely

approximates the !Kung mortality ratio, 31.8 and 33.0, respectively. Therefore, the mortality rate of CA-Ala-329, as representative of Central California, is similar to the contemporary !Kung hunter-gatherers. The comparison of these values is not as clear cut as the comparison of the Oneota sample as reported by Milner et al.

All the California data reported here fall short of matching the !Kung fertility rates by 0.35 to 0.22 except for Doran's Late Horizon where the *GRR* is 1.91. The fertility data for the Yanomamo is 3.25; the California sites reported here are far below this. The results of this research do not lead to any conclusive evidence for mortality and fertility values of CA-SCI-38 or CA-Ala-329 as correlated to either the Yanomamo model or the !Kung model.

Summary

In prehistoric Central California, where dense populations are considered to have existed without an adaptation to agriculture, people were living moderately long lives. For such dense populations to have been supported, there must have been a high degree of social complexity in Central California. This is most problematic as the lack of subadults recovered in this skeletal series generated fertility rates reflective of a population that would not be able to reproduce itself to survive, let alone demonstrate dense populations as reported in the literature. Excellent archaeological recovery methods demonstrated for CA-SCI-38 support an initial hypothesis that all children were not being interred at this mortuary site. This may be due to the fact that children did not have a

social personae, as defined by Binford (1989), important enough to permit ceremonial interment at death.

Female adult mortality is respectively low in the child bearing age classes, 20-40, and rises substantially at ages 40-55 suggesting a second hypothesis that younger females were well cared for during pregnancy or, as in the subadult sample, were just not being interred at this site. Perhaps women who did not survive childbirth were interred elsewhere in a separate cemetery with their non-surviving infants. The same situation is true for CA-Ala-329. Female adult mortality rates at CA-Ala-329, representing the 50-55 age classes, are double that for all other female age classes. Females were outliving males at both CA-SCL-38 and Ca-Ala-329. The high mortality rate for males aged 30-40 at CA-SCL-38 is also striking; this also holds true for the CA-Ala-329 males, aged 35-45.

At first it seems somewhat paradoxical that age estimation methods reported to improve age estimation in the older adult age classes (the auricular surface and the sternal rib end) have not led to an increase in reporting for these age classes. The age estimation methods at CA-SCL-38 have demonstrated no significant variation, suggesting that the achieved ages are reliable. If the ages can be relied upon then, what is happening to cause such high mortality for males at both sites? The single most obvious hypothesis is interpersonal aggression or conflict among males at CA-SCL-38.

Jurmain and Bellifemina (1997 in press), Jurmain (1991, 1983a), Walker (1989), have all reported interpersonal aggression in prehistoric California as evidenced by projectile point wounds embedded in bone and also patterns of bone fracture, especially

cranial trauma. This presents another dilemma, however, as at CA-SCI-38 there is only minor evidence for interpersonal aggression (Bellifemine, Masters Thesis in Progress, San Jose State University) as compared to CA-Ala-329. This would not preclude conflict, however, as evidence of mortal wounds would not necessarily involve the skeleton. The temporal component for CA-SCI-38 is estimated to be from 230 to 1500 AD. This is the time period Walker has established (500 - 1100 AD) as subject to fluctuating periods of drought considered to have led to increased violence as people struggled over declining resources (Walker 1989:359). This may have implications for the large number of young males reported for CA-SCI-38.

This research suggests that CA-SCI-38 may have been a special purpose cemetery where members of a specific status were interred, specifically males and older females. If this is true, the distribution of burial associated artifacts may eventually support this theory as ongoing research unfolds (Bellifemina, 1997). Perhaps a differential status was reserved for certain adult males, the degree which could also be attained by women who lived to older ages. These adult males may have been drawn from a wide geographical area, which would explain the high numbers found for this group. Perhaps adult females who had not reached a hypothetical high status were buried with the children who had also not yet achieved a *social persona*, qualifying them for burial alongside older individuals of high status or reputation.

Concluding Remarks

This study can make no overt statements about the transitional stage of development considered in prehistoric Central California. It does present the skeletal data in a manner that is useful to future anthropological investigation in terms of understanding the biological processes that may be considered representative of the region. It is hoped that the analyses of such important materials will continue to be implemented. There is no other way that such information from the prehistoric societies of this region may be investigated due to the lack of ethnographic records of religious and funerary practices. For this reason, paleodemography is a useful diagnostic tool that should be considered for all important skeletal series recovered. The comprehensive reporting of all skeletal data is pertinent to such study. Archaeologists and osteologists, having the privilege of studying human remains, need to make the most of these valuable remains while they are still available.

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APPENDIX A
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burial	Lth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
1	.	M	28.7+ SD 6.5	complete epiphyseal fusion	25-35	30	.	30	30
3	.	I	.	prox. epiph. MC2, dist. tib & fem unfused, neural arch fused	8.0-10.0	9	.	.	9
4	.	F	48.1+ 14.6	complete epiphyseal fusion	40-50	45	42	49	45
5	.	F	.	complete epiphysis fusion	21-30	25	20	.	24
6	.	I	.	complete except partial union of medial clavicles	21-25	23	.	.	23
7	.	I	.	adult cranial fragments only; cremation	.	.	.	.	x
8	.	M	28.7+ SD 6.5	complete epiphyseal fusion	25-45	35	.	34	34
9	.	F	38.2+10.9	complete epiphyseal fusion	50+	52	.	52	52
10	.	M	45.6+10.4	complete epiphyseal fusion	35-55	45	47	47	47
11	.	I	.	complete except partial union of medial clavicles	17-23	20	.	26	23
12	.	I	.	complete epiphyseal fusion	41+	47	.	47	47
13a	.	I	.	.	.	.	.	.	x
13	.	M	45.6+10.4	complete epiphyseal fusion	30-45	37	.	37	38
15	.	M	45.6+10.4	complete epiphyseal fusion	25-45	33	28	38	37
16	.	M	45.6+10.4	complete epiphyseal fusion	30-50	43	45	46	46
17	.	I	.	complete epiphyseal fusion	35-55	47	.	47	48
18	.	F	30.7 SD + 8.1	complete except partial union of medial clavicles	25-28	30	24	32	30
19	.	I	.	complete epiphyseal fusion	35-50	43	.	43	43
21	.	I	.	complete epiphyseal fusion	18+	18+	.	.	18+
23	.	I	.	partial union of os coxae, eruption of 2nd molar	9.0-12.0	11	.	.	11
24	.	M	35.2+9.4	complete epiphyseal fusion	35-45	40	.	42	39
25	.	M	45.6+10.4	complete epiphyseal fusion	40-50	45	.	.	48
26	.	M	28.7+ SD 6.5	complete epiphyseal fusion	30-50	40	41	44	40
27	.	M	24.7+ SD 4.3	complete epiphyseal fusion	30-35	33	28	33	30
28	.	F	.	complete epiphyseal fusion	40-50	45	.	45	37
29	.	M	35.2+9.4	complete epiphyseal fusion	25-40	33	46	37	38
30	.	I	.	all deciduous teeth present, aged according to metrics	5.0-7.0	6	.	.	6
30a	f	F	.	complete epiphyseal fusion	25+	25+	.	.	25+
31	f	F	60+ SD 12.4	complete epiphyseal fusion	50+	53	55	54	54
32	.	F	19.4+ SD 2.6	crystal fusion partial(14-23), distal femur (14-24),	17-21	19	.	25	23

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burial	loth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
33	.	M		complete epiphyseal fusion	27-37	32	32	33	33
34	.	M	45.6+10.4	complete epiphyseal fusion	35-50	43	34	45	39
35	f	F	38.2+ SD 10.9	complete epiphyseal fusion	25+	43	43	.	43
36	.	I		fragmentary burial, complete fusion ulna, radius, and carpal	25+	25	.	.	25+
37	.	F		cristal fusion incomplete; 17-19; med. clav. unfused	17-19	18	.	.	18
38	.	M	61.5+ SD 12.2	complete epiphyseal fusion	30-50	38	31	36	44
39	.	M	24.7+ SD 4.3	complete except partial union of medial clavicles	20-24	22	.	24	24
40	.	I		adult cranial fragments (cremation)	.	.	.	.	x
41	.	I		all deciduous teeth present, aged according to long bone metrics	9.5-10.5	10	.	.	10
42	.	M	45.6+ SD 10.4	complete epiphyseal fusion	35-50	.	45	.	42
43	.	F	38.2+ SD 10.9	complete epiphyseal fusion	35-55	45	34	47	40
44	.	I		incomplete sacral fusion, 25 decid. teeth, aged by metrics	4.5-6.0	5.25	.	.	5.25
45	.	M	28.7+SD 6.5	complete epiphyseal fusion	25-35	30	30	35	31
46	.	I		aged according to long bone metrics & dentition	12.5-15.0	14	.	.	14
47	.	M		cristal fusion & med. clavicle incomplete	17-21	19	.	.	19
48	.	F	38.2+ SD 10.9	complete epiphyseal fusion	45-55	50	52	51	51
49	.	M	24.7+ SD 4.3	complete epiphyseal fusion	21-35	28	31	32	30
50	.	M	18.5+ SD 2.1	complete epiphyseal fusion	18-21	20	21	22	21
51	.	M	18.5+ SD 2.1	complete epiphyseal fusion	30-40	35	.	29	32
52	.	M	18.5+ SD 2.1	complete epiphyseal fusion	18-23	21	.	30	26
53	.	M	28.7+ SD 6.5	complete except partial union of medial clavicles	30-35	33	31	33	32
54	.	F	48.1+ SD 14.6	complete epiphyseal fusion	35-50	42	48	.	44
55	.	F	30.7+ SD 8.1	complete epiphyseal fusion	35-50	42	35	42	42
56	.	F	48.1+ SD 14.6	complete epiphyseal fusion	35-45	41	.	35	35
57	.	F	48.1+ SD 14.6	complete epiphyseal fusion	35-45	40	32	43	39
58	.	I		humerus; 16-24; medial clavicle incompletely fused	16-21	18	.	18	18
59	.	I		occipital condyle unfused, metrics indicate 1-25	2.0-4.0	3	.	.	3
60	.	M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	42	.	42	38
61	.	M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	39	.	41	35

APPENDIX A
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burial	loth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
61a		I.		occip. condyle development = 0 - 4, 1 cerv. vert, cranial frag.	0-4				0.2
62		M.			17-21	19		19	19
63		F.		complete epiphyseal fusion	25-40	33	31	33	32
64		M	24.7+ SD 4.3	complete epiphyseal fusion	21-29	25		25	25
65		I.		complete epiphyseal fusion	25+	25+			25+
66		I.		distal MC1 unfused, metrics indicate 7-10	10.0-15.0	12			12
67		F	19.4+ SD 2.6	cristal fusion 18+, medial clavicle < 23	18-21	20	14	18	20
68		F	48.1+ SD 14.6	complete epiphyseal fusion	40-60	50	48	50	49
69		M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	40	40	40	33
70		M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	41	37	41	41
71		M.		distal radius, ulna, cristal, & medial clavicle unfused	17-20	18		20	18
72	f	F.		complete epiphyseal fusion	18-30	24			24
73		M	18.5+ SD 2.1	cristal fusion, medial clavicle fusion incomplete	18-21	19	23	28	22
74		F	48.1+ SD 14.6	complete epiphyseal fusion	40-55	47	50	55	47
75		I.		M3 unerupted, humeral fus: 13.5; Os coxae, 15; ulnae, 14-16	13-15	14			14
76		M	30.7+ SD 8.1	complete epiphyseal fusion	40-50	45	55	45	50
76a		I.		infant occipital condyle, unfused verts, and MT5					0.5
77		I.		vertebral lamina fused, no billowing	21+	21+			21+
78		F	38.2+ 10.9	complete epiphyseal fusion	40-50	44	55	44	42
79		M	35.2+ SD 9.4	complete epiphyseal fusion	29-35	32	33	40	34
80		M	35.2+ 9.4	complete epiphyseal fusion	40-50	44		44	37
81		F	48.1+ SD 14.6	complete epiphyseal fusion	35-50	45	60	44	46
82		M	35.2+ SD 9.4	complete epiphyseal fusion	31-40	34	30	31	35
83		I.		femur, vertebrae fused	25+	25+			25+
84		M	18.5+ SD 2.1	distal fibulae, med. clav. unfused, cristal fusion incomplete	16-20	18	19	19	18
85		F	25.0+ SD 4.9	complete epiphyseal fusion	20-30	26		26	23
86		M.		complete epiphyseal fusion	35-50	35	36		36
87		M	35.2+ SD 9.4	complete epiphyseal fusion	35-50	44	33	44	43
88		M	24.7+ SD 4.3	complete except partial union of medial clavicles	21-35	28	24	33	27
89		M	35.2+ SD 9.4	complete epiphyseal fusion	41-50	46		46	42

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burial	loth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
90	.	F	25.0+ SD 4.9	complete except partial union of medial clavicles	20-25	22	17	19	23
90a	.	I.		unfused occipital condyle, immature spineous process	4	4	.	.	4
91	.	I.		fusion of ulnae: 14-16, fibulae and tibiae: 15-17	16-20	18	.	.	18
92	.	M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	38	36	38	35
93	.	F	60+ SD 12.4	complete epiphyseal fusion	45-55	51	.	50	49
94	m	M		complete epiphyseal fusion	25-35	31	.	.	31
95	.	M	18.5+ SD 2.1	radius, ulnae unfused: 14+	15-17	16	.	.	16
95a	.	I.		proximal/distal radius med. clav. unfused	15-18	16	16	.	16
96	.	I.		vertebrae unfused	17+	17+	.	.	17+
97	.	M	18.5+ SD 2.1	complete except partial union of medial clavicles	18-23	21	21	20	21
98	.	F	19.4+ SD 2.6	epiphyseal fusion complete except cristal iliac fusion	18-22	20	.	26	22
99	.	F.		complete epiphyseal fusion	25-35	31	.	.	31
100	.	I.		complete epiphyseal fusion	25+	25+	.	.	25+
101	.	F.		complete epiphyseal fusion	35-45	41	.	41	41
102/4	.	I.		unfused cervical vertebrae and os coxa	9.0-13.0	11	.	.	11
103	.	F.		complete epiphyseal fusion	45-55	49	.	49	49
105	.	M	45.6+10.4	complete epiphyseal fusion	35-45	40	39	.	40
105a	.	I.		M3 erupted, neural arch fused; lamina, humerii & femora unfused	18+	18	15-17	.	18
106	.	I.		proximal humerus unfused	16+	16+	.	.	16+
107	.	F	38.2+ SD 10.9	complete epiphyseal fusion	35-45	44	37	44	42
108	.	I.		humerii, radii, ulnae unfused	8.5-9.5	9	.	.	9
109	.	M	18.5+ SD 2.1	complete except partial union of medial clavicles	21-30	25	24	27	24
110	.	F.		complete epiphyseal fusion	35-50	42	.	40	41
111	.	M	28.7+6.5	complete epiphyseal fusion	25-35	30	.	30	30
112	.	F	19.4+ SD 2.6	cristal fusion almost complete	17-23	20	.	27	23
113	.	M	24.7+ SD 4.3	complete except partial union of medial clavicles	21-27	24	.	24	24
114	.	I.		prox. humerus fused; med. clav. unfused	16+	16+	.	.	16+
115	.	I.		dentition = 3.8+5.0	3.8-5.0	4.5	.	.	4.5
116	.	F	30.7+ SD 8.1	complete except partial union of medial clavicles	23-30	27	.	.	27

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burial/loth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
117/30	M		cristal fusion 15+, vertebral lamina unfused	15-24	19	.	.	19
118	M	35.2+ SD 9.4	complete epiphyseal fusion	30-45	38	39	36	38
119	I		fusion of neural arches = 1.5	1.0-2.5	15	.	.	1.5
120	F	19.4+ SD 2.6	anterior cristal fusion complete, ischial tuber just fusing	18-20	19	19	20	19
121	M	45.6+10.4	complete epiphyseal fusion	40-50	45	38	47	45
122	F		complete epiphyseal fusion	41-50	45	.	45	45
123	F	38.2+ SD 10.9	complete epiphyseal fusion	45-55	48	.	48	48
124	I		complete epiphyseal fusion	21+	21+	.	.	21+
125	F	48.1+ SD 14.6	complete epiphyseal fusion	45+	45	47	46	45
126	F	60.0+SD 12.4	complete epiphyseal fusion	40-50	46	.	48	46
127	I		fusion of neural arches = 1.5	0.5-1.5	0.5	0.5	.	0.5
128	I		fusion of neural arches = 1.5	0.5-1.5	1	1	.	1
129	F	48.1+ SD 14.6	complete epiphyseal fusion	40-50	44	43	41	44
131	M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	40	43	38	40
132	M		cristal fusion incomplete	16-20	18	17	21	18
133	I		distal tibiae, os coxae unfused: 13-18	13-18	16	.	.	16
134	I	19.4+ SD 2.6	prox. humerus, ulna, and radius unfused: 15-23 partial cristal fusion	15-19	17	.	.	17
135	I		In complete fusion of neural arches, longbones, and os coxae	8.0-10.0	10	.	.	10
136	I		one neural arch complete	20-30	2.5	.	.	2.5
137	I		metric data = 3-4; dentition = 3+12 mos.	30-40	3.5	.	.	3.5
138	M	35.2+ SD 9.4	complete epiphyseal fusion	35-40	39	42	37	40
139	I	24.7+ SD 4.3	complete epiphyseal fusion	21-30	25	.	.	25
140	M	35.2+ SD 9.4	complete epiphyseal fusion	31-40	35	38	36	38
141	M	18.5+ SD 2.1	complete except partial union of medial clavicles	17-23	25	24	28	23
142	M	18.5+ SD 2.1	proximal humerus, distal femora unfused: 15-18	15-18	16	.	23	18
143	M	24.7+ SD 4.3	complete epiphyseal fusion	21-30	26	20	25	26
144	M	18.5+ SD 2.1	vertebral lamina, med. clav. incomplete fusion	18-25	23	23	27	25
145	F	48.1+ SD 14.6	complete epiphyseal fusion	35-45	40	.	39	41
146	F	60+ SD 12.4	complete epiphyseal fusion	47-60	55	58	55	55

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burial	loth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
147	.	M	35.2+ SD 9.4	complete epiphyseal fusion	31-40	35	.	35	35
148	.	M	35.2+ SD 9.4	complete epiphyseal fusion	30-44	36	.	36	35
149	.	I.	I.	prox. femur fused	25+	25+	.	.	25+
150	.	I.	I.	iliac crest unfused, prox. femur & greater troc. fused	15-23	15	.	.	15
151	.	I.	I.	prox. femur and greater troc. fused	25+	25+	.	.	25+
152	.	M	18.5+ SD 2.1	complete epiphyseal fusion	18-22	20	21	21	22
153	.	I.	I.	complete epiphyseal fusion	25+	25+	.	.	25+
154	.	I.	I.	fusion of distal femur: 17-18	17+	17+	.	.	17+
155	.	I.	I.	dentition = 1+4 mos.	7-1.25	1	.	.	1
156	.	I.	I.	dentition = 2 + 8 mos.	1.0-2.0	1.5	.	.	1.5
157	.	M	24.7+ SD 4.3	complete epiphyseal fusion	25-35	30	.	32	25
158	.	I.	I.	epiphyseal fusion: 15-17	15-17	15	.	.	15
159	.	I.	I.	epiphyseal fusion: 3.5 - 4.5	4.0-5.0	4.5	.	.	4.5
160	.	M	24.7+ SD 4.3	complete epiphyseal fusion	20-29	25	.	29	25
161	.	M	35.2+ SD 9.4	complete epiphyseal fusion	30-45	40	43	42	43
162	.	M	24.7+ SD 4.3	vertebral lamina not completely fused	25-35	31	28	31	29
163	.	M.	M.	humerus fused	21+	21+	.	.	21+
164	.	M.	M.	complete epiphyseal fusion	35-45	40	32	40	35
165	.	M.	M.	complete epiphyseal fusion	41-50	43	.	43	43
166	.	M	18.5+ SD 2.1	incomplete fusion prox humeri: 16-24, distal femora: 14-22, radii: 15-23	15-23	19	.	20	19
167	.	M	18.5+ SD 2.1	complete except for cristal: 15-23	18-24	22	.	24	20
167a	.	I.	I.	.	16+	16+	.	.	16+
168	.	M	18.5+ SD 2.1	med. clav., dist. radius & ulna: 15-23, prox. humerus: 16-24	18-23	21	21	20	21
169	.	I	3.5-5.5	vertebral centrum unfused	3.5-5.5	4.5	.	.	4.5
170	.	M	18.5+ SD 2.1	complete epiphyseal fusion	25-35	30	29	30	35
171	.	M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	41	35	42	37
172	.	M	24.7+ SD 4.3	complete epiphyseal fusion	31-40	35	26	37	31
173	.	I.	I.	distal humerus: 13-18, proximal ulna & radius: 14-20	13-20	17	.	.	17
174	.	I.	I.	vertebral lamina fused	adult	16+	.	.	16+

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burial	loth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
175	.	M.		complete epiphyseal fusion	25-35	30	28	30	25
176	.	M	28.7+ SD 6.5	complete epiphyseal fusion	25-30	27	.	.	27
177	.	I.		lumbar vertebrae unfused	2.5-3.5	3	.	.	3
178	.	I.		dentition = 3 + 12 mos.	2.0-4.0	3	.	.	3
179	.	M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	40	45	43	43
180	.	M.		complete epiphyseal fusion	35-39	37	.	.	37
181	.	I.		sacral fusion incomplete, intervertebral lamina fused: 19-24	19-24	22	.	.	32
182	.	M.		complete epiphyseal fusion	25-35	30	23	.	30
183	.	F	60+ SD 12.4	complete epiphyseal fusion	45-55	50	45	45	46
184	.	F.		complete epiphyseal fusion	50-60	55	.	60	60
185	.	I.		complete epiphyseal fusion	25+	32	.	32	32
186	.	I.		dentition = 9 mos. + 3 mos.	.75-1.0	1	.	.	1
187	f	F	24.7+ SD 4.3	complete epiphyseal fusion	21-30	25	22	29	20
188	.	M	38.2+ SD 10.9	complete epiphyseal fusion	35-50	42	.	44	42
189	.	F	48.1+ SD 14.6	complete epiphyseal fusion	35-50	42	.	48	48
190	.	F	38.2+ SD 10.9	complete epiphyseal fusion	35+	35+	.	.	35+
191	.	M.		complete except partial union of medial clavicles	17-23	20	.	.	20
192	.	I.		complete epiphyseal fusion	25+	50	50	.	50
193	f	F.		complete epiphyseal fusion	25+	25+	.	.	25+
194	.	M	24.7+ SD 4.3	complete epiphyseal fusion	25-35	31	.	.	31
194a	.	I.		os coxae, femora unfused: 10-18	10.0-13.0	12	.	.	12
195	.	I.		vertebral fusion: 3-7; MC's incompletely fused	5.0-7.0	6	.	.	6
195a	.	I.		adult based on dentition	15-22	20	.	.	20
196	.	F	19.4+ SD 2.6	crystal fusion incomplete: 16-23	16-23	19	15	25	19
197	.	M	35.2+ SD 9.4	complete epiphyseal fusion	35-45	41	35	34	35
198	.	M	28.7+ SD 6.5	complete epiphyseal fusion	30-50	40	.	42	42
201	.	M	28.7+ SD 6.5	complete epiphyseal fusion	35-50	44	.	44	35
202	m	M.		complete epiphyseal fusion	25+	25+	.	42	42
203	.	I.		fusion of neural arches: 3-7	7.0-10.0	8.5	.	.	8.5
204	.	M.		complete epiphyseal fusion	16+	16+	.	.	16+

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burial	loth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
205a		I.		unfused pubis and ischium	7	7			7
205		F	30.7+ SD 8.1	complete epiphyseal fusion	35-50	43		43	37
206		F	30.7+ SD 8.1	complete epiphyseal fusion	25-45	38		45	40
207		F	48.1+ SD 14.6	complete epiphyseal fusion	45-50	47	28	27	47
208		I.		distal proximal femur incompletely fused	18-23	20			20
209		F.		crystal fusion in progress: 16-23, medial clavicle unfused	16-23	20		20	20
210		F.		complete epiphyseal fusion	25+	58		58	58
211		I.		complete epiphyseal fusion	25+	28	28		28
212		F	38.2+ SD 10.9	complete epiphyseal fusion	35-45	40	42	45	43
213		M.		complete epiphyseal fusion	24-34	29			29
214		I.		fusion of ulnae, tibiae & humeri: 4.0-6.0	4.0-6.0	5			5
215		F.		complete epiphyseal fusion	40-50	44		44	44
216		I.		distal humerus & radius fused: 16+	16+	16+			16+
217		I.		proximal humerus 7 tibia, distal femur unfused	5	6			6
218		F	48.1+ SD 14.6	complete epiphyseal fusion	35-45	38	39	40	38
219		M.		complete except partial union of medial clavicles	25-30	27		30	27
220		I.		metopic suture unfused: < 2, neural arch fusion: 1-3	5-1.0	0.75			0.75
221		F		complete epiphyseal fusion	25-35	31	30	34	31
222		I.		proximal humerus = 5.5-6.5, tibial & femoral fusion = 5	6.0-7.0	6.5			6.5
223		F.		complete epiphyseal fusion	35-45	40		49	49
223a		I.		maxilla with deciduous teeth = 18 mos.					15
224		M	24.7+ SD 4.3	complete epiphyseal fusion	21-26	24	24	25	24
225		I.		complete epiphyseal fusion except lamina on C6 & C7	17+	17+		25	25
226		M	18.5+ SD 2.1	partial fusion of crystal, humerus & med. clav.: 15-24	17-21	19	20	20	19
227	f	F	18.5+ SD 2.1	partial fusion of humerus, radius, ulna & vertebral elements: 15-19	15-19	17	17		17
228	m	M	24.7+ SD 4.3	complete epiphyseal fusion	25-35	29		29	25
229		M	30.7+ SD 8.1	complete epiphyseal fusion	35-45	40	30	41	35
229a		I.		fragmentary neonate mandible,					0.2
230		F	30.7+ SD 8.1	complete epiphyseal fusion	31-40	35		40	35

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burial	loth	sex	Suchey/Brooks	Epiphyseal fusion	range	comp	rib	aur	final
230a		I.		(see B.230) infant right ulna					0.5
231		M	28.7+6.5	complete epiphyseal fusion	30-40	35		30	35
232		F	48.1+ SD 14.6	complete epiphyseal fusion	35-50	43	40	41	43
233		M	35.2+ SD 9.4	complete epiphyseal fusion	30-45	37		31	35
234	f	F		complete epiphyseal fusion	35+	50		50	50
235		I.		fusion of neural arches = 3.5-5.0	3.5-5.0	1			1
235a		I			3.25				3.25
236		F		medial clavicle unfused, cristal fusion complete	21-30	25		25	27
237		M	24.7+ SD 4.3	complete epiphyseal fusion	18-25	22	22	23	22
238		M	36.8+ SD 9.6	complete epiphyseal fusion	25-35	31	32	39	35
238a		I.		vertebral body of an infant					0.5
239		I.		partial fusion of os coxae: 10-15	10.0-15.0	12			12
240		M		greater trochanter fused	21-35	28		30	30
241		M	28.7+6.5	complete epiphyseal fusion	25-35	31		37	31
242		I.		fusion complete including cristal: 25+	25+	25+			25+
243		I.		fusion of radius: 7.5-9.5	7.5-9.5	8.5			8.5

APPENDIX B
Sternal Rib End Age Data

Phase Descriptions for Sternal Rib End Age Estimation (after Iscan 1989:108-115)

White Female Phase

phase 0 (13 and younger): The articular surface is nearly flat with billows or ridges. The outer surface of the sternal extremity of the rib is bordered by what appears to be an overlay of bone. The rim is regular with rounded edges and the bone itself is smooth and firm.

phase 1 (14-15): A beginning, amorphous indentation can be seen in the articular surface. Ridges or billowing may still be present. The rim is rounded and regular with a little waviness in some cases. The bone remains solid, firm, and smooth.

phase 2 (16-19): The pit is considerably deeper and has assumed a V-shape between the thick-smooth anterior and posterior walls. Some ridges or billowing may still remain inside the pit. The rim is wavy with some scallops beginning to form at the rounded edge. The bone itself is firm and solid.

phase 3 (20-24): There is only slight if any increase in pit depth, but the V-shape is wider, sometimes approaching a narrow U as the walls become a bit thinner. The still-rounded edges now show a pronounced, regular scalloping pattern. At this stage, the anterior or posterior walls may first start to exhibit a central, semicircular arc of bone. The rib is firm and solid.

phase 4 (24-32): There is a noticeable increase in the depth of the pit which now has a wide V-pr narrow U-shape with at times, flared edges. The walls are thinner, but the rim remains rounded. Some scalloping is still present, along with the central arc; however, the scallops are not as well defined and the edges are worn. The quality of the bone is fairly good, but there is a decrease in density and firmness.

phase 5 (33-46): The depth of the pit stays about the same, but the thinning walls are flaring into a wider V- or U-shape. In most cases, a smooth, hard, plaque-like deposit lines at least part of the pit. No regular scalloping pattern remains and the edge is beginning to sharpen. The rim is becoming more irregular, but the central arc is still the most prominent projection. The bone is noticeably lighter in weight, density, and firmness. The texture somewhat brittle.

phase 6 (43-58): An increase in pit depth is again noted, and its V-or U-shape has widened again because of pronounced flaring at the end. The plaque-like deposit may still appear but is rougher and more porous. The walls are quite thin with sharp edges and an

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irregular rim. The central arc is less obvious and, in many cases, sharp points project from the rim of the sternal extremity. The bone itself is fairly thin and brittle with some signs of deterioration

phase 7 (59-71): In this phase, the depth of the predominately flared U-shaped pit not only shows no increase but actually decreases slightly. Irregular bony growths are often seen extruding from the interior of the pit. The central arc is present in most cases but is now accompanied by bony projections, often at the superior and inferior borders, yet may be evidenced anywhere around the rim. The very thin walls have irregular rims with sharp edges. The bone is very light, thin, brittle, fragile, with deterioration most noticeable inside the pit.

phase 8 (70 and older): The floor of the U-shaped pit in this final phase is relatively shallow, badly deteriorated or completely eroded. Sometimes it is filled with bony growths. The central arc is barely recognizable. The extremely thin, fragile walls have highly irregular rims with very sharp edges, and often fairly long projections of bone at the inferior and superior borders. "Window" formations sometimes occur in the walls. The bone itself is in poor condition-extremely thin, light in weight, brittle and fragile.

White Male Phases

phase 0 (16 and younger): The articular surface is flat or billowy with a regular rim and rounded edges. The bone itself is smooth, firm and very solid.

phase 1 (17-19): There is a beginning amorphous indentation in the articular surface, but billowing may also still be present.

phase 2 (20-23): The pit is now deeper and has assumed a V-shaped appearance formed by the anterior and posterior walls. The walls are thick and smooth with a scalloped or slightly wavy rim with rounded edges. The bone is firm and solid.

phase 3 (24-28): The deepening pit has taken on a narrow to moderately wide U-shape. Walls are still fairly thick with rounded edges. Some scalloping may be present, but the rim is becoming more irregular. The bone is still quite firm and solid.

phase 4 (26-32): Pit depth is increasing, but the shape is still a narrow to moderately wide U. The walls are thinner, but the edges remain rounded. The rim is more irregular with no uniform scalloping pattern remaining. There is some decrease in the weight and firmness of the bone, however, the overall quality of the bone is still good.

phase 5 (33-42): There is little change in pit depth, but the shape in this phase is predominately a moderately wide U. Walls show further thinning and the edges are becoming sharp. Irregularity is increasing in the rim. Scalloping pattern is completely

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gone and has been replaced with regular bony projections. The condition of the bone is fairly good, however, there are some signs of deterioration with the evidence of porosity and loss of density.

phase 6 (43-55): The pit is noticeably deep with a wide U-shape. The walls are thin with sharp edges. The rim is irregular and exhibits some rather long bony projections that are frequently more pronounced at the superior and inferior borders. The bone is noticeably lighter in weight, thinner and more porous, especially inside the pit.

phase 7 (54-64): The pit is deep with a wide to very wide U-shape. The walls are thin and fragile with sharp, irregular edges and bony projections. The bone is light in weight and brittle with significant deterioration in quality and obvious porosity.

phase 8 (65 and older): In this final the pit is very deep and widely U-shaped. In some cases the floor of the pit is absent or filled with bony projections. The walls are extremely thin, fragile and brittle with sharp, highly irregular edges and bony projections. The bone is very lightweight, thin, brittle, friable, and porous. "Window" formation is sometimes seen in the walls.

Description of the Morphology of the Sternal Rib Ends of CA-SCI-38

Female rib sample:

n = 28; phase I, n = 2; phase II, n = 2; phase III, n = 3; phase IV, n = 5; phase V, n = 7; phase VI, n = 7; phase VII, n = 1; phase 8, n = 0

Burial 4 4th right rib: no central arc, shallow, porotic, v-shaped pit; phase VI, age 42

Burial 5 4th left rib: central arc present, shallow v-shaped pit, smooth floor, smooth, scalloped, regular walls with scallops; phase III, age 20

Burial 18 4th left rib: central arc developing, smooth, v-shaped pit, smooth, thick walls; phase III, age 24

Burial 31 4th left rib: no central arc, porotic, plaque-lined, u-shaped pit, walls thick from porotic activity; phase VI, age 54

Burial 43 4th right rib: no central arc, porotic, flared, u-shaped pit, scallops on thick walls; phase V, age 34

Burial 48 4th left rib: vague central arc, irregular bony growth and porotic activity in pit, no scallops on thick walls; phase VI, age 52

Burial 54 3rd right rib: central arc present, wide smooth u-shaped pit, irregular wall with bony projection on superior articular margin; phase VI, age 48

Burial 55 4th right rib: central arc present, wide, porotic, flared u-shaped pit thinning walls, some scalloping present but mostly eroded post-mortum: Phase V, age 35

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Sternal Rib End Age Data

- Burial 57 5th left rib: central arc present, deepening v-shaped pit, walls are flared, thinning and scallops are worn; phase IV, age 32
- Burial 63 4th left rib: amorphous and smooth pit, wavy rim; phase IV; age 31
- Burial 67 5th left rib: no central arc, wavy rim; phase I, age 14
- Burial 68 4th left rib: central arc present, bony projections in pit floor, irregular rim is thin and sharp, no scallops; phase VI, age 48
- Burial 74 4th left rib: vague central arc, v-shaped pit is porous and flared, walls are thin and irregular; phase VI, age 50
- Burial 78 3rd left rib: no central arc, pit is frail and porous with bony projections; phase VI, age 55
- Burial 81 4th left rib: no central arc, shallow and porous pit, bony projections on inferior wall; phase VII, age 60
- Burial 90 5th right rib: no central arc, initial v-shape, scallops are beginning to form on thick walls; phase II, age 17
- Burial 107 4th left rib: central arc present, u-shaped pit is shallow, thinning walls have remnant scalloping; phase IV, age 37
- Burial 120 5th left rib: shallow v-shaped pit, smooth floor, scallops on thick walls; phase II, age 19
- Burial 125 4th right rib: no central arc, deep v-shaped pit with bony projections, thin walls are irregular with bony projections; phase VI, age 47
- Burial 129 4th left rib: central arc present, shallow v-shaped pit, thin walls flare slightly, scallops have been damaged post mortem; phase, III, age 43
- Burial 146 4th right rib: There is a central arc present. The u-shaped, plaque lined pit is not deep because of porotic activity. The walls are eroded causing the pit to be shallow; phase VI, age 58
- Burial 183 4th left rib: remnant central arc displays scallops, shallow pit is porotic and flared, thick walls appear flattened, remnant scallops; phase V, age 45
- Burial 196 3rd right rib: developing central arc, amorphous articular surface, smooth pit, walls are thick and scalloped; phase I, age 15
- Burial 207 4th right rib: central arc present, v- shaped pit has thick flared walls, scallops present; phase IV, age 28
- Burial 212 is female individual initially assigned 25-45 with a midrange of 35 on the basis of the pubic symphysis (Suchey/Brooks). Further investigation of the sternal rib end shows bony projections both in the pit and along the rim. The rim is thin, irregular, and widely u-shaped. phase VI, (43-55). This individual is assigned age 42. This individual is also probably male. In studying the pubic symphyses as they are set out for aging, this pubic symphysis is among the most massive present in the sample. The morphology of the ventral arc also follows the morphological characteristics of this population.
- Burial 218 5th right rib: diminished central arc, shallow u-shaped pit with centrally located bony projections, thin walls are sharp with bony projections superiorly, no scallops; phase V, age 39
- Burial 221 4th left rib: central arc present, u-shaped pit has smooth thinning walls, walls are flared and the rim has no scallops; phase IV, age 30

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Burial 232 4th left rib: no central arc, very shallow pit, very flared walls, pit is plaque-lined and porous, scallops remain; phase IV, age 40

Male Rib Sample:

n = 55; phase 0, n = 0; phase I, n = 3; phase II, n = 12; phase III, n = 7; phase IV, n = 16; phase V, n = 14; phase VI, n = 4; phase VII, n=0

Burial 10 4th & 5th left rib: porous u-shaped pit has bony projections, rim is sharp and irregular, no scallops remain; phase VI, age 47.

Burial 15 4th right rib: wide u-shaped pit, scallops on irregular walls; phase III, age 28.

Burial 16 4th left rib: widely u-shaped pit with bony projections, irregular rim, scallops have degenerated into bony projections; phase VI, age 45.

Burial 26 4th right rib: wide u-shaped porous pit, walls are irregular and thin with bony projections; phase V, age 41.

Burial 27 4th left rib: wide u-shaped pit is porous, remnant scalloping, rounded walls, the outer rim displays woven bone; phase IV, age 28.

Burial 29 4th left rib: u-shaped pit is porous, no scalloping, thin irregular rim has bony projections inferiorally and superiorally; phase V, age 46.

Burial 33 4th left rib: regular scalloping is gone but some scallops remain, walls remain rounded but are thinning, u-shaped pit is wide; phase IV, age 32.

Burial 34 5th left rib: shallow u-shaped pit is porous, no scallops, rim is thinning; phase V, age 34.

Burial 38 3rd left rib: porous u-shaped pit, no scallops, thin walls still rounded; phase IV, age 31.

Burial 45 4th right rib: porous u-shaped pit, scallops, thin rim has rounded edges; phase IV, age 30.

Burial 49 3rd left rib: mod. wide u-shaped pit, scallops diminished, thinning walls are rounded and irregular; phase IV, age 31.

Burial 50 4th left rib: billowy pit, scallops in initial development, thick, rounded walls; phase II, age 21

Burial 53 4th left rib: moderately u-shaped pit, minimal scalloping, walls are irregular and thin but still rounded; phase IV, age 31.

Burial 61 5th left rib: moderate u-shaped pit, walls hardly developed and are thick, rounded and scalloped. There is a deep circular insertion which is very smooth as if the tip of an ice pick had been inserted for 1/16th of an inch; phase II, age 18.

Burial 69 4th or 5th left rib: sharp rim with initial bony projections, porous pit with bony projection; phase V, age 40.

Burial 70 4th right rib: wide u-shaped pit, no scallop, sharp walls display bony projections and are irregular; phase V, age 37.

Burial 73 4th right rib: increase in pit depth, scallops are worn post-mortem, the walls are thick, the depth of the side profile matches the photograph for phase II; phase II, age 23.

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Burial 79 4th right rib: very porous and wide u-shaped pit, remnant scalloping on irregular but still rounded rim; phase V, age 33.

Burial 82 4th right rib: moderate u-shaped pit, thick walls with remnant scalloping still rounded but becoming irregular; phase III, age 30.

Burial 84 4th left rib: initial indentation, rounded wavy rim; phase I, age 19.

Burial 86 4th right rib: wide u-shaped, porous pit, no scallops; walls rounded but thinning; phase IV, age 36.

Burial 87 4th right rib: (partial)u-shaped pit; irregular scalloping; walls thin but rounded; phase IV, age 33.

Burial 88 4th left rib: u-shaped scallops on thick walls; phase III, age 24.

Burial 92 4th left rib: porous, wide u-shaped pit; irregular rim developing projectiles; phase V, age 36.

Burial 97 4th right rib: initial v-shaped pit, scalloped walls with smooth, round edges; phase II, age 21.

Burial 100 is indeterminate and initially aged 25+ on the basis of fusion of the medial clavicle. Two left, central sternal rib ends were located and studied. The rims display eroded scalloping on thin walls. The walls are still rounded. The pit is moderately wide and u-shaped. The central arc is still present along with the scalloping. This is female phase IV, 24-32 and male phase IV, 26-32. This individual may be seriated to age 30.

Burial 105 4th right rib: remnant scallops on rounded rim, moderately u-shaped pit; phase V, age 39.

Burial 109 4th left rib: This rib is very gracile; it is also difficult to fit into one of the categories, the walls show little scalloping but the pit depth is characteristic of phase III, a phase associated with scalloping. There is no porosity in the pit. The walls are flared and thinning and slightly rounded. It bears an non-symmetrical articular surface; phase III, age 24.

Burial 118 4th left rib: thin, sharp walls with projectiles beginning; porous pit; phase V, age 39.

Burial 121 4th left rib: thin, sharp walls with projectiles beginning, moderately wide u-shaped pit; phase V, age 38.

Burial 131 4th right rib: very deep porous pit, bony projections on sharp rim; phase VI, age 43.

Burial 132 4th right rib: regular, billowy, flat face; slight indentation, rounded rim; phase I, age 17.

Burial 138 4th left rib: sharp walls with irregular bony projections, wide u-shaped pit; phase V, age 42.

Burial 140 4th left rib: thin walls, pit has two unusual blunt, cylindrical, bony projections; moderately u-shaped pit; phase V, age 38.

Burial 141 4th left rib: u-shaped pit, scallops on thick, round walls; phase III, age 24.

Burial 143 4th left rib: shallow, narrow v-shaped pit; wavy rim starting to scallop, round, thick walls; phase II, age 20.

Burial 144 4th right rib: v-shaped pit; smooth, thick rounded walls with scalloped rim; phase II, age 23.

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Burial 152 4th right rib: although there is post-mortum destruction of the rim, a scalloped rim with smooth rounded edges can be identified. The scallops extend into the pit, classic phase II, age 21.

- Burial 161 4th right rib: large bony projections on sharp rim; porous pit is very thin; phase VI, age 43.

Burial 162 5th right rib: walls are thick, narrow and shallow u-shaped pit is not developed but the scallops are diminished, plaque is accreted in the pit; phase III, age 28.

Burial 164 4th left rib: Thin walls are still rounded, moderately wide u-shaped pit is slightly porous; phase IV, age 32.

Burial 168 4th left rib: v-shape commencing; wavy rim developing scallops; round, thick walls; phase II, age 21.

Burial 170 4th right rib: remnant scallops on thinning walls; moderately u-shaped pit; phase IV, age 29.

Burial 171 4th right rib: porous, shallow, moderately wide u-shaped pit; bony projection inferiorly; phase V, age 35.

Burial 172 4th left rib: v-shaped pit with thick, round, scalloped walls; phase III, age 26.

Burial 175 4th right rib: remnant scallops on rounded walls; u-shaped pit; phase IV, age 28.

Burial 179 4th right rib: moderately u-shaped porous pit; sharp walls developing bony projections; phase VI, age 45.

Burial 182 4th left rib: initial v-shaped pit; scallops on rounded rim; phase II, age 23.

Burial 187 4th right; narrow u-shaped pit; scallops on thick, rounded walls; phase II, age 22. This male individual is aged initially at 20 on the basis of an incomplete pubis, phase I or II (Suchey/Brooks). Two right central ribs were studied and confirm that this is phase II. 20-23 (Ischan) on the basis of a scalloped rim and initial v-shaped pit formation.

Burial 197 3rd left rib: thin, sharp walls; porous, u-shaped pit; phase V, age 35.

Burial 224 4th left rib: narrow u-shaped pit; scallops on regular, rounded rim; phase II, age 24.

Burial 226 4 right rib: initial v-shaped pit; thick, wavy rim developing scallops; phase II, age 20.

Burial 227 3rd right rib: initial indentation in a billowy face; rounded rim forming; phase I; age 17.

Burial 229 central rib: wide u-shaped pit, remnant scallops; walls are rounded; phase IV, age 30.

Burial 237 4th right rib: v-shaped pit; wavy, thick walls developing scallops; phase II, age 22.

Burial 238 4th left rib: moderately u-shaped pit; remnant scallops on thinning walls; phase IV, age 32.

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The Auricular Surface of the Ilium Data

Methods of Application of the Auricular Surface of the Ilium (after Lovejoy et al. 1985a) Description of phases:

20-24 The surface displays fine granular texture and marked transverse organization. There is no retroauricular activity, apical activity, or porosity/ The surface appears youthful because of broad and well-defined billows, which impart the definitive transverse organization. Billows are well-defined and cover most of the surface. Any sub-chondral defects are smooth-edged and rounded. Note distinctive transverse billows and very fine granularity.

25-29 Changes from the previous phases are not marked and are mostly reflected in slight to moderate loss of billowing, with replacement by striae. There is no apical activity, porosity, or retroauricular activity. The surface still appears youthful owing to marked transverse organization. Granulation is slightly more coarse.

30-34 Both faces are largely quiescent with some loss of transverse organization. Billowing is much reduced and replaced by (definite) striae. The surface is more coarsely and recognizably granular than in previous phase with no significant changes at apex. Small areas of microporosity may appear. Slight retroauricular activity may occasionally be present. In general, coarse granulation supersedes and replaces billowing.

35-39 Both faces are coarsely and uniformly granulated, with marked reduction of both billowing and striae, but striae may still be present under close examination. Transverse organization is present but poorly defined. There is some activity in the retroauricular area but this is usually slight. Minimal changes are seen at the apex, microporosity is slight, and there is no macroporosity. This is the primary period of uniform granularity.

40-44 No billowing is seen. Striae may be present but very vague. The face is still partially (coarsely) granular and there is a marked loss of transverse organization. Partial densification (which may occur in islands) of the surface with commensurate loss of grain is present along with slight to moderate activity in the retroauricular area. Occasional macroporosity is seen, depending on the degree of densification. The primary feature is the transition from a granular to a dense surface.

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45-49 Significant loss of granulation is seen in most specimens, with replacement by dense bone. No billows or striae are present. Changes at apex are slight to moderate but are almost always present. There is a distinct tendency for the surface to become dense. No transverse organization is evident. Most or all of microporosity is lost to densification process. There is increased irregularity of margins with moderate retroauricular activity and little or no macroporosity.

50-60 This is a further elaboration of previous stage, in which marked surface irregularity becomes the paramount feature. Topography, however, shows no transverse or other form of organization. Moderate granulation is occasionally retained, but is usually lost during the previous phase and is generally absent. No striae or billows are present. The inferior face generally is lipped at inferior terminus, so as to extend beyond the body of the innominate bone. Apical changes are almost invariable and may be marked. Increasing irregularity of margins is seen. Macroporosity is present in some cases but is not requisite. Retroauricular activity is moderate to marked in most cases.

60+ The paramount feature is a nongranular, irregular surface. with distinct signs of sub-chondral destruction. No transverse organization is present and there is a definitive absence of any youthful criteria. Macroporosity is present in about one third of all cases Apical activity is usually marked but is not requisite for this category. Margins become dramatically irregular and lipped, with typical degenerative joint change. The retroauricular area becomes well-defined with profuse osteophytes of low to moderate relief.

Description of the morphology of the auricular surfaces from the CA-SCI-38 sample

Burial 1 is a male individual assigned age 25-35 based on epiphyseal fusion. The auricular surface is coarse with vague striations. The pariauricular area shows minimal activity. Age estimation assigned this individual to Phase III, age 37

Burial 4 is a female individual 40-50 years old based on epiphyseal fusion. The surface is dense with micropores. The margin is severely lipped. The apical area is severely active. This is phase VI, aged 49.

Burial 8 is a male individual assigned age 25+ on the basis of fusion of the medial clavicle. The auricular surface is slightly coarse with remnant billowing. There is little apical activity and minimal retroauricular activity. Age estimation was reassigned to phase III and the individual is seriated to age 34.

Burial 9 is a female individual initially aged 30+ on the basis of a portion of the pubic symphysis utilizing the Suchey-Brooks method. The auricular surface is very irregular

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with both macro and microporotic activity. There is no transverse organization. The apex is severely modified. The retroauricular is moderately active. The margins are folded and lipped. This individual was reassigned phase VII and seriated to age 52.

Burial 10 is a male individual aged 35-55 based on epiphyseal fusion. The grain is coarse with moderate periapical activity. This is Phase VI, age 47

Burial 11 is a male individual aged 17-23 based on epiphyseal fusion. The surface is fine with billows. There is no periapical activity. This is Phase II, age 26.

Burial 12 is indeterminate sex and was initially assigned age 18+ on the basis of the fusion of the medial clavicle. A closer look at the remains revealed a portion of the auricular surface of the ilium. Based upon densification of the irregular surface and the loss of transverse organization and irregular margins this individual is at least a phase VI, 45-49 and seriated at 47.

Burial 13 is a male individual aged 30-45 based on the pubic symphysis. The surface is coarse to dense with vague striae. There is moderate periapical activity indicating Phase IV, aged 37.

Burial 14 is a male assigned age 21+ on the basis of fusion of the medial clavicle. The auricular surface of the ilium displays "islands" of densification and has an irregular surface with a few interspersed macropores. This is classic phase V, 40-44. Because it is mid phase V in this population, it is assigned to 42.

Burial 15 is a male individual aged 25-45 based on the pubic symphysis. The surface is coarse to dense. The periapical area is moderately active. This is Phase IV, age 42.

Burial 16 is male assigned an age range of 30-45 on the basis of Suchey-Brooks pubic symphyseal method. The auricular surface is coarse with islands of densification. There is minimal margin and apical activity with moderate retroauricular activity. This places the age estimation to Phase V, 35-39. Seriation assigns the age to 46.

Burial 17 is indeterminate sex and is aged 25+ on the basis of suture closure. Portions of both left and right auricular show a macroporotic surface with marked changes in the periauricular areas. The dense bone is gone and the surface is entirely porotic. The margin has begun to blend in with the surrounding bone. This is phase VI, 45-49. The ribs display rims that are eroded and there are bony projections in the pit. There is no central arc remaining. This is at least phase VI, 43-58. This individual may be seriated to 47.

Burial 18 is female and aged at 21-28 on the basis of the pubic symphysis (Suchey-Brooks) with a median assigned age 25. Both left and right auricular surfaces demonstrate fine to coarse texture on the surface with minimal apical, retroauricular and margin activity. The left auricular is microporotic on the inferior demiface but there are

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remnant billows superiorly. On this basis the individual is assigned to phase III, 30-34, and seriated to age 32.

Burial 19 is male assigned age 25+. However the auricular surface is coarse to dense with moderate activity on the periauricular regions. The surface is also microporotic. Therefore is reassigned phase V and seriated to age 43.

Burial 24 is a male individual aged 35-45 by the pubic symphysis. The surface has "islands of densification" and the periauricular area is moderately active. This is phase V, age 42

Burial 26 is male aged 27-46 on the basis of the Suchey-Brooks pubic symphyseal method. The auricular surface reveals uniform densification with microporotic activity. The apex and retroauricular areas are minimally active. The margins are moderately active. This individual was reassigned to phase V and seriated to age 44.

Burial 27 is male assigned 30+ on the basis of the pubic symphysis (Suchey-Brooks). The grain of the auricular surface is coarse to fine. The transverse organization shows reduced billowing and imminent striae. There is no marginal activity and minimal retroauricular activity. Auricular age was estimated as phase III and seriation assigned age 33.

Burial 28 is female aged initially at 25-35 with a median age of 31. Transverse organization is gone and there is significant loss to dense bone. The apical margin is moderately active. There is distinct microporosity and lipping of the margin along the entire perimeter. The auricular surface of the ilium is aged at phase VI, 45-49, and seriated at age 45.

Burial 31 is a female individual initially aged 40+ on the basis of the pubic symphysis (Suchey 1986). The auricular surface of the ilium is macroporotic and the apical margin shows marked change. This is auricular phase VII. The rim of a central rib is very irregular and displays boney projections on the inferior margin. The pit is porous. This is at least phase VI (Iskan 1989), 43-58. This individual is seriated to age 54.

Burial 32 is a female individual aged 17-21 by the pubic symphysis. The surface is fine with billows. This is Phase II, aged 25.

Burial 33 is a male individual aged 27-37 based on the epiphyseal fusion. The surface is fine to coarse with billows. This is Phase III, aged 33.

Burial 34 is a male individual aged 35-50 based on the pubic symphysis. The surface is dense with micropores. The periauricular area is moderately active. This is Phase VI, aged 45.

Burial 38 is male aged 45-60 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is uniformly coarse and demonstrated transverse striae. There is

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retroauricular and apical activity. There is moderate margin activity. This element was assigned to phase IV and seriated to age 36.

Burial 42 is a male individual aged 35-50 based on the pubic symphysis. The periauricular area is coarse to dense with macropores. The periauricular area is moderately active. This is Phase V, aged 42.

Burial 43 is female initially aged 35-50 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is marked with irregularity, microporosity, and macroporosity. All periauricular areas demonstrate marked activity. This is phase VI (43-58). this individual was seriated to age 47.

Burial 45 is male initially aged 25-31 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is uniformly coarse with vague transverse organization. Periauricular activity is minimal. This individual was assigned phase IV and seriated to age 35.

Burial 48 is female and was assigned age 35-50 based on pubic faces (Suchey-Brooks) which are "not well defined". The auricular surface is at least phase VI based on densification of bone, severe apical activity, moderate retroauricular activity, an irregular, macroporotic surface with lipped margins. It is more likely phase VII, 50-59. The sternal rib end also puts this individual into the 50's seriated to age 51.

Burial 49 is male initially aged 21-30 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface demonstrates fine to coarse grain. Billows turning to striae define the transverse organization. There is no apical activity and moderate retroauricular and margin activity. This individual is assigned phase III and seriated to age 32.

Burial 50 is male aged 18-21 by the pubic symphysis. The surface is fine with billows. There is no periauricular activity. This is Phase I, aged 22.

Burial 52 is male initially aged 18-23 on the basis of pubic symphyseal development. The auricular surface is coarse with some striae remaining in a relatively quiescent face. The periauricular region demonstrates minimal activity. This individual is phase III, seriated to age 30.

Burial 54 is female initially aged 34-50 with a midrange of 42 on the basis of the pubic symphysis (Suchey-Brooks). Todd's 10 phase put this individual at the degenerative phase VIII, 40-44. The ribs also places this individual at phase VI, 43-58, on the basis of the bony projections on the rim and the widely u-shaped pit. This individual is seriated age 48.

Burial 55 is female initially aged 27-32 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is fine to coarse with billows becoming striae. The apex

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and margin is moderately active, the retroauricular minimally active. This is phase V and this individual was seriated to age 42.

Burial 61 is male initially aged 25-35 according to the pubic symphysis with a midrange of 30. The auricular surface of the ilium is phase V, 40-44. there is poorly defined transverse organization, bone is mostly dense, the periauricular areas are moderately active except for the apex which is slightly active. This individual is seriated to age 41.

Burial 64 is male aged 21-29 by the pubic symphysis. The surface is fine to coarse with billows. There is minimal periauricular activity. This is Phase II, age 25.

Burial 67 is a female aged 18-21 by the pubic symphysis. The surface is fine to coarse with billows. This is Phase II, age 18.

Burial 63 is a female individual initially aged 25+. The auricular surface is coarse and quiescent. There is minimal retroauricular activity but no apical or other marginal activity. This is phase III and this individual is seriated to age 33.

Burial 68 is female initially aged 33-60 on the basis of a fragment of the pubic symphysis (Suchey-Brooks). The auricular surface of the ilium and the rib age estimation place this individual at least age 48 to 50. The auricular surface is coarse to dense grain. There is microporotic activity of the surface. the retroauricular region demonstrates severe breakdown and the margin, marked irregularity. This individual is seriated to age 50.

Burial 69 is a male individual initially aged 27-36 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is coarse to dense grain. There is no transverse organization and the apex and margin demonstrate no activity. there is minimal retroauricular activity. This is phase V and seriation places this individual at age 40.

Burial 70 is a male individual initially aged 35-45 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is mostly coarse with vague transverse organization. The apex and retroauricular area demonstrated minimal activity. The inferior dorsal margin is lipped. This individual is phase V, seriated to age 41.

Burial 71 is a male individual aged 17-20 based on epiphyseal fusion. The surface is fine with billows. There is little periauricular activity. This is Phase I, aged 20.

Burial 74 is a female individual initially aged 35+ on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface of the ilium demonstrates "islands of densification" and is markedly irregular with no transverse organization. There is moderate retroauricular activity. The margin is very irregular and has become lipped and then folded. This individual is assigned auricular phase VII and seriated to age 55. Rib age estimation confirms this advanced age.

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Burial 76 is a male individual initially aged 25+ on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is dense with macropores and there is no transverse organization. the apex demonstrates moderate activity, as does the rest of the margin. The retroauricular area is minimally active. This individual is assigned to phase VI and seriated to age 45.

Burial 78 is female and is initially aged at 30-45 on the basis of the pubic symphysis. Assigned to phase IV or V (Suchey-Brooks) this mid ranges are 38 to 48. Todd's 10 phase puts this at VIII, 40-44 because the rim is complete and the face is slightly depressed from the rim. The auricular surface of the ilium is dense with "islands" and bears vague striations. The periauricular areas are moderately active. This is Phase V, 40-44. This individual may be seriated to age 44.

Burial 79 is indeterminate sex assigned age 29-35 by the pubic symphysis. The surface is coarse to dense. There is moderate apical activity. This is Phase V, aged 40.

Burial 80 is a male individual initially aged 25-35 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is dense with no transverse organization. The apex is not active but the margin and retroauricular areas are active. This is a phase V, seriated to age 44.

Burial 81 is male aged individual initially aged 25-35 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is dense with no transverse organization. The apex is not active but the margin and retroauricular areas are active. This is a phase V, seriated to age 44.

Burial 82 is male aged 31-40 by the pubic symphysis. The surface is coarse with striae. The apical area is minimally active. This is Phase III, age 31.

Burial 84 is male aged 16-20 by the pubic symphysis. The surface is fine to coarse. There are billows. the apical area is not active. This is Phase I, age 23.

Burial 85 is a female individual initially assigned 18-20 years. The auricular surface demonstrated fine grain. Billowing is turning to striae. The periauricular areas are inactive. The phase is II and seriation is age 26.

Burial 87 is a male individual aged 25-40 on the basis of the pubic symphysis (Suchey-Brooks). The auricular demonstrates coarse grain but some irregular billowing remains. There is minimal activity in the periauricular areas. This is phase V and age is seriated to age 44.

Burial 88 is a male individual initially aged 21-29 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is fine but becoming coarse. Billows are being replaced with striae. The periauricular areas are minimally active. This is phase III, seriated to age 33.

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Burial 89 is a male individual initially aged 27-46 on the basis of pubic symphyseal development (Suchey-Brooks). The auricular surface is dense with macropores on the inferior demiface. There is no transverse organization. The apex demonstrates severe lipping and the retroauricular and margin regions moderately active. This is phase VI, seriated to phase 46.

Burial 90 is a female aged 20-25 based on the pubic symphysis. The surface is fine with billows. There is no apical activity. This is Phase I, age 19.

Burial 92 is a male individual initially aged 27-37 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is uniformly coarse and transverse organization is poorly defined. The margin and apex demonstrate no activity but the retroauricular area is minimally active. This is phase IV, seriated to age 38.

Burial 93 is female aged 45-55 by the pubic symphysis. The surface is coarse with macropores. there is moderate activity of the periauricular area. This is Phase VII, aged 46.

Burial 97 is male aged 18-23 by the pubic symphysis. The surface is fine with billows and minimal activity. This is Phase I , age 20.

Burial 98 is female aged 18-22 by the pubic symphysis. The surface is fine to coarse with billows. The periauricular area is minimally active. This is Phase II, age 26.

Burial 101 is a male individual initially aged 25-40 on the basis of pubic symphyseal development (Suchey-Brooks). The auricular surface is coarse to dense with no transverse organization. the apex and retroauricular area demonstrate moderate activity, the margin minimal. This is phase V, seriated to age 41.

Burial 103 is a male individual initially aged 35+ on the basis of epiphyseal fusion. The auricular surface is coarse to dense with micro and macroporotic activity and no transverse organization. There is marked activity of the margin. This is phase V and this individual is seriated to age 49.

Burial 107 is a female individual aged 25-30 on the basis of pubic symphyseal development (Suchey-Brooks). The auricular surface is coarse with islands of densification. The apex and margin demonstrate minimal activity. The retroauricular is moderately active. This is phase V, seriated to age 45.

Burial 109 is a male individual initially aged 20-24 on the basis of pubic symphyseal development (Suchey-Brooks). The auricular surface demonstrates fine to coarse grain and billows are reduced. There is minimal activity at the margin and apes and moderate activity at the retroauricular area. This is phase II, seriated to age 27.

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Burial 110 is a female individual aged 30+ on the basis of epiphyseal fusion. The auricular surface is coarse to dense with vague striae. The apex demonstrates minimal activity while the retroauricular and margins are moderate. This is phase V, seriated to age 41.

Burial 111 is a male individual initially aged 21-30 on the basis of pubic symphyseal development (Suchey-Brooks). The auricular surface is fine to coarse grain. The face is quiescent with striae. The periauricular areas demonstrate minimal activity. This is phase III, seriated to age 30.

Burial 116 is a female individual initially assigned age 23-30 and given a mid-range of 27 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is present as well and has islands of densification, active margin and retroauricular but still no apical activity. This is a classic phase V, 40-44 The pubic symphysis of this os coxa is assigned phase II. (Suchey-Brooks). The "symphyseal face is completely rimmed with some slight depression of the face itself, relative to the rim. Moderate lipping is {usually} found on the dorsal border. There is little or no rim erosion"(description of Suchey-Brooks Phase V, accompanying casts). There are ligamentous growths on the inferior ventral rampart which indicate this is later than phase 3. This goes along with the auricular surface estimation. Revised Todd 10 Phase (Meindl, 1985) defines age interval 25-29 as having no ventral rampart formation. This element has ventral rampart formation complete. According to these definitions, 116 is at least 40 years old. Burial 116 is a Todd (1920) phase VIII, seriated to 40 years old. One central sternal rib end was found and aged to phase V because of thinning walls and a wide u-shaped pit. only a small portion of the central arc projected above the rim. Iscan (1989) phase V is 33-46. This individual is originally assigned age 27 and this original age was deferred to.

Burial 122 is a male individual initially aged 25+ on the basis of fusion of the medial clavicle. The auricular surface is uniformly grain with vague striae. The margin demonstrates minimal activity, the retroauricular is moderately active. This is phase V, seriated to age 45

Burial 123 is a female individual initially aged 25+ on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is coarse to dense with no transverse organization. The surface is breaking down under macroporotic conditions. The apical region demonstrated marked activity and the margin is severely distorted. The ventral margin is lipped and distorted. The retroauricular area is moderately active. This is phase VI, seriated to age 48.

Burial 141 is a male individual initially aged 17-23 on the basis of pubic symphyseal development (Suchey-Brooks). The auricular surface is fine to coarse grain. billows are reduced. There is minimal activity in all three periauricular areas. This is phase II, seriated to age 28.

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Burial 144 is a male individual initially aged 18-25 on the basis of pubic symphyseal development (Suchey/ Brooks). The auricular surface is fine to coarse grain and billows are reduced. Minimal activity is demonstrated for all periauricular areas. This is phase II, seriated to age 27.

Burial 148 is a male individual aged 25-35 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is uniformly coarse with poorly organized striae. There is no activity at the apex. The retroauricular and margin demonstrates minimal activity. This is phase IV, seriated to age 36.

Burial 157 is male individual initially aged at 21-25 with a midrange of 23. on the basis of a Suchey-Brooks (phase II, 19-35). The ventral rampart is complete but the face is not well defined. There is retention of the granular surface The auricular surface of the ilium is coarse grained and billows have become striae. The apex is slightly active. This is phase III, 30-34 seriated to age 32.

Burial 162 is a male individual initially aged 25-35 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is fine grain with billows. There is no periauricular activity. This is phase III, seriated to age 31.

Burial 164 is a male individual aged 32-38 on the basis of the auricular surface. The auricular surface demonstrates islands of densification with micropores and vague transverse organization. The apex demonstrated marked activity. The retroauricular and margin areas are moderately active. This is phase V, seriated to age 40.

Burial 165 is a male individual initially aged 35+ on the basis of fusion of the medial clavicle. The auricular surface is microporotic with islands of densification. Minimal activity of the apex and retroauricular area and moderate activity along the margin is present. This is phase V. seriated to age 43.

Burial 167 is a male individual aged 18-20 on the basis of the pubic symphysis. (Suchey-Brooks). The auricular surface is fine to coarse with billowing reduced. The three periauricular areas demonstrate minimal activity. This is phase II, seriated to age 24.

Burial 170 is a male individual aged 20-24 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is fine to coarse with striations. There is minimal activity of the three periauricular areas. This is phase II, seriated to age 30.

Burial 171 is a male individual aged 35-39 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is coarse with islands of densification. There are vague striations. The retroauricular area is damaged post-mortum. The apex and margin demonstrate minimal activity. This is phase V, seriated to age 42.

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Burial 172 is a male individual aged 25-35 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is uniformly coarse with striae. All three periauricular areas demonstrate minimal activity. This is phase IV, seriated to age 37.

Burial 175 is a female individual aged 25+ on the basis of epiphyseal fusion. The auricular surface is fine to coarse with striae replacing billows which are still evident. The periauricular areas demonstrate minimal activity. This is phase III, seriated to age 30.

Burial 181 is an indeterminately sexed "adult" on the basis of epiphyseal fusion.. A portion of the auricular surface was located. The grain of the surface is becoming coarse, and there are striations. There is slight activity along the margin and at the apex. This is phase III, 30-34. This individuals is seriated at age 34.

Burial 184 is female aged 60 on the basis of the auricular surface. Subchondral destruction of the auricular surface is extensive. All periauricular areas are severely active. The margin is almost obliterated. There is partial fusion of the sacrum along the anterior superior margin of the left elements which includes the apical area. This individual is assigned to phase VIII and seriation assigns age 60+.

Burial 185 is indeterminate aged at 25+ on the basis of fusion of the medial clavicle. The ribs were studied and a portion of a central rib was located. This rib has no scalloping left. The rim is thin and sharp. Although the sex is indeterminate, in both phase analysis, thin and sharp walls indicate at least phase V 32-42 in males and 33-46 in females. This individual may be aged at least 32.

Burial 189 is a female aged 35-50 with a mid range of 42 (Suchey-Brooks V-2/VI-1; 25-87 years). Todd's 10 phase method (1921a) places the pubic symphysis into the degenerative phase IX. 45-50. The dorsal face is rimmed and the dorsal rim is breaking down. The face is porotic and irregular. The auricular surface of the ilium is macroporotic with marked changes in the periauricular areas. There is some dense bone remaining. This is phase VI, 45-49. This individual may be seriated to age 48. The ribs are also a later degenerative phase with porous pits and boney projections. The rim is breaking down; phase VI, 43-55.

Burial 198 is a female individual aged 25-30 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is uniformly coarse with no transverse organization. The apex and retroauricular areas are inactive. There is minimal activity on the margin. This is phase V, seriated to age 42.

Burial 201 is a male individual aged 25-35 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is uniformly coarse with no transverse organization. There is no activity of the apex. The retroauricular area demonstrates moderate activity, the margin minimal activity. This is phase V, seriated to age 44.

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Burial 202 is indeterminate and aged at 25+ on the basis of epiphyseal fusion of the long bones. The auricular surface of the left ilium is coarse with islands of densification and transverse organization is poorly defined. The margins are moderately active especially at the apex. There is moderate retroauricular activity. This is phase V, age 41-45. This individual is assigned age 42.

Burial 205 is a female individual aged 31-40 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is microporotic and dense with no transverse organization. There is no activity at the apex. The retroauricular and margin areas demonstrate moderate activity. This is phase V, seriated to age 43.

Burial 206 is a female individual aged 25-40 on the basis of the pubic symphysis (Suchey-Brooks). The right auricular surface is coarse to dense with macropores. There is vague transverse organization. The apex demonstrates minimal activity, the retroauricular and margin areas are both moderately active. This is phase V, seriated to age 45.

Burial 210 is female individual initially assigned to age 25+ on the basis of fusion of the medial clavicle. Inspection of a partial auricular surface shows vague transverse organization and "islands" of densification. The retroauricular is moderately active and there is slight activity of the apical margin. This is phase VII, seriated to age 58.

Burial 215 is a female individual initially aged 35+ on the basis of fusion of the medial clavicle. The auricular surface demonstrates islands of densification with no transverse organization. The apex is moderately active, the retroauricular severe, and the margin minimally active. This is phase VI, seriated to age 44.

Burial 221 is female aged 25-35 based on the pubic symphysis. The surface is quiescent. The periauricular area is markedly active. This is Phase III, age 34.

Burial 223 is female initially aged at 35++ based on epiphyseal fusion of long bones. The auricular surface of the ilium still displays coarse grained bone. The retroauricular area is moderately active. The apex on the left side is not active but the right apex is moderately active. This is the only specimen looked at in which the posterior margin is gone. Still the entire surface is not dense. Phase is estimated to VI, 45-49. This individual is aged at 49.

Burial 224 is male aged 21-26 based on the pubic symphysis. The surface is fine to coarse with billows reduced. The periauricular area is minimally active. This is Phase II, age 25.

Burial 225 is indeterminate and very fragmented but fortunately both auriculars are available for study. The billowing has been replaced by striae. There is slight retroauricular activity. This is phase II, 25-29. This individual is aged at 25.

Burial 228 is of indeterminate sex aged 17-25 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is fine to coarse texture with billows reduced. There is no periauricular activity. This is phase II, seriated to age 29.

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Burial 229 is a male individual aged 25-35 on the basis of the pubic symphysis (Suchey-Brooks). The auricular surface is coarse to dense with vague striae. There is moderate periauricular activity of all three regions. This is phase V, seriated to age 41.

Burial 231 is indeterminately sexed, aged 30-40 based on the pubic symphysis. The surface is fine to coarse with billows. The periauricular area is minimally active. This is Phase III age 30.

Burial 232 is female, aged 35-50 based on the pubic symphysis. The surface is coarse with severe activity in the periauricular area. this is Phase VII, aged 41.

Burial 234 is indeterminate and aged at 35+. The auricular surface of the ilium is partially fused with the sacrum. The apical margin and the retroauricular are severely distorted. The surface is completely dense and the entire margin is irregular and lipped. This is phase VII, 50-60. This individual is aged 50.

Burial 236 is aged male aged at 17-23, midrange = 20. Cristal fusion is complete and shows not a trace of the fusing process. The billows are reduced and coarse granularity is taking over. This is phase II, 25-29. Considering the medial clavicle is not fused, this individual could be estimated to be age 25.

Burial 237 is a male individual aged 18-25 based on the pubic symphysis. the surface is fine to coarse with vague striae. The periauricular area is minimally active. this is Phase I, age 23.

Burial 238 is a male individual aged 25-35 based on the pubic symphysis. The surface is uniformly coarse with minimal activity. The margin is lipped. This is Phase IV, age 39.

Burial 240 is a male individual aged 18-25 on the basis of epiphyseal fusion. The auricular surface is fine to coarse grain. The surface is quiescent. There is moderate activity at the apex and minimal activity of the retroauricular and margin areas. This is phase III, seriated to age 30.

APPENDIX C
The Auricular Surface of the Ilium Data

Burial #	sex	sd	ph	grain	transverse	apex	retro	margin	lg	sc	age
1	m	l	3	becoming coarse	vague	min	min	mod	a	a	30
4	f	l	6	dense/macropor	a	mod/sev		sev/lipped	a	a	49
8	m	l	3	fine/coarse	billows	a	min	a	a	a	34
9	f	l	6	irreg/micro; macropor	a	severe	mod	lipped	p	a	52
10	m	l	6	coarse/dense	a	mod	mod	mod	p	a	47
11	m	l	2	fine	billows	a	a	min	a	a	26
12	l	l	6	dense	a	mod	mod	mod	p	a	47
13	m	l	4	coarse/dense	vague	mod	mod	mod	a	a	37
15	m	l	4	coarse/dense	vague	min	min	mod	p	a	38
16	m	l	5	coarse/dense	vague	min	mod	min	a	a	46
18	f	l	4	fine/coarse	billows	min	min	min	p	p	32
19	m	r	5	coarse/dense	vag/micropore	mod	mod	mod	p	a	43
24	m	l	5	islands	vague	mod	min	mod	p	p	42
26	m	l	5	dense/micropor	a	min	min	mod	a	a	44
27	m	r	3	fine/coarse	billows	a	min	a	a	a	33
28	f	l	6	cor/dens/macro	a	marked	mod	mod	a	a	44
29	m	l	4	coarse/dense	striae	a	mod	mod	p	a	37
31	f	l	7	subchon destr/microp	a	severe	severe	severe	p	a	53
32	f	l	2	fine/coarse	billo redux	a	a	min	p	a	25
33	m	r	3	fine/coarse	billo/stria	a	min	a	a	a	33
34	m	l	6	dense/micro	a	mod	mod	mod	a	a	45
38	m	l	4	uniformly coarse	stria	min	min	mod	a	a	36
39	f	l	6	fine/coarse	billo/stria	a/patho	min	min	p	p	24
42	m	r	5	c/d/macro	a	mod	absent	mod	a	a	42
43	f	l	6	marked irreg, macroµ	a	marked	marked	marked	p	p	47
45	m	l	4	uniform coarse	vague	min	min	min	a	a	35
48	f	l	6	dense, micro¯o	a	mod	mod a.a.	mod, lip	p	p	49
49	m	l	3	fine/coarse	billo/stria	a	min	min	p	a	32
50	m	r	1	fine	billows	a	a	a	a	a	22
51	m	r	2	fine/coarse	billo redux	a	des	a	a	a	29
52	m	l	3	coarse/quiescent	striae	min	min	a	a	a	30

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The Auricular Surface of the Ilium Data

Burial #	sex	sd	ph	grain	transverse	apex	retro	margin	lg	sc	age
53	m	l	3	fine/coarse	striae	a	min	a	a	a	33
55	f	l	5	fine/coarse	billo/stria	mod	min	mod	a	a	42
56	f	l	3	fine/coarse	stria	mod	mod	mod	p	p	35
57	f	l	5	islands	vag. stria	min	mod	min	p	a	39
58	f	l	2	fine/coarse	billows	min	min	min	p	p	path
60	f	l	4	uniformly coarse	vague	mod	mod	mod	p	p	42
61	m		5	uniformly coarse	vague	mod	mod	mod	p	p	41
62	m	r	1	fine	billows full	a	a	developing	a	a	19
63	m	l	3	coarse	striae	a	min; a.a.	a	a	a	33
64	m	l	2	fine/coarse	bil/stria	a	a	min	p	a	25
67	f	l	2	fine/coarse	billows redux	a	a	a	p	p	18
68	f	r	6	coarse/dense	irreg	macro	severe	marked irreg	p	p	50
69	m	l	5	coarse/dense	a	min	mod	min	a	a	40
70	m	l	5	fine/coarse	striae	min	min	min	a	a	41
71	m	l	1	fine	billows	min	min; a.a.	min	a	a	20
73	m	l	2	fine/coarse	billows inferior	min	min	min	a	a	28
74	f	l	6	islands	a	min	mod	min	a	a	55
76	m	l	6	dense/macropores	a	mod	mod; a.a.	min	p	a	45
79	m	l	5	dense/coarse	a	min	mod	mod	a	a	40
78	f		V	uniformly coarse	vague	mod	mod	mod	p	p	44
80	m	l	6	dense	a	min	mod	mod	p	a	44
81	m	l	6	coarse	a	mod	mod	mod	a	a	44
82	m	l	3	coarse	billo/striae	min	min	mod	a	a	31
84	m	l	1	fine	billows	a	a	min	p	a	23
85	f	r	2	fine	billow/stria	a	a	a	a	p	26
87	m	l	5	coarse	billo/irregren	min	min	min	a	a	44
88	m	r	3	fine/coarse	billo/striae	min	min	min	p	a	33
89	m	l	6	dense/macro	a	flipping	mod	mod	a	a	46
90	f	l	1	fine	billows	a	a	a	a	a	19
92	m	l	4	uniformly coarse	vague striae	a	min	a	p	a	38
93	f	l	7	coarse/macropores	a	mod	mod	mod	p	p	46

APPENDIX C
The Auricular Surface of the Ilium Data

Burial #	sex	sd	ph	grain	transverse	apex	retro	margin	lg	sc	age
97	m	l	2	fine	billows	porosity	min	min	a	a	20
98	f	l	2	fine/coarse	billow/striae	min	min	min	a	a	26
101	f	l	5	coarse/dense	vague	min	mod	mod	des	p	41
103	m	l	5	destruct of subchondral	macro/micro	min	marked	marked	des	p	49
107	f	l	3	fine/coarse	striae	min	min	min	a	a	45
109	m	l	2	fine/coarse	billows redux	min	a	min	a	a	27
110	f	l	5	coarse/dense	vague	min	mod	mod	des	p	40
111	m	l	3	fine/coarse	quiescent/striae	a	min	min	p	a	30
112	f	l	2	fine	billows redux	a	min	min	p	p	27
113	m	l	2	uniformly coarse	a	a	a	a	a	a	24
118	m	l	4	coarse/dense/macros	striae	mod	mod'a.a.	min	a	a	38
120	f	l	1	fine	billows	a	min	min	a	a	20
121	m	l	6	dense/macropores	a	min	mod	mod	a	a	47
122	m	r	4	uniform	vague	min	mod'a.a.	min	a	a	39
123	f	l	6	coarse/dense	a	marked	mod	severe	p	p	48
125	f	l	6	microporotic	a	mod	mod	mod	a	p	46
126	f	l	6	dense/macro	a	mod	marked	marked	a	p	48
129	f	r	5	coarse/dense/micropores	vague	mod	mod'a.a.	mod	p	p	41
131	m	l	4	coarse	vague	min	min	mod	p	a	38
132	m	l	1	fine	billows	a	a	a	a	a	21
138	m	l	3	fine/coarse	billows/striae	min	mod	min	p	a	36
140	m	l	4	uniformly coarse	vague striae	min	min	a	a	a	36
141	m	l	2	fine/coarse	billows redux	min	min	min	a	a	28
142	f	l	1	fine	billows	lipped	min	a	a	a	23
143	m	l	2	fine/coarse	billows redux	a	min	a	a	a	25
144	m	l	2	fine/coarse	billows redux	min	min	min	a	a	27
145	m	r	4	uniformly coarse	vague	min	mod'a.a.	mod	p	a	39
146	f	l	7	destruct subchond/macros	a	marked	mark;a.a.	mod	p	a	55
147	m	r	4	uniform	striae	min	min	min	a	a	35
148	m	r	4	uniform	vague striae	a	min	min	p	a	36
152	f	l	1	fine	billows	a	a	a	a	a	21

APPENDIX C
The Auricular Surface of the Ilium Data

Burial #	sex	sd	ph	grain	transverse	apex	retro	margin	lg	sc	age
157	m	l	3	fine/coarse	striae	min	min	min	p	p	32
160	m	l	3	fine/coarse	striae	min	min	min	a	a	29
161	m	r	5	coarse/dense	vague	mod	mod	mod	a	a	42
162	m	l	3	fine	billows	a	a	a	a	a	31
164	m	l	5	dense/micros	vague	marked	mod	mod	a	a	40
165	m	l	5	microporous	a	min	min	mod	a	a	43
166	m	l	2	fine/coarse	billows redux	a	a	a	dest	a	20
167	m	r	2	fine/coarse	billows redux	min	min	min	a	a	24
168	m	l	1	fine/coarse	billows redux	a	a	a	a	a	20
170	m	l	3	fine/coarse	striae	min	min	min	a	a	35
171	m	l	5	islands	vague	min	dest	min	dest	a	42
172	m	l	4	fine/coarse	striae	min	min	min	a	a	37
175	f	l	3	fine/coarse	billow/striae	min	min	min	a	a	30
179	m	l	5	islands	vague	mod	mod	min	a	a	43
183	f	l	6	coarse/dense/macros	a	mod	mod	mod	a	p	45
184	f	l	8	subchondral dest.	a	severe	severe	severe	p	p	60
187	m	l	2	fine/coarse	billows redux	min	a	min	a	a	29
189	f		6	coarse/dense/macros	a	mod	mod	mod	a	p	48
196	f	l	2	fine/coarse	billows redux	mod	path	mod	a	p	25
197	m	l	3	fine/coarse	vague	a	min	min	a	a	34
198	f	l	4	uniform	a	a	a	mod	a	a	38
201	m	l	5	uniformly coarse	a	a	mod	min	a	a	44
205	f	l	5	dense/macropores	a	min	mod	mod	p	p	43
206	f	l	6	dense and irreg		mod	mod	mod	p	p	45
207	f	r	2	fine/coarse	billows redux	porous pathology	mod	mod	p	p	27
209	f	r	1	fine	billows	min	severe	min	p	a	20
210	f	l	8	subchondral dest.	a	severe	severe	severe	p	p	58
212	f	l	6	fine/coarse	striae	marked	marked;a.a.	marked	p	p	45
215	f	r	5	dense/islands	vague	mod	severe	min	p	p	44
219	m	l	3	fine/coarse	vague billows	a	min	min	a	a	30
221	f	l	3	coarse/quiescent	striae	marked	min	marked	a	p	34

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The Auricular Surface of the Ilium Data

Burial #	sex	sd	ph	grain	transverse	apex	retro	margin	lg	sc	age
223 f	f	l	6	microporotic	a	mod	mod	mod	a	p	49
224 m	m	l	2	fine/coarse	billows redux	a	min	min	a	a	25
225 i	f	l	2	fine/coarse	billows redux	porous pathology	mod	mod	p	p	25
226 m	m	l	1	fine	billows	a	a	a	a	a	20
228 m	m	r	2	fine/coarse	billows redux	a	a	a	a	a	29
229 m	m	r	5	coarse/dense	vague	mod	mod	mod	a		41
230 f	f	l	5	islands	vague	min	min	mod	p	p	40
231 m	m	l	3	fine/coarse	billows/striae	a	min	min	p	a	30
232 f	f	l	7	coarse/dense	a	min	severe	min	p	p	41
233 m	m	l	3	fine/coarse	billows/striae	min	min	a	a	dest	31
236 m	m	r	3	fine/coarse	quiescent	a	a	a	a	a	30
237 m	m	l	2	fine/coarse	vague striae	min	min	min	p	a	23
238 m	m	r	4	uniformly coarse	striae	min/porous	min	lipped	a	a	39
240 m	m	l	3	fine/coarse	quiescent	mod	min	min	a	a	30
241 m	m	r	3	uniformly coarse	vague striae	min	mod	min	a	a	37

APPENDIX D
Calculations for Life Table Analysis (after Mensforth 1988)

x : Age interval in years

d_x : Absolute number of individuals dead at age x

l'_x : Absolute number of individuals in the population who are alive at age x .

$$\text{1st } l'_x \text{ value} = \sum d_x$$

$$\text{all } l'_x + 1 \text{ values} = [l'_x - d_x]$$

l_x : Absolute number of individuals in the population who are alive at age x , out of a specified radix (i.e., 100, 1000, 10,000, etc.)

$$\text{1st } l'_x \text{ value} = 1,000$$

$$\text{all } l'_x + 1 \text{ values} = \left[\frac{(l'_x + 1)}{l'_x} \right] 1,000$$

L_x : Number of person years lived in age class x

$$L_x = \frac{[l_x + (l_x + 1)]}{2} \times n$$

n = number of years in age interval

L'_x : The proportion of person years lived in age class x , based on a specified radix.

$$L'_x = \frac{L_x}{1000}$$

T_x : The total number of person years to be lived by the population now at age x , before all are dead.

$$\text{1st } T_x \text{ value} = \sum L_x$$

$$\text{all } T_x + 1 \text{ values} = [T_x - L_x]$$

E_x : Life expectancy at age x , the total number of years that a person who reaches age x can expect to live beyond age x .

$$E_x = \frac{T_x}{l_x}$$

Q_x : Probability of dying in age class x .

$$Q_x = \frac{d_x}{l'_x}$$

APPENDIX D
Calculations for Life Table Analysis (after Mensforth 1988)

C_x : Age distribution, the percent of the population at age x .

$$C_x = \frac{L_x}{\sum L_x}$$

K_x : Mean age-specific fertility coefficients, archetypal fertility data (i.e., annual rates).

mL'_x : Age-specific fertility adjusted for mortality in age class x .

$$mL'_x = L'_x (K_x)$$

$\bar{B}$: Mean annual fertility rate, the average number of daughters born per year to women aged 15-50.

$$B = \sum mL'_x$$

$$\bar{B} = \frac{1}{B}$$

Fb_x : Annual age-specific fertility rates for daughters, female births (i.e., FB).

$$Fb_x = \bar{K}_x (\bar{B}_x)$$

GRR : Gross reproductive rate of completed family size, the average number of daughters born to women who reach 50 years of age.

$$GRR = \sum FB_x (5)$$

$TCFS$: Total completed family size, the average number of daughters and sons born to women who reach age 50.

$$TCFS = 2 (GRR)$$

MFS : Mean family size, the average number of male and female offspring that must be born to women who reach age 15 in order to replace their cohort before menopause.

$$MFS = \frac{2 (R_0)}{l_{15}} \times 1,000$$

R_0 : Net reproductive rate, this must always equal 1 for stationary populations.

APPENDIX D
Calculations for Life Table Analysis (after Mensforth 1988)

$\bar{T}$: Generation length, the mean age at reproduction in a stationary population.

$$\bar{T} = \sum [FB_x \cdot L'_x \cdot mn]$$

mn: Midpoint of the age interval in years.

CBR: Crude birth rate, number of births per person per year.

CDR: Crude death rate, number of deaths per person per year. In a stationary population the $CDR = CBR$

$$CDR = \sum FB_x (C_x)$$

DR: Dependency ratio. ratio of consumers to producers in a population. The ratio of those under and over the age of reproduction to those individuals within the reproductive period.

$$DR = \frac{[D_{0-15} + (D_{50+})]}{(d_{15-50})}$$

d_{xr} : d_x adjusted for an observed or simulated rate of population growth or decline (r). The adjustment is made for each d_x value included in the life table.

$$d_{xr} = d_x (1+r)^y$$

r : Population growth rate (+/-).

y : For each d_x value, y represents the midpoint of the corresponding age interval in years.

Mean Age: Mean age of the population computed as a weighted average across all age classes.

$$\text{Mean Age} = \frac{\sum (d_x \cdot y)}{N}$$