

INTEGRATIVE APPROACHES TO THE STUDY OF ANCIENT HEALTH: AN EXAMPLE FROM THE SANTA BARBARA CHANNEL AREA OF SOUTHERN CALIFORNIA

Walker Ph L

Department of Anthropology
University of California, Santa Barbara

One of the principal goals of bioarchaeological research is to identify regularities in the way human populations respond to changing environmental conditions. Paleopathology has a key role to play in this research since osteological indices of physiological stress provide objective measures of the nature and adequacy of a population's response to environmental challenges.

Major theoretical and methodological advances have been made in bioarchaeology during the past two decades. Researchers are becoming increasingly aware of the problems inherent in making inferences about the living through studies of the skeletal remains of the dead. One set of problems concerns systematic biases in preservation and in age and sex determination that greatly complicate demographic reconstructions (Walker *et al.* 1988, Walker 1995). The "osteological paradox" is another related interpretive difficulty that arises from the demographic characteristics of archaeological skeletal collections (Wood *et al.* 1992). Although it seems illogical, sometimes "better health makes for worse skeletons". This paradoxical situation arises because a person who survived a disease long enough to develop skeletal lesions is obviously healthier than someone who died from the disease before any skeletal lesions had formed.

These realizations have stimulated a vigorous ongoing debate that is leading researchers to reevaluate the assumptions they make when they attempt to reconstruct the demographic structure and health status of ancient populations. The overall effect of this debate has clearly been very beneficial. Although simplistically equating the "health" of the dead with that of the living without considering alternative interpretations is no longer defensible, there is also a growing consensus that the substantial interpretive problems we face do have solutions.

It is clear, for example, that one of the keys to increasing the reliability of paleopathological reconstructions lies in using a broad range of conceptually and methodologically independent data sources to develop and test alternative hypotheses about a group's health status. By testing hypotheses using osteological evidence in conjunction with data from archaeology, paleoecology, and other fields, bioarchaeologists can greatly increase the reliability of the inferences they make. One source of data on the health of an ancient population may be open to multiple or paradoxical interpretations. However, as the number of independent data sources that are consistent with the same conclusion increases, the viability of alternative explanations decreases dramatically.

To illustrate this approach, I will describe research my colleagues and I have done to document the responses the prehistoric population of the Santa Barbara Channel area of southern California made to spatial and temporal variation in the local environment. First I will show how hypotheses about health and nutrition based on analysis of spatial variation in resource availability have been tested using paleopathological and isotopic data. This is followed by a discussion of how hypotheses derived from paleoclimatic data have been tested using paleopathological evidence.

Spatial variation in resource availability

The Santa Barbara Channel area is an extremely diverse environment with mountain, coastal, and island habitats (Figure 1). This ecological diversity influenced local food availability and has many implications for the health and nutrition of the Native Americans who lived in this area of southern California.

The ecology of the four northern Channel Islands contrasts in many respects with that of the adjacent mainland. Because of their small size and isolation, they lack many of the plants and animals found on the mainland. The diversity of plants on the Channel Islands is approximately half that of the mainland coast. After the late Pleistocene extinction of the Channel Island pygmy mammoth population, the only native terrestrial mammals to survive on the northern Channel Islands were a small species of fox, a skunk, and three rodent species (Walker 1980).

These deficiencies in the terrestrial environment were offset to some extent by the rich supply of marine resources available to the Channel Island Indians. The marine environment of the islands is heavily influenced by exposure to upwelling water that moves southward along the California coast, pulling nutrients up from deep in the ocean to the surface. These nutrients support plankton that attract large schools of sardines, anchovies, and other small fish. These fish in turn are fed upon by larger fish such as

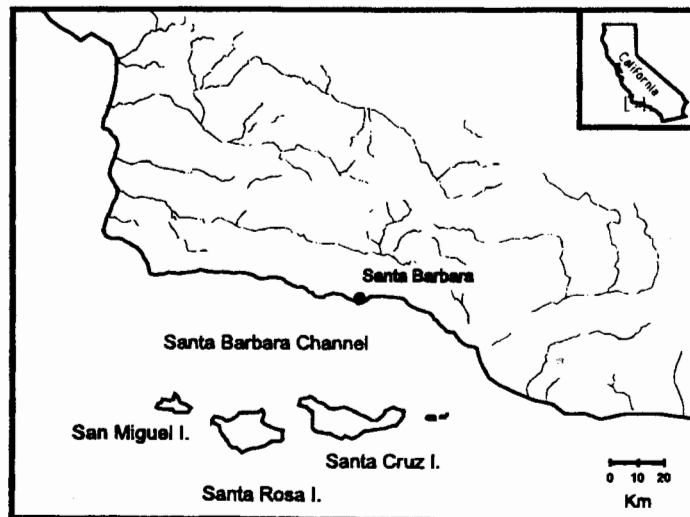


Figure 1: Map of the Santa Barbara Channel area.

tuna, as well as seals, sea lions, and sea birds which breed in tremendous numbers on Channel Island rookeries.

There is considerable inter-island variability in the abundance of marine and terrestrial resources. Traveling from east to west along the chain from Santa Cruz to Santa Rosa to San Miguel there is a decrease in island size, topographical relief, and terrestrial plant and animal diversity. Availability of marine resources varies in the opposite direction. San Miguel Island has greater exposure to the nutrient-laden water of the California Current than the other islands and is the site of one of the Pacific Coast's largest seal and sea lion rookeries, inhabited annually by over 20,000 animals. The beaches of Santa Rosa Island and Santa Cruz Island, in contrast, are not used by large numbers of sea lions.

In addition to these differences in access to potential food sources, the islands and mainland also differ in other respects. Water availability is much more limited on the Channel Islands than it is on the mainland. The islands also differ among themselves in this respect. Because of its small size and limited watershed, San Miguel Island has only a few freshwater springs. On the other hand, access to freshwater was comparatively good on Santa Cruz Island because of its much larger size and greater topographical relief.

Hypotheses about diet and health based on local ecology

These island-mainland differences in food and water availability have clear dietary and health implications that we have explored in our bioarchaeological research. People living on the islands had greater access to marine resources than people living on the mainland. Terrestrial plant foods, in contrast, were more abundant on the main-

land coast and mountains of the mainland interior. Based on this, we hypothesized that the isotopic composition of collagen from the bones of islanders would show the highest concentrations of stable isotopes that are most abundant in marine foods (^{13}C and ^{15}N) and that the bones of people living away from the coast in the mainland interior would show the lowest concentrations of these same isotopes.

Regional differences in food and water availability also have implications for inter-island and island-mainland differences in health. The limited number of island water sources suggests that health problems associated with water contamination would be more common on the islands (especially the smaller islands such as San Miguel) than they would be on the mainland. The low diversity of terrestrial resources available to the islanders suggests that the nutritional problems they faced were greater than those of the mainlanders. The islanders did have better access to iron-rich marine protein sources (fish, shellfish, and sea mammals) than the mainlanders. However, this advantage does not adequately compensate for their limited access to carbohydrate-rich plant foods. Trading with people on the mainland was one of the only ways in which the islanders could effectively deal with this problem. The mainlanders, in contrast, had the option of augmenting their dietary protein through hunting deer and other terrestrial mammals not found on the islands.

Bioarchaeological tests of ecologically based hypotheses

We have tested these ecologically based hypotheses about regional variation in health and nutrition using data obtained from Santa Barbara Channel skeletal collections. Isotopic data clearly show the relationship we

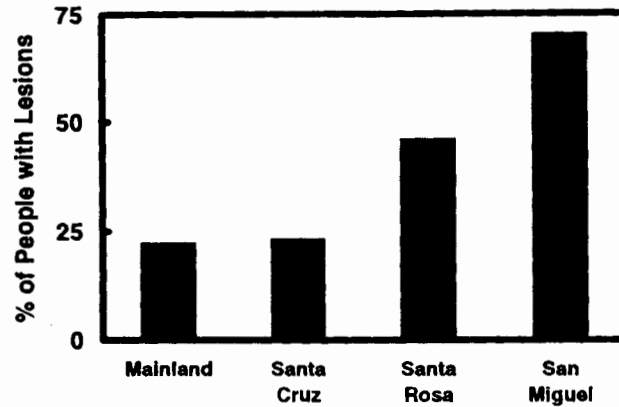


Figure 2: Geographical variation in the frequency of crania with cribra orbitalia in the Santa Barbara Channel area. These data are from Walker (1986).

predicted between local ecology and diet. The isotopic values of the islanders indicate a heavy dependence on marine protein sources, those of people who lived on the mainland coast are intermediate, and the isotopic values of people who lived away from the coast in the mountains of the mainland interior suggest a heavy dependence on terrestrial protein sources (Walker and DeNiro 1986).

Skeletal studies have also confirmed the hypothesis that the health and nutrition of people on the islands was poorer than that of people on the mainland. This is suggested, for example, by the significantly smaller average stature of the late prehistoric period island population in comparison to that of contemporaneous people on the mainland (160.6 cm versus 162.7 cm, $t=1.9$, $P=0.05$). It seems likely the islander's small stature reflects comparatively unfavorable conditions for the growth and development of children on the islands. Island-mainland genetic differences may have contributed to the stature difference. However, we know that marriage partners were exchanged between the two areas (Johnson 1988) and this suggests that island-mainland genetic differences were not great.

Significant island-mainland and inter-island differences in health are also suggested by spatial variation in cribra orbitalia, a skeletal pathology associated with anemia (Walker 1985, 1986). The frequency of cribra orbitalia is greatest on tiny San Miguel Island; less on Santa Rosa Island with its larger size and more diverse terrestrial resources (Figure 2). On Santa Cruz, the largest of the Northern Channel Islands, the frequency of this pathology is only slightly higher than on the mainland.

The island-mainland and inter-island difference in evidence of anemia conform closely to our predictions based on differences in local ecology. Since marine resources are rich in iron, it seems unlikely that the prevalence of anemia on the Channel Islands reflects a diet deficient in iron. A plausible alternative explanation is that iron loss owing to diarrheal disease contributed to the high frequency of cribra orbitalia among the islanders. This is suggested by the fact that diarrheal infections caused by water contamination are an important cause of childhood anemia in modern populations (Mata *et al* 1980). As mentioned earlier, such health problems would have been especially likely on the smaller Channel Islands such

as San Miguel where access to freshwater is limited and many people would be forced to use the same water source (Walker 1986).

Temporal variation in resource availability

An extremely detailed paleoecological record is preserved in laminated sediment in the deep submarine trench that separates the Channel Islands from the mainland coast. This record of temporal variation in the local environment provides many opportunities to test bioarchaeological hypotheses about the relationship between fluctuations in environmental productivity and health. Deep sea cores obtained from these sediments provide a year-by-year record of climatic fluctuations and biological productivity in the Channel Island environment during the past 8,000 years.

Studies of the relative abundance of temperature-sensitive plankton species in these cores show that the temperature of the ocean surrounding the Channel Islands has fluctuated markedly through time (Figure 3, Pias 1978). These changes in water temperature

would have a dramatic effect on the availability of fish and other marine animals to the Channel Island Indians. During cold water periods upwelling would be strong and marine productivity high. During warm water periods, in contrast, marine productivity would be low.

Of special interest in this regard are the environmental changes that occurred around the end of the last millennium (Figure 3). It was at this time that the chiefdoms documented ethnographically in the Santa Barbara Channel area were forming. Studies of Santa Barbara Basin sediments and other paleoclimatic indicators show that the period between A.D. 500 and A.D. 1300 was one of relative climatic instability with warm-dry conditions punctuated by episodes of severe drought and reduced marine productivity (Pias 1978 1979, Moratto et al. 1978:151, Moratto 19984, Stine 1994).

Environmental conditions were especially unfavorable between the 8th and 12th centuries. During this period there were episodes of severe drought and unusually warm ocean temperatures. Such conditions would greatly reduce local productivity and this

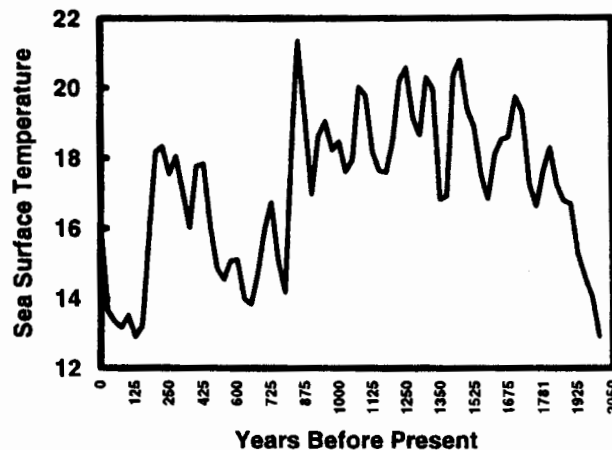


Figure 3: Estimates of fluctuations in sea surface temperature in the Santa Barbara Channel during the last two thousand years. Values are in degrees centigrade. They are based on analysis of radiolarian assemblages in deep sea cores taken from the Santa Barbara Channel (Pias 1978).

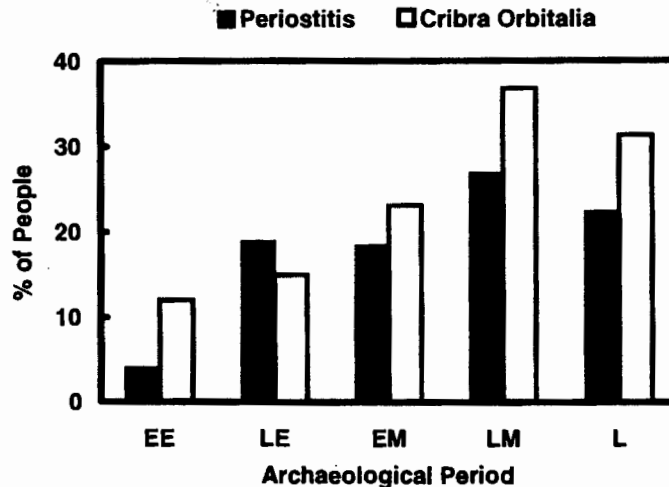


Figure 4: Temporal variation in cribra orbitalia and tibial periosteal reactions in the Santa Barbara Channel area. Data are from Lambert (1994). EE =Early Early period (ca. 3500-6000 B.C.), LE= Late Early Period (ca 2400-1400 B.C.), EM= Early Middle period (ca. 800 B.C. -A.D. 300), LE= Late Middle period (ca. A.D. 300-A.D. 1150), L= Late Period (ca. 1150-1782)

would have significant health implications for the Santa Barbara Channel area population. Skeletal remains of people who lived during this period would be expected to show increased evidence of malnutrition and infectious disease. Evidence of warfare and violence might also be expected to increase owing to competition among groups for scarce resources.

Understanding the process through which these people adapted to the environmental challenges they faced at this time is of considerable theoretical interest. These responses resulted in the development of local economic specialization, increased social differentiation, and the rise of chiefdoms that integrated the local population into larger polities. Since this period was one of environmental instability and rapid social change in other parts of the world, the processes affecting the Santa Barbara Channel population at this time may have analogs in other areas and thus be of general significance.

Temporal variation in health

Studies of Late Middle period skeletal collections dating from this period of unfavorable environmental conditions confirm the hypothesis that these were stressful times in which the health of the Santa Barbara Channel area population declined and warfare and violence increased (Walker and Lambert 1989, Lambert and Walker 1991, Lambert 1994). For example, the frequency of people with cribra orbitalia is higher in the Late Middle period than it is before or after it (Figure 4, Lambert 1994). This apparent increase in anemia during a time of drought is consistent with the hypothesis presented earlier that problems of water shortage posed a health hazard, especially on the Channel Islands.

The frequency of burials with periosteal reactions on their tibiae also increases during the Late Middle period (Figure 4). Lesions such as these are produced by a variety of pathological processes including infec-

tions and traumatic injuries. Their increase during the Late Middle is strong evidence that the health of the Santa Barbara Channel area population declined at this time.

Skeletal evidence that warfare and violence increased during the Late Middle period reinforces paleopathological evidence for a decline in health and nutrition during this period. The frequency of burials with evidence of projectile point injuries increases dramatically between the Early Middle period and Late Middle period and then decreases markedly in the Late period (Figure 5 Lambert 1994). This increase in violence is consistent with the hypothesis that unfavorable environmental conditions increased competition over access to local subsistence resources.

Conclusions

Bioarchaeological data from the Santa Barbara Channel area show a reassuring cor-

relation between spatial and temporal variations in environmental conditions and skeletal evidence for nutritional stress and infectious disease. As predicted based upon variation in the abundance of essential resources in the local ecosystem, the skeletons of people who lived in marginal island environments such as that of San Miguel Island show greater evidence of nutritional stress than people who lived on the mainland. A positive correlation has also been demonstrated between periods of unfavorable environmental conditions and skeletal evidence of poor health.

This consistency between independent data sources shows that the problems bioarchaeologists face in making inferences about the health of the living from the remains of the dead are not insurmountable. It suggests that in many cases there is a positive correlation between the frequency of skeletal pathologies and the health of the living. In some cases better health undoubtedly

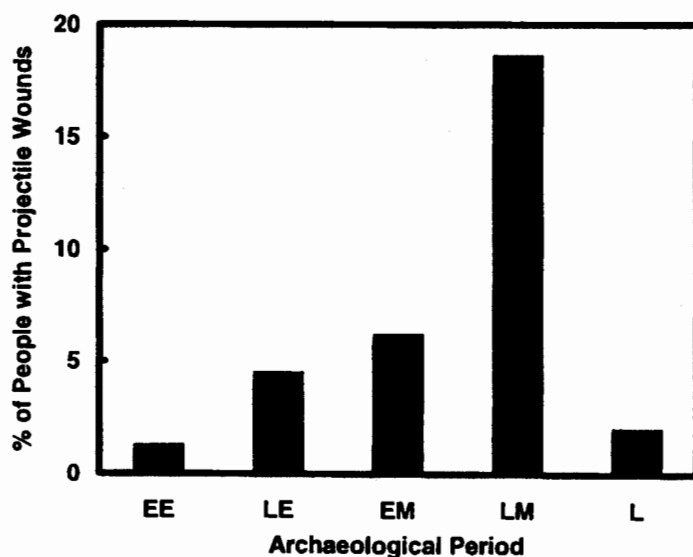


Figure 5: Temporal variation in burials with evidence of projectile point injuries in the Santa Barbara Channel area. Data are from Lambert (1994). EE = Early Early period (ca. 3500-6000 B.C.), LE = Late Early Period (ca. 2400-1400 B.C.), EM = Early Middle period (ca. 800 B.C. - A.D. 300), LM = Late Middle period (ca. A.D. 300-A.D. 1150), L = Late Period (ca. 1150-1782).

does result in worse skeletons. I believe that the best strategy for identifying and accurately interpreting such paradoxical situations is a broad-based integrative approach that exploits strengths of many independent data sources like that described in this paper.

Literature Cited

- JOHNSON, J.R. (1988) *Chumash Social Organization: An Ethnohistoric Perspective*. Ph.D. dissertation, University of California, Santa Barbara.
- LAMBERT, P.M. (1994) *War and Peace on the Western Front: A study of violent conflict and its correlates in prehistoric hunter-gatherer societies of coastal southern California*. University of California, Santa Barbara.
- LAMBERT, P.M. AND WALKER, P.L. (1991) Physical anthropological evidence for the evolution of social complexity in coastal southern California. *Antiquity* **65**: 963-73.
- MATA, L., KRONMAL, R.A. AND VILLEGAS, H. (1980) *Diarrheal diseases: A leading world health problem*. In: Cholera and Related Diarrheas. 43rd Nobel Symposium, Basel: Karger.
- MORATTO, M.J., KING, T.F. AND WOOLFENDEN, W.B. (1978) Archaeology and California's climate. *The Journal of California Anthropology* **5**(2): 147-161.
- MORATTO, M.J. (1984) *California Archaeology*. New York: Academic Press.
- PISIAS, N.G. (1978) Paleooceanography of the Santa Barbara Basin during the last 8000 years. *Quaternary Research* **10**:366-384.
- PISIAS, N.G. (1979) Model for paleo-oceanographic reconstructions of the California current during the last 8,000 years. *Quaternary Research* **11**(3): 373-386.
- STINE, S. (1994) Extreme and persistent drought in California and Patagonia during the mediaeval time. *Nature* **369**: 546-549.
- WALKER, P.L. (1980) Archaeological Evidence for the Recent Extinction of Three Terrestrial Mammals on San Miguel Island, The California Islands: *Proceedings of a Multi-disciplinary Symposium*, D. Power, ed. Santa Barbara Museum of Natural History.
- WALKER, P.L. (1985) Anemia among prehistoric Indians of the American Southwest. In *Health and Disease in the Prehistoric Southwest*, edited by C.F. Merbs, and R.J. Miller, pp.139-164. Arizona State University, *Anthropological Research Papers* No. **34**.
- WALKER, P.L. (1986) Porotic hyperostosis in a marine-dependent California Indian population. *American Journal of Physical Anthropology* **69**:345-354.
- WALKER, P.L. (1995) *Problems of preservation and sexism in sexing: Some lessons from historical collections for paleodemographers*. In: A. Herring and S. Saunders (eds.) *Grave Reflections: Portraying the Past Through Skeletal Studies*. Canadian Scholars' Press: Toronto, pp 31-47.
- WALKER, P.L., JOHNSON, J. AND LAMBERT, P. (1988) Age and Sex Biases in the Preservation of Human Skeletal Remains. *American Journal of Physical Anthropology* **76**(2): 183-188.
- WALKER, P.L. AND LAMBERT, P.M. (1989) Skeletal evidence for stress during a period of cultural change in prehistoric California. In *Advances in Paleopathology, Journal of Paleopathology: Monographic Publication No. 1*. Marino Solfanelli: Chieti, Italy.
- WALKER, P.L. AND DE NIRO, M.J. (1986) Stable nitrogen and carbon isotope ratios in bone collagen as indices of prehistoric dietary dependence on marine and terres-

- trial resources in southern California.
American Journal of Physical Anthropology **71**:51-61.
- WOOD, J.W., MILNER, G.R., HARPENDING,
H.C. AND WEISS, K.M. (1992) The osteological paradox: problems of inferring prehistoric health from skeletal samples.
Current Anthropology **33**(4):343-370.