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ENVIRONMENTAL CHANGE AND CULTURAL TRANSITION IN THE EARLY PREHISTORY OF SOUTH-COASTAL CALIFORNIA

by

Larry A. Carbone

B.A., Simon Fraser University, 1981

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS

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THESIS ABSTRACT

It has been postulated that climatic changes have directly influenced cultural patterns in the early prehistory of some areas of North America. However, previous research efforts have yielded little empirical evidence to support or refute this premise. In addition, the problem of explaining cultural change has been compounded by an underestimation of the difficulty in determining the causes.

In order to investigate the likelihood that a distinct change in the cultural patterns of an early south-coastal California population was climatically induced, paleoclimatic and paleoenvironmental data were synthesized and correlated with evidence from the archaeological record. The research focused upon determining the magnitude of climatic and environmental transformation that occurred in a relatively limited geographical region and temporal duration. This entailed examining the available proxy data (pollen remains, lake and marine sediments, tree rings and tree line elevations, faunal distributions and remains, isotopic fluctuations, etc.) that can be used to delineate climatic change. Also, archaeological evidence pertaining to subsistence strategies, technology, settlement patterns and data relating to social organization was analyzed and interpret-

ed. These data were critically evaluated in order to determine if any degree of co-variation exists between patterns of climatic and cultural change.

Evaluation of this evidence indicates that beginning approximately 7,500 years ago the Paleo-Indian San Dieguito population was subjected to a significant environmental change, and in response a systemic readaptation toward archaic La Jolla patterns is suggested.

This research is
gratefully dedicated to
Anthony and Patricia Carbone;
and to the One who
has the power to embrace
the entire world at once.

ACKNOWLEDGEMENT

Although there is but one name affixed to the authorship of this report, it will be remembered by this author as a team effort. Among the many people that are responsible for the successful completion of this research, I am indebted to Dr. Richard Shutler, Jr. for sharing his archaeological experience and direction. His encouragement during times of potential adversity will forever be appreciated.

My special gratitude goes to Prof. Phil Hobler for his approachable mien and willingness to confer advice and assistance; to Dr. B.O.K. Reeves for providing me with the opportunity to gain practical experience in field work relating to early Californian prehistory; to Dr. Knut Fladmark for his constructive observations and positive feedback concerning my professional promise; and to Ken Hedges for allowing me access to collections housed at The San Diego Museum of Man.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

For decades it has been postulated that human populations inhabited the regions of southern California at least 10,000 years ago. The habitation area included the southwestern littoral region as well as the present desert region to the east. Although cultural adaptations of early populations in southern California are not well understood, it is presently accepted by archaeologists that their economy was initially oriented around generalized hunting. Other cultural aspects are even less understood.

This report is primarily concerned with the coastal strip of southern California, with a main focus upon San Diego County (Figure 1). The archaeological evidence from this region suggests that approximately 7,500 years ago a major change occurred in adaptive patterns and possibly social behavior of the people occupying the region (Cressman 1977; Kaldenberg 1982; Meighan 1965; Warren 1968). Although it may never be understood specifically why this occurred, it is important to investigate this problem in order that a clearer reconstruction of this portion of New World prehistory can be formulated.

There is multidisciplinary evidence indicating that many areas of North America experienced warming trends of varying intervals and intensities during the Holocene, and

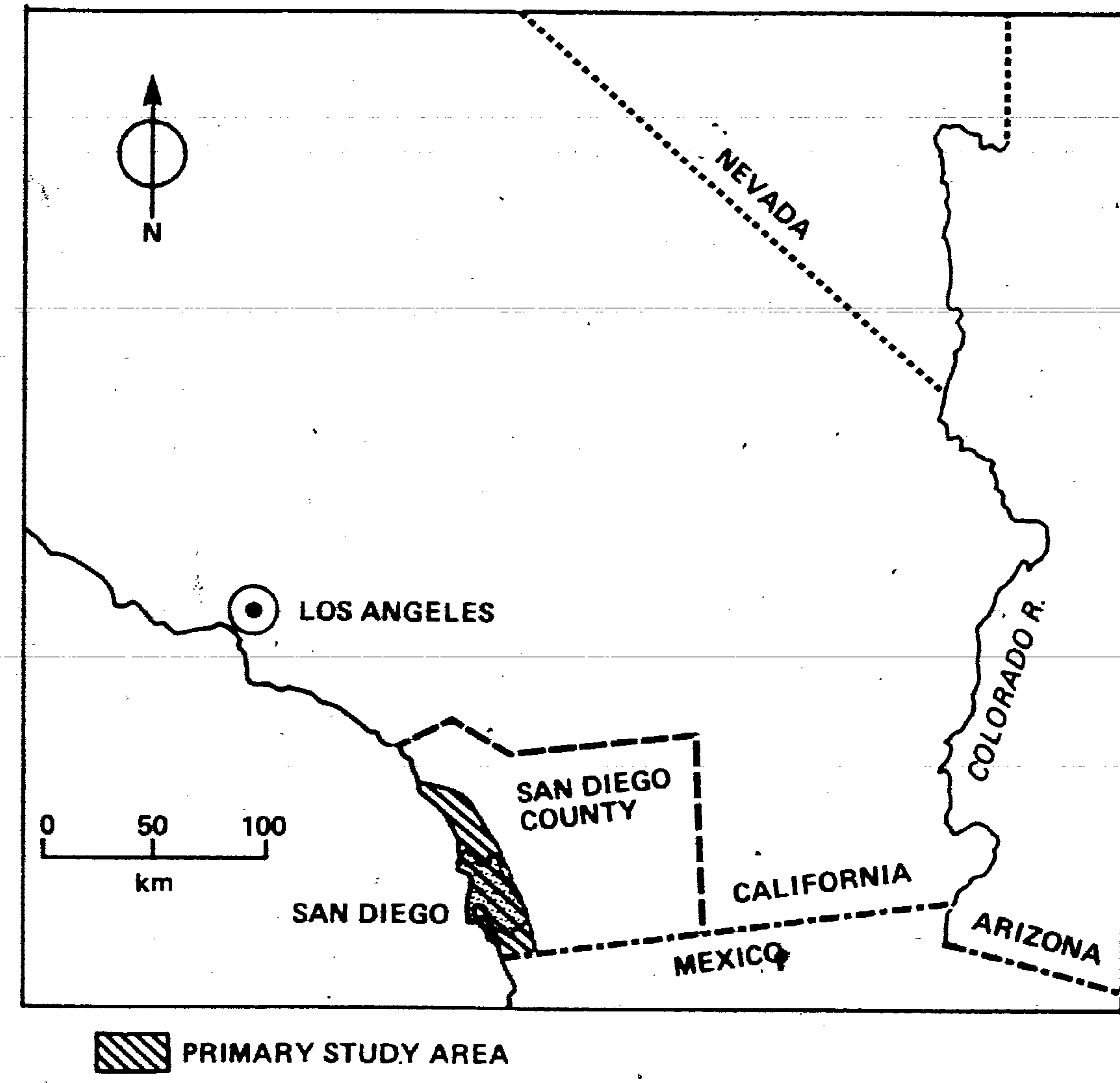


Figure 1. San Diego County study area

southern California is no exception; Holocene is here used as a chronological term and does not refer to a landscape or ecological description. Although changes in climate cannot presently be proven as the unequivocal causative factor for the diversification or displacement of prehistoric cultural traditions, an analytic approach with this focus is warranted. That is, a climatic change that would initiate a shift in the biotic and geophysical environment might be shown to influence or regulate cultural responses within ecological and social parameters. This problem entails not only ascertaining what degree of climatic change occurred, but also how this change would influence a restructuring of adaptive behavior of human populations in a given region. This report investigates the factors that may explain the change in cultural tradition from the Paleo-Indian San Dieguito to the Archaic La Jolla. This discontinuity may reflect an adaptation by an existing population to changing environment, a response to other stimuli, a combination of these factors, or possibly the two traditions represent discrete populations.

II. METHODOLOGY

It is necessary to elucidate the degree of climatic change that occurred in southern California between 8,000 - 7,000 B.P. and then to hypothesize whether the climatic change was of sufficient magnitude to be the primary cause of the reorganization of subsistence and social patterns of the San Dieguito. If it was, one important consideration pertaining to the mechanism of cultural adaptation is to what extent and with what degree of accuracy climatic changes were actually perceived by a contemporaneous human population. It must also be borne in mind, as Wigley, Ingram and Farmer (1981:6) have emphasized:

> "When reconstructing a record of past climate for a particular region it is not sufficient simply to group together any information from previously published sources. There are very important questions concerning data accuracy, consistency and reliability that must be considered before any synthesis can be performed."

Therefore a researcher cannot easily demonstrate that climatic change was the determining element of cultural transition, only that it might have been a contributing or likely factor. Every observable manifestation of a particular culture must be weighed and scrutinized before any hypotheses concerning this problem can be advanced.

Although much evidence of past climatic change is contained within the long geological record, and some response times take as long as 100,000 years (Cloud 1978), only a fragment of this evidence can be used by researchers to study changes that occurred within the last 10,000 years. Therefore, variables other than geological become important. The primary approach in this report will be to correlate the proxy data applicable to climatic change (pollen remains, lake and marine sediments, tree rings and tree line elevations, faunal distributions and remains, isotopic fluctuations, etc.) with data from the archaeological record pertaining to culture. Correlations of this nature have been previously attempted by Bennedict (1975), Buchner (1980), Butzer (1978), Clark (1965), Evans (1975), Mackey and Holbrook (1978), Paulson (1976), and Shaw (1976), all with varying degrees of application.

The paleoenvironmental reconstruction undertaken in the present study is similar in method to that advanced by Kutzbach (1975), but with the addition of other variables. This report is concerned with making possible the interpretation of synoptic environmental patterns in terms of fluctuations in these climatic variables. The archaeological evidence applied in the investigation is derived from literature and field work pertinent to the study of regional variation in patterns of cultural and climatic change.

Despite a substantial amount of previous research, difficulties have arisen in reaching agreed-upon interpretations of these changes. For example, generalizations that define changes over large continental areas tend to obscure individual variation occurring coincidentally in restricted local environments. It is expected that this problem will be somewhat alleviated by evidence presented in this report.

III. PALEOENVIRONMENTAL DATA

In their report on postglacial climatic change published in 1965, Baumhoff and Heizer (in Kaldenberg 1982:27) observed that "there is no consensus concerning the chronology for environmental change." Since that time numerous studies of paleotemperature variation and consequential environmental transformations have been carried out.

The available data pertaining to Holocene climatic changes in southern California have not been fully synthesized; however there is sufficient evidence to allow partial reconstruction of the paleoenvironment, even for relatively short intervals of time. Alluding to this effort Cloud (1978:29) stresses that:

> "Indeed Holocene paleoclimatic data are already sufficiently numerous and reliable... that synoptic reconstructions at time intervals of 1,000 or 2,000 years are now being attempted."

There seems to be little doubt that a warming/drying trend known variously as the Altithermal (Antevs 1953), Hypsithermal (Deevy and Flint 1957), or Xerothermic (Axelrod 1981), occurred during the early Middle Holocene and has not been equalled in intensity since. For the purpose of continuity in this report, the duration of climatic optimum will be referred to as the Thermal Maximum. There is some difficulty in establishing explicitly when this period commenced and oscillated in specific continental areas.

Almost a quarter of a century ago, Hubbs (1960:105) hypothesized that:

> "Fluctuations in aridity during Recent time seem to have affected coastal regions and offshore islands, as well as the interior of western North America. And at least some of the changes were simultaneous in the diverse regions."

Recent evidence verifies that Hubbs' hypothesis was accurate and is increasingly supported as interpretations are refined for local regions.

Climatological and paleoecological research has been successful to the extent that a general overview of the Thermal Maximum can now be established for southern California.

It has been noted by Tartaglia (1976:28) "that temperature is the most important single factor in limiting the range of communities as well as species." Biological responses to climatic changes have provided an important means of assessing the histories of paleoclimates. An important consideration in the study of these responses is to correctly interpret changes in abundance and distribution of fossil organisms. As Ford (1982:51) has discussed:

> "If fossil remains can be identified with modern species whose tolerance limits are known, the deductions concerning the prevailing climatic conditions (especially temperature) in earlier times may be possible."

As outlined by Pisias (1978), the onset of warmer climate in the Holocene is implied by changing frequencies and types of radiolarian faunal species recovered from nearshore varved sediments from southern California. He points out that the appearance of subtropical radiolaria, commencing ca. 8,000 B.P., exhibits a warmer sea surface temperature than had previously existed. Since changes in sea and air temperatures are very closely correlated (Hubbs 1960) the adjacent land areas must have been similarly affected.

Subsequently, Pisias (1979) projected his data into graphic illustrations estimating sea surface temperatures for the California Borderland coastal strip (Santa Barbara to San Diego, Figure 2) which indicated a sharp increase in temperature from ca. 7,400-7,200 B.P. This was interpreted as a rise in the annual February land temperature from 16° to 25°C (Figure 3), and represents the optimum period of aridity in the Holocene. The evidence relating to sea water paleotemperatures has been supplemented by Kahn, Oba and Ku (1981). Oxygen isotopic analysis of the benthic foraminiferal species Uvigerina peregrina was performed on marine sediment cores from Tanner Basin, 150 km west of the San Diego Coast (Figure 4). From δ0-18 values it was estimated that "an increase in the mean surface-water temperature of 5±.8°C occurred from near the end of the Wisconsin glaciation to the Holocene Thermal Maximum at about 7,500 yr. B.P." (Kahn et al. 1981:489). This assessment was possible because the ratio of the oxygen isotopes (0-18/0-16) employed in the skeletal development of foraminifers is water temperature dependent.

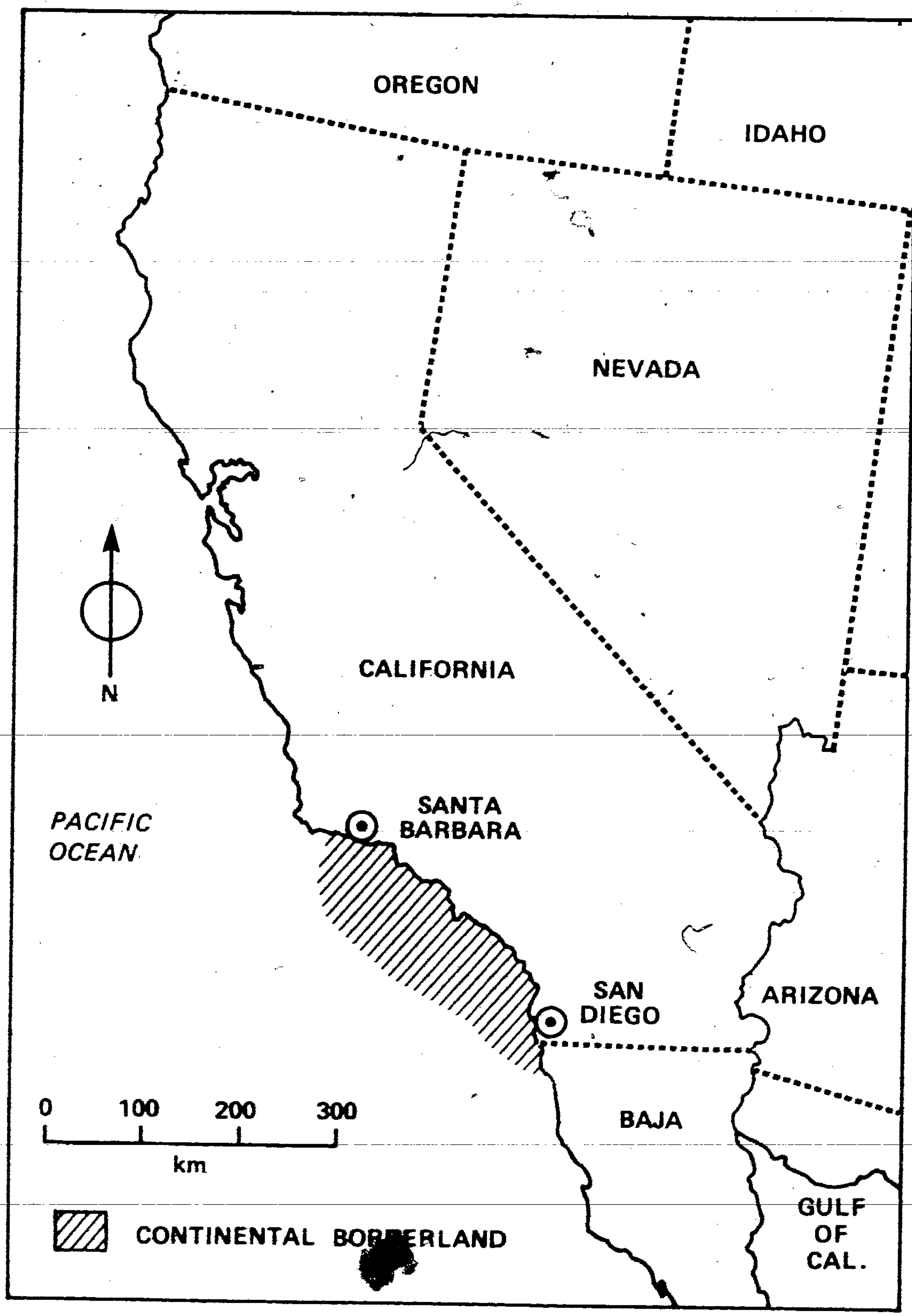


Figure 2. California Continental Borderland

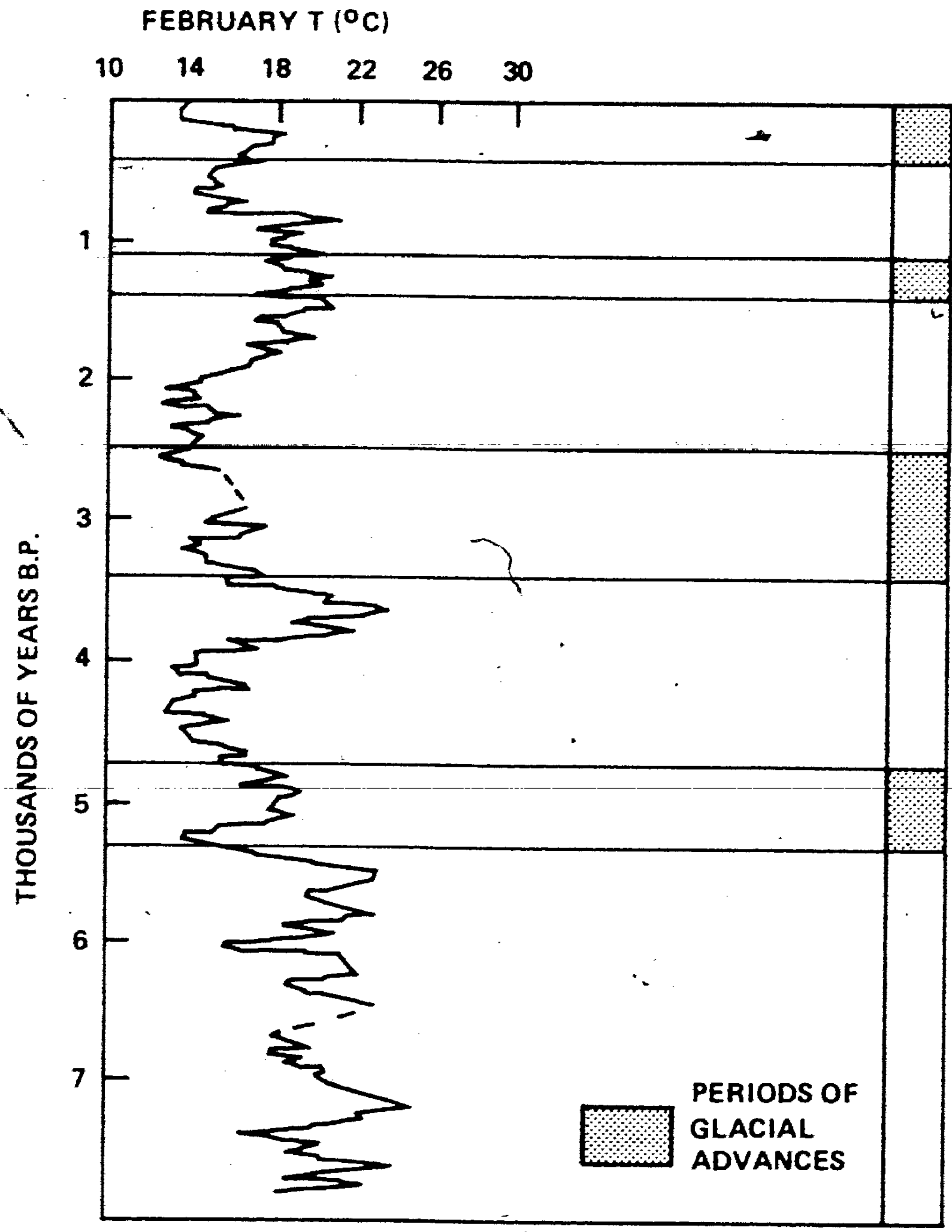


Figure 3. Mean February Paleotemperatures (from Pisias 1979 : 377)

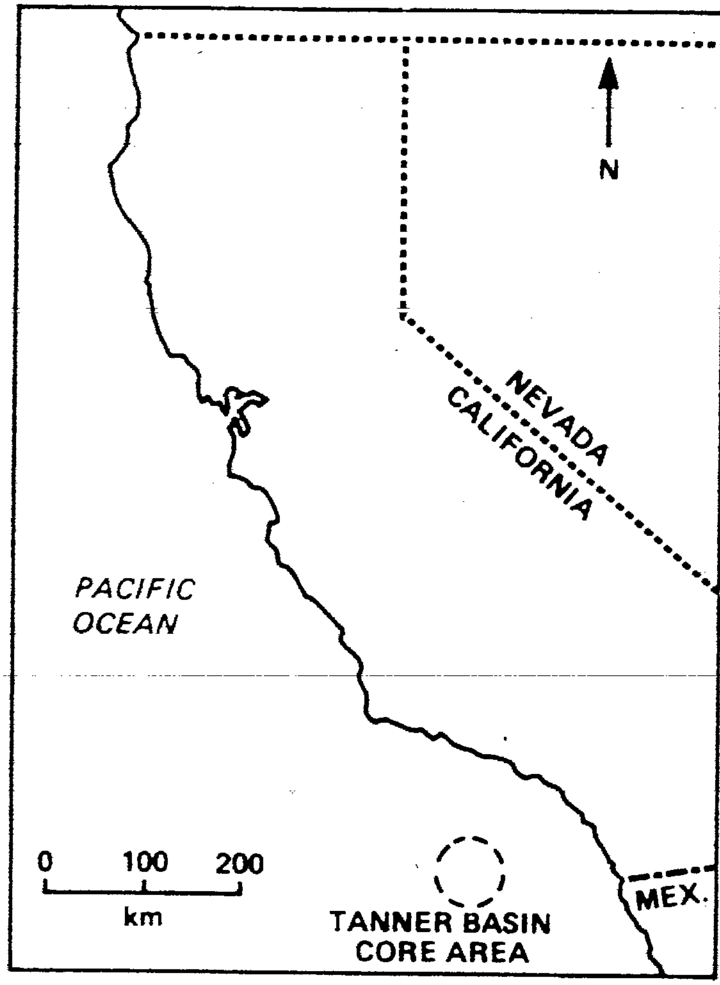


Figure 4. Map Showing Tanner Basin Core Location
(From Kahn, Oba and Ku 1981 : 486)

Recent studies of planktonic foraminiferal populations have demonstrated that the coiling direction of _Globigerina pachyderma_ is directly dependent upon water temperature (Kheradpir 1970). Cold water specimens tend to coil in a left (sinistral) direction while tropical and temperate populations coil in a right (dextral) manner. Tartaglia (1976) maintains that approximately 98 percent of a foraminiferal population residing in extreme ocean temperature ranges (i.e. warm vs. cool) will exhibit coiling oriented in the direction corresponding to the water temperature to which it was exposed. A paleotemperature increase in the surface water adjacent to the southern California coast was illustrated for the late Pleistocene and Holocene epochs from the coiling ratio of _Neogloboquadrina pachyderma_. As determined from Tanner Basin core samples, about 15,000 years ago approximately 90 percent of this species was sinistrally coiled. As the surface ocean water warmed during the Holocene transgression the coiling orientation shifted and by 7,500 B.P. virtually all of the specimens were dextrally coiled (Kahn et al. 1981:486). This indicated a constant temperature increase until a peak was reached approximately 7,500 years ago (Figure 5).

Studies of calcium carbonate content and foraminifera productivity which vary according to temperature, oceanic circulation and nutrient level, are valuable for reconstructing paleotemperatures. Marine sediment cores that were secured from the Borderland area of San Diego County

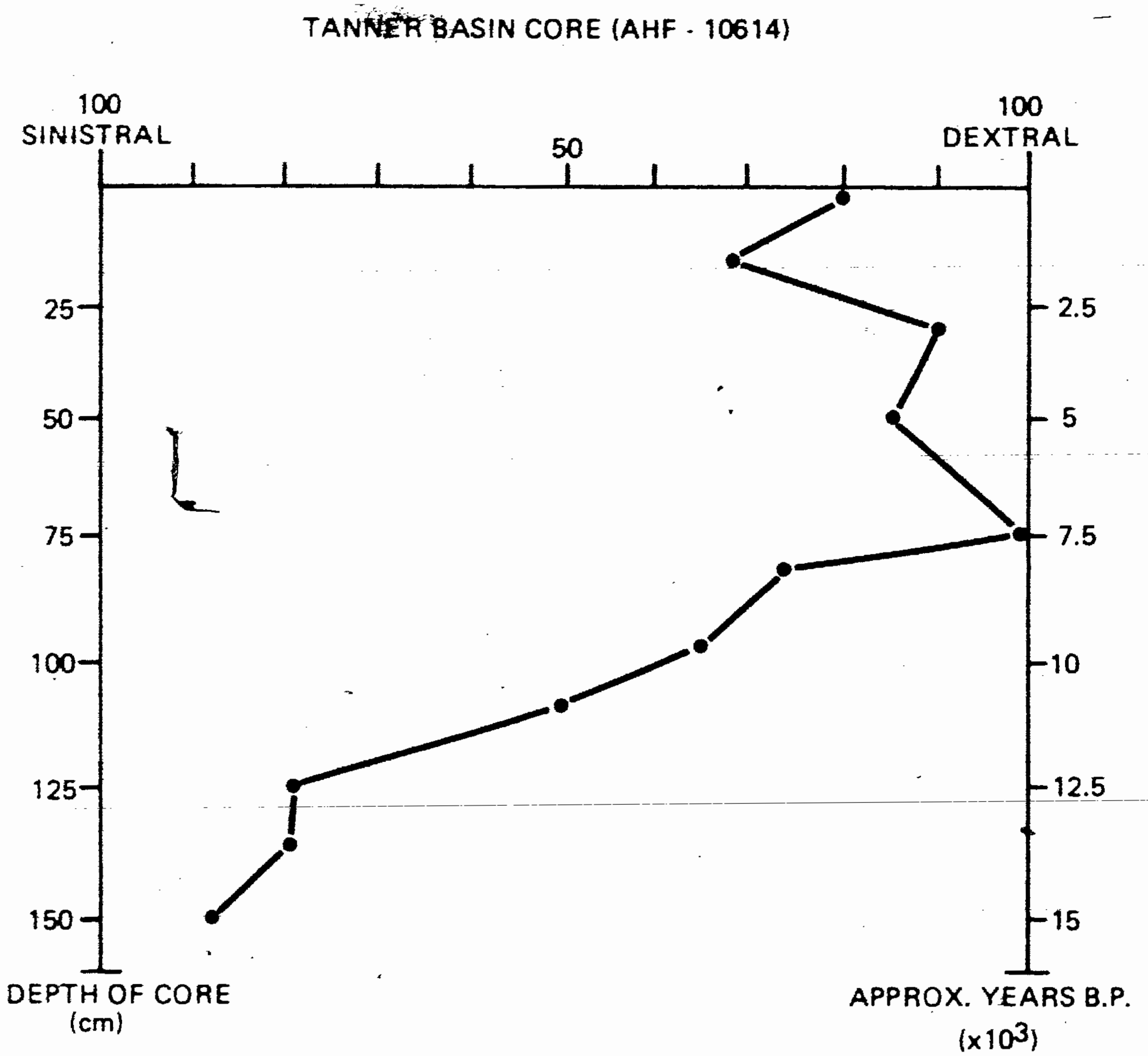


Figure 5. Coiling Ratio of *Globoquadrina pachyderma*
(Modified from Khan et al. 1981:487)

and northern Baja California seem to reflect adjacent terrestrial climatic events of the Holocene. After evaluating the core elements Gorsline and Prensky (1975:149) reported that:

> "Radiocarbon dating ... has suggested that the carbonate maximum in the topmost high-carbonate layers [of marine cores] probably occurred about ... 7,000 yr B.P. and may correlate with the Hypsithermal interval originally defined as a time when temperatures were possibly warmer."

Concurrent with this carbonate increase there is a maximum of foraminiferal abundance per gram of dry sediment which also attests to warming temperatures at ca. 7,500-7,000 B.P. (Gorsline and Prensky 1975; Johnson 1977). Gorsline and Prensky (p. 150) do not strictly adhere to these dates and suggest that "they may well prove to be as much as 1,000 years early or late." Considering the response time that may have been necessary for maximization of the sediment components, the onset of the Thermal Maximum might be placed as early as 8,000 B.P. By correlating radiocarbon dated segments of cores with percent of calcium carbonate and foraminiferal abundance, Kheradpir (1970) has demonstrated a post-pleistocene warming trend which indicates a peak at ca. 7,500 B.P. (Figure 6).

From pollen analyses of shallow ocean cores from the Santa Barbara Basin (Figure 7) Huesser has demonstrated that major changes in the distribution of upland and lowland plant communities occurred ca. 8,000 B.P. Contemporaneous with this change there is indicated a general decrease in

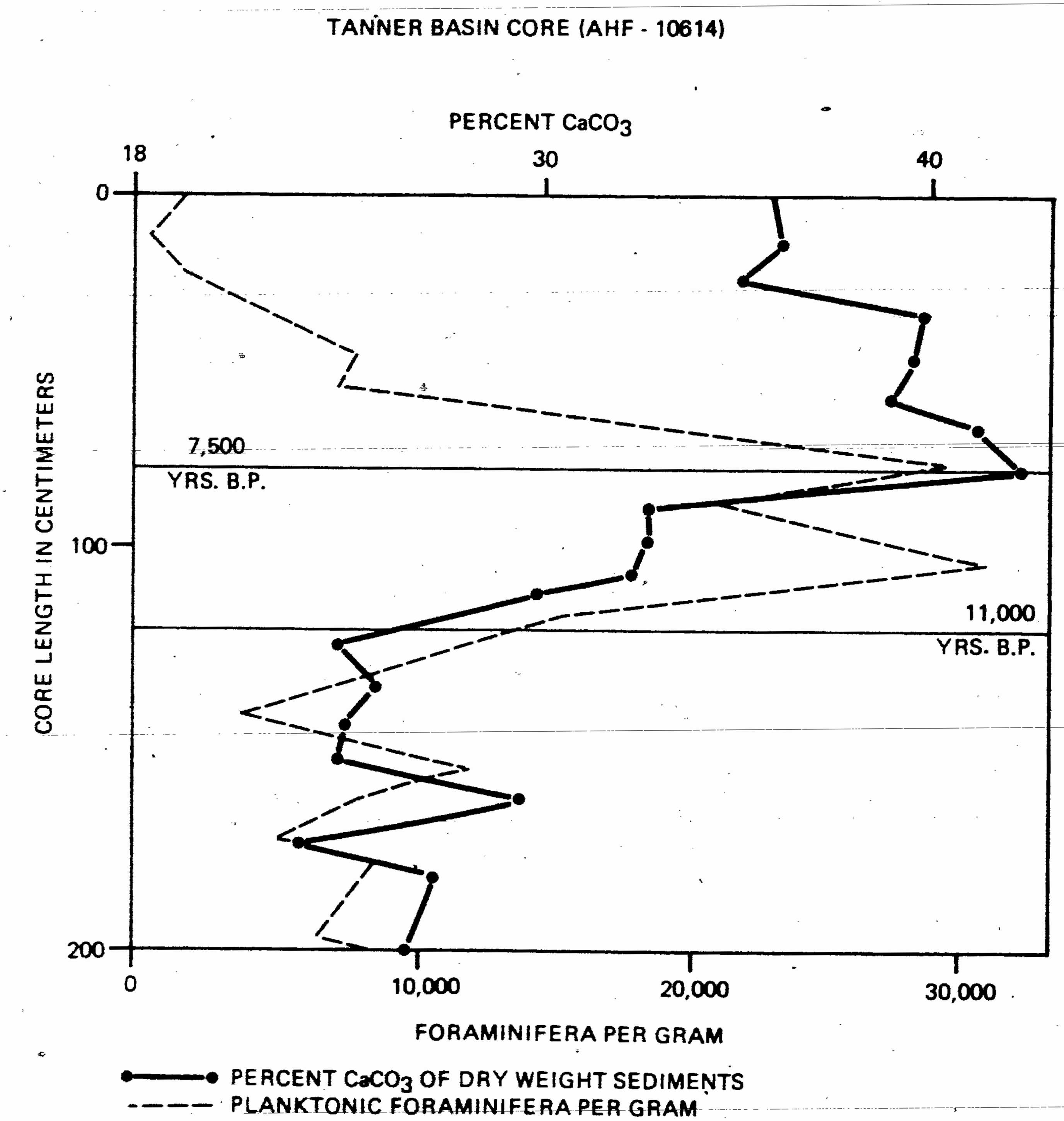


Figure 6. Percentage of Calcium Carbonate and Planktonic Foraminiferal numbers. (From Kheradpir 1970:105)

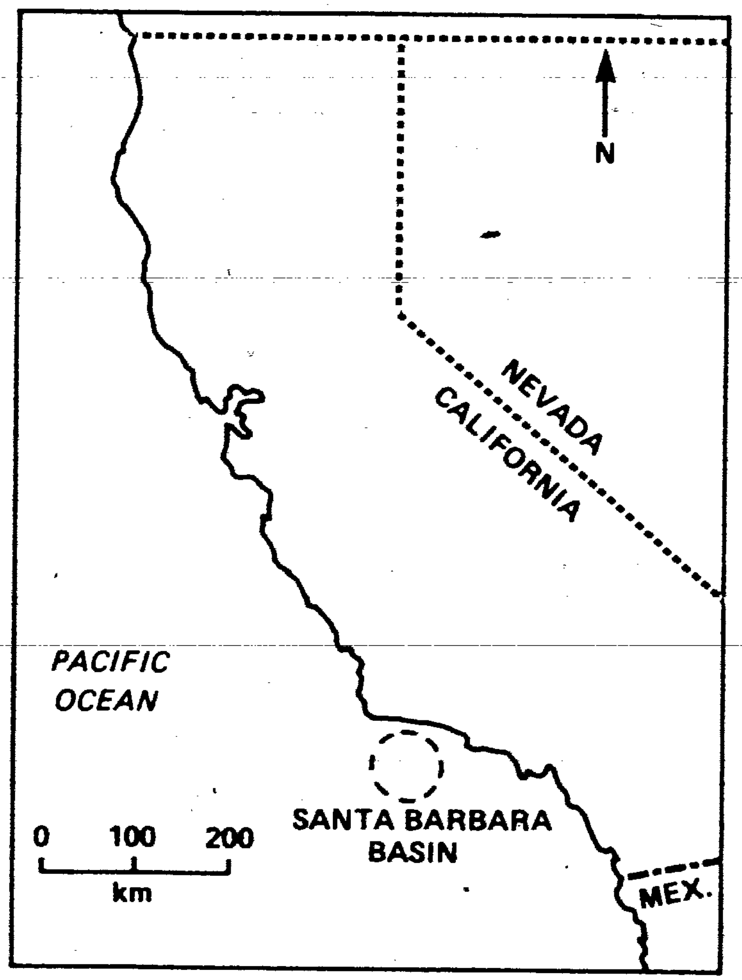


Figure 7. Santa Barbara Basin Area

pollen deposition which she attributes to being "partly an artifact of the synchronous increase in herb and shrub frequencies" (Heusser 1978:676). This also indicated that pine forest was generally replaced by woodland and chaparral. These events are assumed to have coincided with a warming trend that was also apparent from fluviomarine pollen diagrams which illustrate a change in the precipitation/evaporation ratio ca. 7,800 B.P.

Paleoclimatic evidence also indicates that woodland or forest plant communities existed until ca. 8,000 years ago in areas that are the modern hot deserts of southern California. The conifer paleobotanical record of Lucerne Valley (Figure 8) denotes that a cool, moist climate persisted until 7,800 B.P. and an "arid desert environment apparently did not occur in the study area until after" this time (King 1976:103). According to Van Devender and Spaulding (1979: 706) the end of the early Holocene woodlands in southeastern California, initiated by decreased available moisture, "appears to have been a rapid widespread, synchronous event about 8,000 years B.P." Packrat middens indicative of modern desert vegetation become common after this time. At Newberry Cave, south-central California, middens of uriniferons creosote material, which is characteristic of a dry, arid climate were C-14 dated to 7,400±150 B.P. In summary, Van Devender and Spaulding (p. 702) hypothesize that southern California floral communities "appear to have responded quickly to climatic changes compared to the gradual respon-

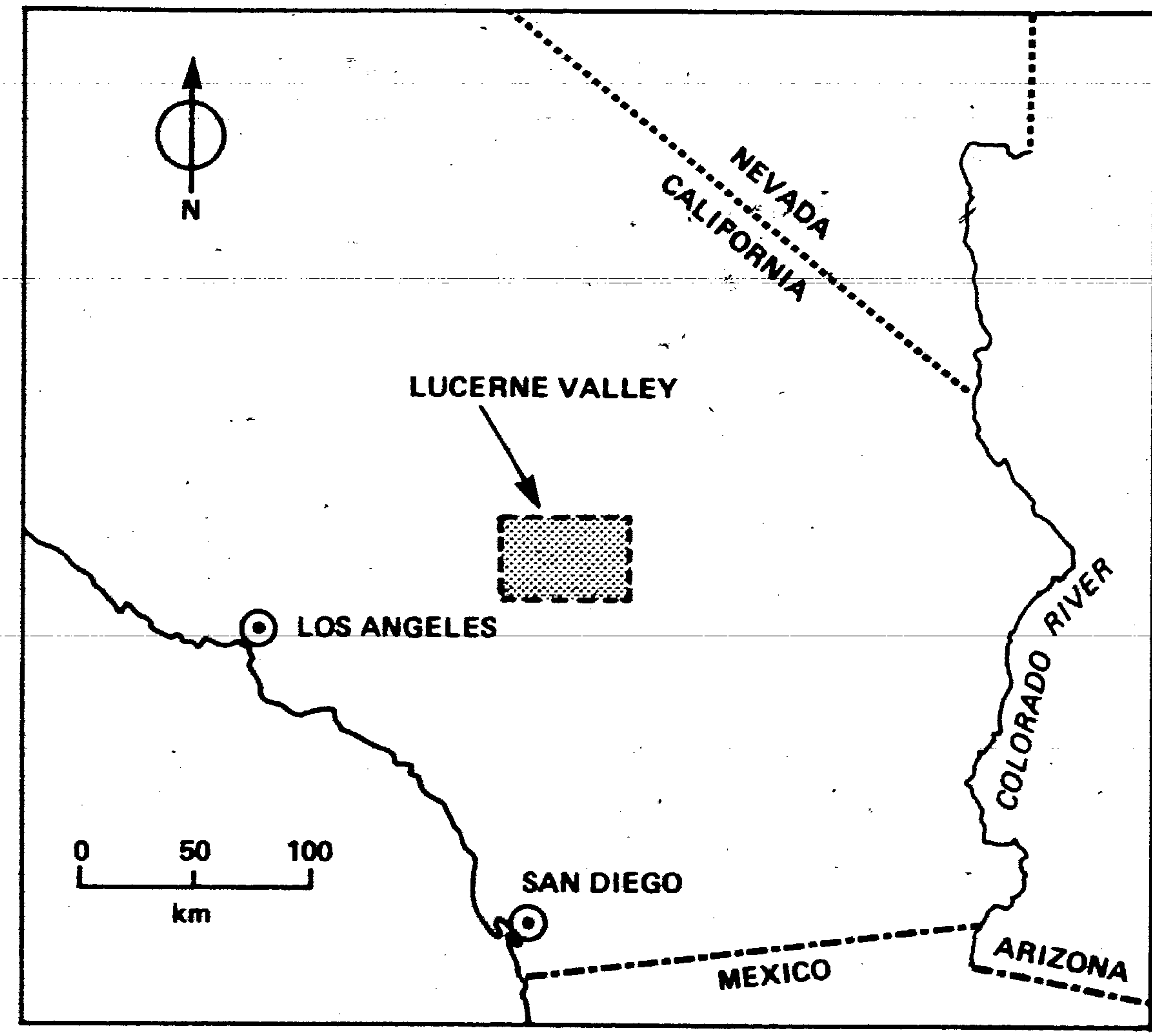


Figure 8. Lucerne Valley Area

ses of central and eastern United States forest communities." It is also noteworthy that Gorsline and Pao (1976:10) found that "Transition from cold to warm cycles is relatively abrupt, while deterioration from warm to cold appears to be a more gradual process ... " This was concluded through high resolution studies of southern California Basin sedimentation related to climatic-oceanographic changes.

Adam (1967) reported that the high Sierra of California apparently experienced a postglacial climatic optimum as evidenced by the pollen record. In a stratigraphic sequence from Osgood Swamp, observed frequencies of Artemisia pollen become minimal while ericaceae disappear entirely at a certain interval (Figure 9). Adam (1967:289) states that "Because of their prominence in the early postglacial and, in some cases, the Little Ice Age, I consider these taxa to be indicators of cool conditions." Also alnus, which is indicative of warm, dry summers appeared and dramatically increased almost coevally with the decrease in the former two species. These events occurred, in stratigraphic context, nearly midway between a suspected Mazama Ash layer (ca. 6,600 B.P.) and a radiocarbon date of 9,900±800 B.P. Relating to Adam's data, Johnson (1977:175) suggests "that the coastal area was similarly affected" by temperature increases as is evidenced by the concurrent climatic marine record of the coastal Borderland.

If certain qualifications are observed, past changes in

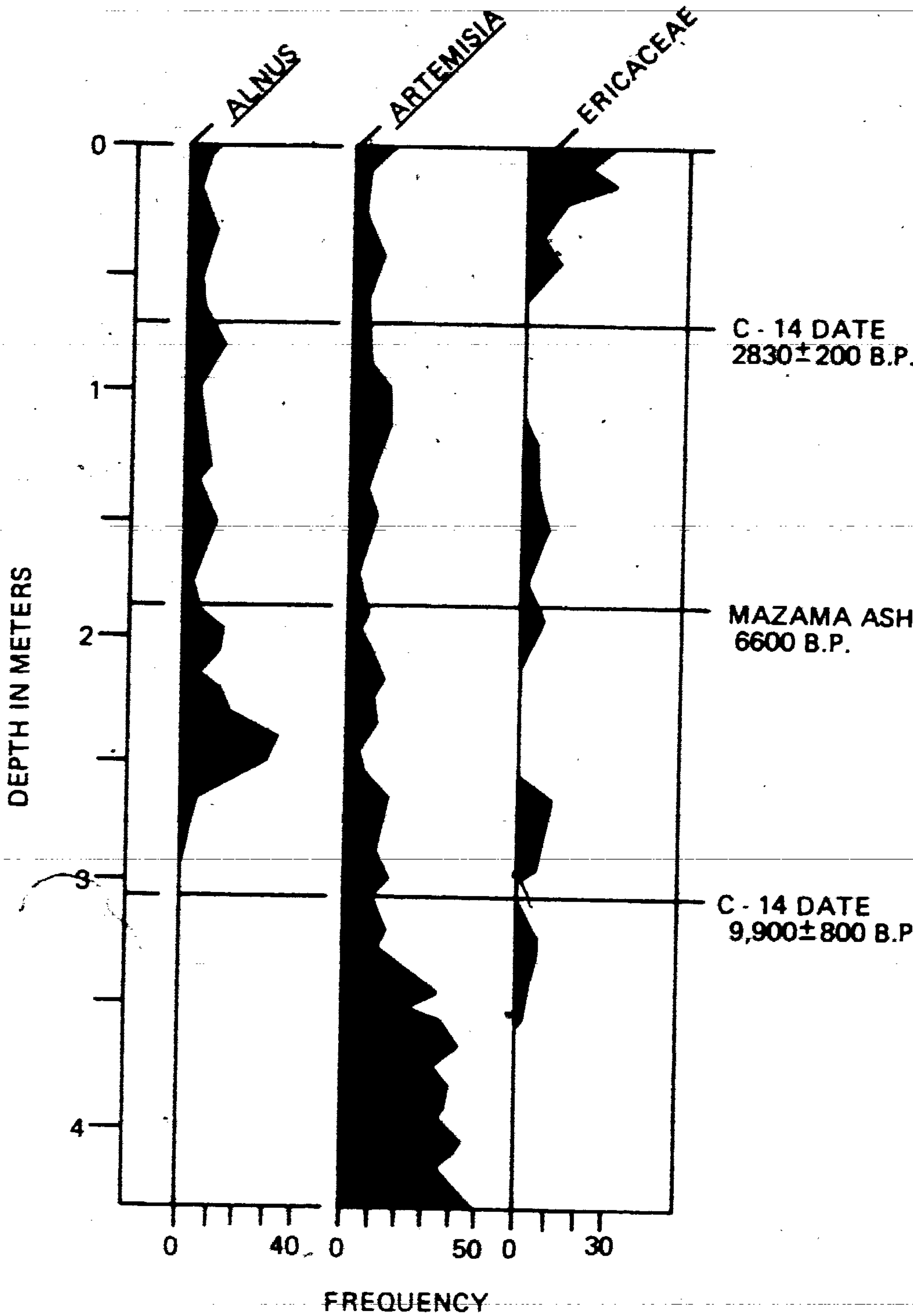


Figure 9. Osgood Swamp, California Pollen (From Adam 1967:287)

treeline levels can be interpreted in terms of climatic variation. LaMarche (1973) reported that ancient tree-lines of *Pinus longaeva* have been found 150m in elevation above the present treeline in the White Mountains of south-central California. Standing snags and other remnants of these specimens were radiocarbon dated and were found to represent trees established before 7,400 B.P. Since tree-line movements are sensitive to warm season temperatures and considering that "the response of the treeline probably lags behind climatic fluctuations" (LaMarche 1973:654), the heyday of a warming trend may have occurred a hundred or more years previous to the response, possibly before 7,500 years ago.

Axelrod (1981:851) suggests that a Holocene warming trend which he refers to as the Xerothermic (= Hypsithermal) is substantiated by the recent paleoecological evidence and that "these data support distributional evidence that more arid, interior woody taxa spread into the coastal strip of southern California, as well as northward in the Coast Ranges during the Xerothermic." Axelrod defines the Xerothermic as the drying period commencing ca. 8,000 B.P.

Tree ring analyses are important for climatic reconstructions because the annual growth rings are a reflection of prevailing environmental conditions, given certain criteria. Unfortunately, there is no dendroclimatic history available for California before 7,484 years ago (Ferguson 1970). This prohibits the possible detection of a pattern of increasing aridity before this time.

Although Clear Lake, California, is not situated in the immediate region of study, some data were gathered there which upon analysis revealed a chronology of varying Holocene growth rates of fish species (Casteel, Adam and Sims 1977) which might be indicative of southern California paleoclimate. Casteel et al. (p. 133) suggest that the "patterns of growth probably reflect changes in climate" because of dependence upon temperature. Since fish are poikilotherms their metabolism may be expected to vary with the effective temperature of their environment.

Mean standard lengths of the species Hysterocarpus traski Gibbons were derived from scale anuli by using empirical regression of fish length on scale radius and then extrapolated into graphic curves. The results indicate a warming trend commencing roughly 7,000 years ago which "might be expected to produce a pattern of growth in fish populations similar to that shown in the curves" of Figure 10, C-L, (Casteel et al. 1974:141). These data seem to be consistent with the aforementioned conclusions of Adam (1967) and LaMarche (1973) concerning inferred temperature fluctuations of the Holocene in the general regions.

Although sea level elevation curves have been determined for the Holocene of southern California by Curray (1965) and Nardin, Osborne, Bottjer and Scheidman (1981), their application to paleoclimatic episodes seems not to be reliable yet as far as short-term geophysical periods are

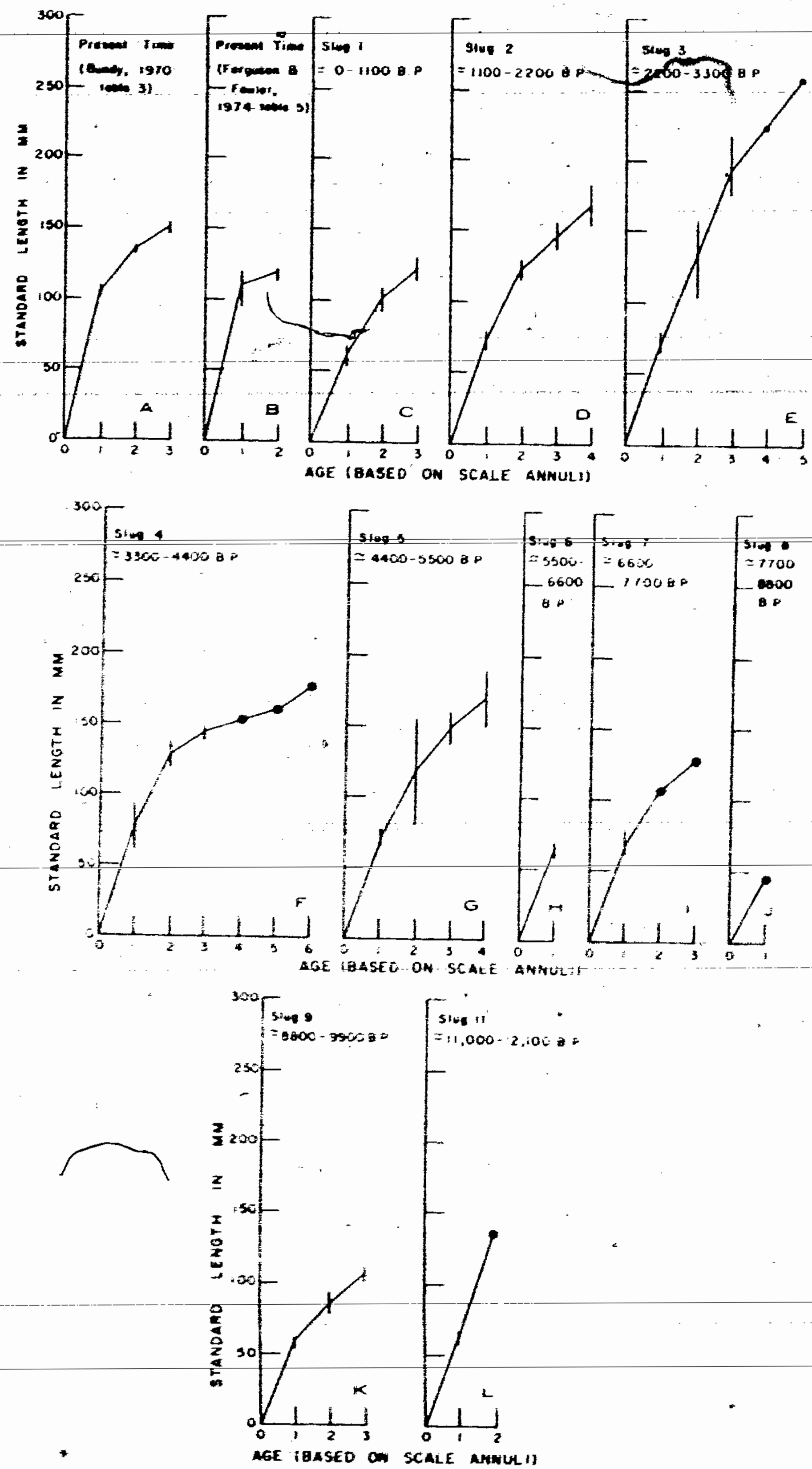


Figure 10. Holocene growth increments of Hysterocarpus traski (from Casteel, Adam, and Sims 1977:138)

concerned. As Cronin (1982:177) has noted:

> "Most sea level studies, however, lack paleoclimatic data and thus the relationship between sea level and climate for intervals of 10,000 to 1,000 years remains unclear."

Sea levels will, however, be later discussed within a context of archaeological relevance.

IV. ARCHAEOLOGICAL EVIDENCE

Major cultural changes in subsistence patterns and possibly social behavior are evidenced in the archaeological record of south-coastal California beginning approximately 7,500 years ago. This cultural change is so apparent that some archaeologists have considered the evidence as representative of two separate cultural traditions. As generally referred to in this report, south-coastal California is defined as the narrow area encompassed between Point Conception in the north and the Mexican border in the south (Figure 11), including the canyons cutting into the coast as well as the lagoons along the strip.

Some of the concepts that are of value to archaeologists in the study of culture have been defined by Hole and Heizer (1973:23-24). They present the interpretation that:

> "An archaeological culture is an assemblage of artifacts repeatedly associated together in dwellings of the same kind with burials of the same rite. The arbitrary pecularities of all cultural traits are assumed to be concrete expressions of the common social traditions that bind together a culture."

An archaeological culture, as a representative of a preexisting social reality cannot be recognized or identified with or by a single class of artifact. In order to isolate elements of cultural change the artifact populations recovered from representative strata must be large enough for any significant internal dissimilarities to be illustrated and be conclusive. Other cultural elements besides

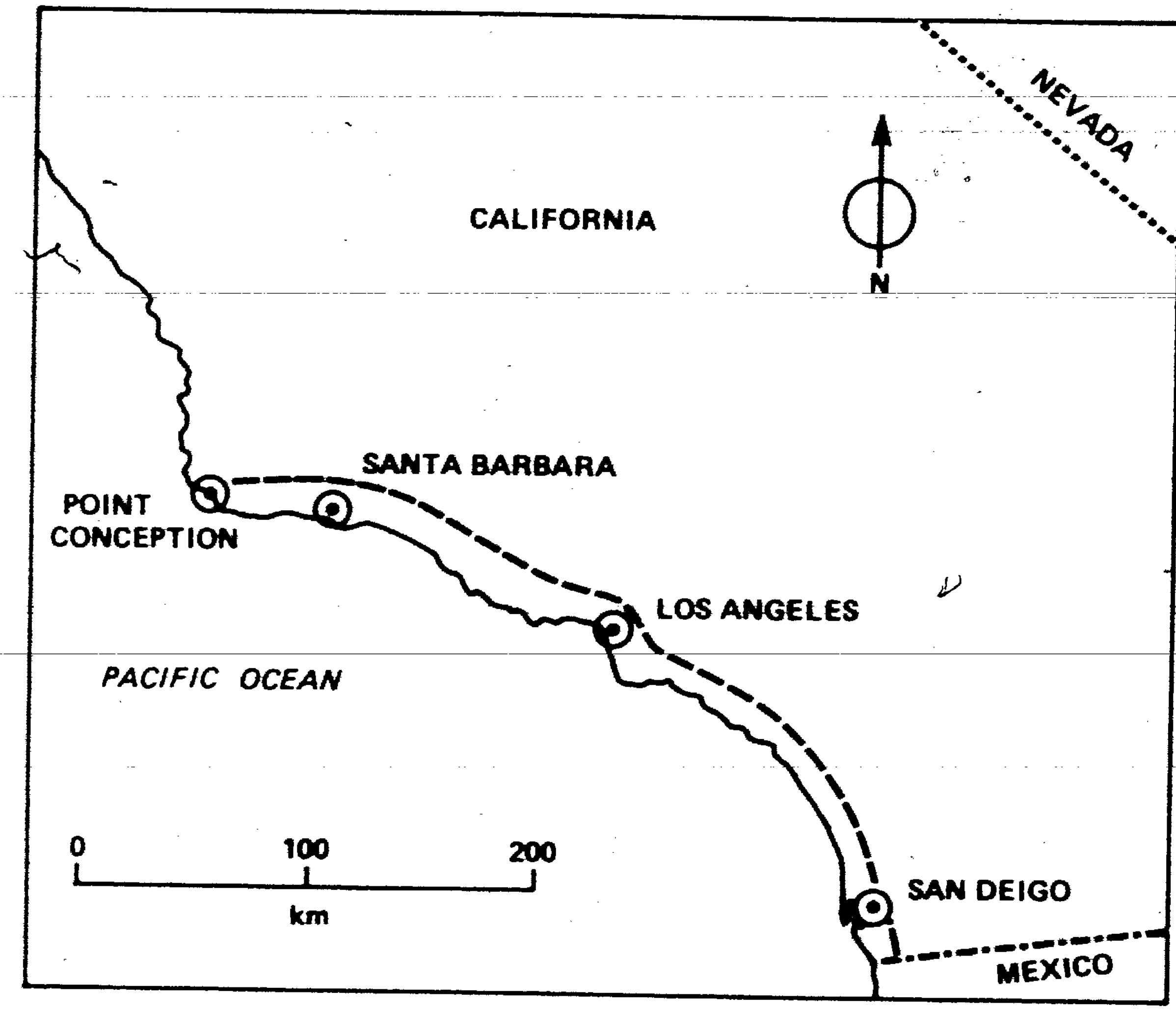


Figure 11. Map of south - coastal California

tools must be recognized and data that are complete as possible must be considered in order to distinguish differences between traditions as gleaned from the archaeological record. Table 1 is a synopsis of the available data outlining characteristic traits of the terminal San Dieguito and initial La Jolla phases.

4.1 Early Cultural History

The San Dieguito is considered to have been the earliest culture with identifiable patterns in southern California, of which technological attributes are the most easily observed. The San Dieguito complex has been described as representative of a culture that extended over a wide area from the western Great Basin and Arizona to the south coast of California (Davis 1969; Rogers 1966; Warren 1967b). The coastal manifestation of this complex dates earlier than 9,000 B.P. as confirmed by radiocarbon dating (Rogers 1966; Warren 1966), but it is believed to have occupied the coastal strip by 11,000 B.P. (Warren and True 1961).

The San Dieguito population is postulated to have migrated to the coastal zone along a route southward through the western extremity of the Great Basin and then westward through southern California (Figure 12). This has been discerned from typological analyses of assemblages that bear San Dieguito flaking attributes and morphological similarities. Warren (1967b:168) asserts that this complex "is one

SAN DIEGUITO (10,000?-7,500 B.P.)	LA JOLLA (7,500-3,500? B.P.)
- absence of burials	- flexed burials
- little evidence of mollusc exploitation	- many shell mounds of food debris
- mostly felsitic stone used for tool manufacture	- mostly quartzites used for tool manufacture
- very transitory occupation sites	- more sedentary settlements
- generalized hunting with some gathering	- heavy dependence upon gathering
Artifacts:	Artifacts:
- well-made bifacially flaked points/knifes	- large, crude projectile points (rare)
- varieties of scrapers	- retouched flakes
- core-choppers/hammers	- beach-cobble choppers
- crescentic stones	- *olivella* shell beads
- push-planes	- doughnut stones (late)
- no conclusive evidence of milling stones	- heavy use of milling stones
- gravers	- pendants (rare in early phase)

no evidence of dwelling structures for either tradition

Table 1. Cultural traits of the San Dieguito and La Jolla

(From Cressman 1977; Kaldenberg 1982; Meighan 1965; Rogers 1966; Warren 1966)

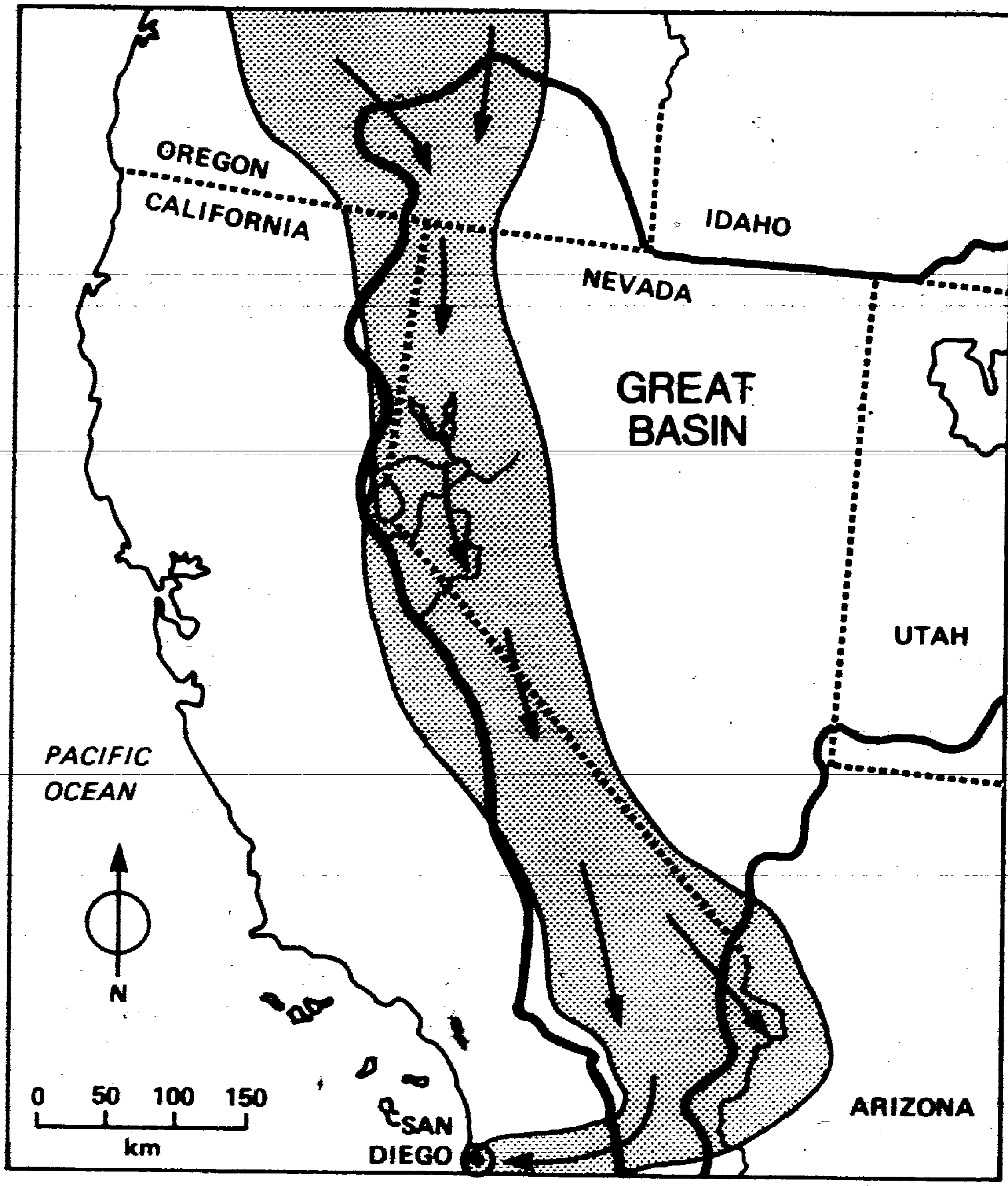


Figure 12. Proposed route of San Dieguito migration to the south - coast

of the most important cultural manifestations of Early Man in the western United States."

The C-14 date of 9,640±200 B.P. that has been applied to the artifact complex of the Lake Mojave culture is relevant to the interpretation of Pacific Coast San Dieguito assemblages. As Meighan (1965:711) has observed:

> "Lake Mojave is properly a Great Basin site, but the characteristic artifacts are comparable to the San Dieguito [type] site and culture, so this material and the date are relevant to the coastal sequence as well."

The archaeological chronology of West Coast prehistory is presently in a state that can be categorized only in a broad picture. There is much to be learned of the early coastal cultures especially concerning the ecological adaptations of the people. The representative tool assemblages of the earliest inhabitants appear to be exclusively land oriented. As Meighan (1965:713) explains "The earliest West Coast peoples ... appear to have been hunters who concentrated on larger game and had no particular interest or involvement with the resources of the sea." Evidence indicates that it was not until ca. 7,500 years ago when the La Jolla culture was established that a subsistence shift was initiated which resulted in a more diversified economy. This is witnessed in subsequent La Jollan deposits which include plant processing implements, accumulation of shell middens, and scarce remains of marine vertebrates.

Warren (1967b) has redefined the San Deiguito complex and subsumed the Death Valley I, Lake Mojave, and Playa I and II complexes as regional variants of the San Dieguito. Although these complexes are found in what is now desert they are distinct from the "Desert Culture" as defined by Bennyhoff (1958), Davis (1963), and Jennings (1964) in that grinding tools are not an element in the earlier complexes. Brott (1969) considers the San Deiguito tradition as a pattern of the Paleo-Indian Stage of the Western Lithic Co-Tradition described by Davis (1969). Recent evidence suggests that coastal San Dieguito is sufficiently distinct to be classified specifically as a unique manifestation of this broader Western tradition, although the complex does not indicate strict coastal adaptation. The coastal San Dieguito tradition as a whole is identified by three phases, each defined by changes in tool technology and location of sites (Rogers 1966). In general, all phases are characterized by significant proportions of well made scrapers of various shapes, bifacially flaked points and knives, scraper-planes, smaller frequencies of modified flakes, borer/engravers, and crescents. Warren and True (1961:275) have hypothesized that San Dieguito represents a phase of an early hunting culture, and they propose that

> "The artifact inventory argues for a basically hunting economy, although the artifact assemblage is considerably different from that of the Great Plains, and the evidence for specialized hunting activities of early man in Southern California is not nearly so clear-cut or precise as that from the Plains ... The scraping tools, knives and dart points suggest that hunting activities were undertaken. Knives and scrapers are rela-

tively numerous while dart points are relatively rare."

The frequency of types that are assumed to be projectile points decrease through time (Kaldenberg and Ezell 1974). The San Dieguito knapping technology seems to have been executed to the degree that basic cores are practically non-existent; the scraper-planes, and hammer-type tools (which will be later discussed) are very likely the result of exhausted cores. Technologically the San Dieguito complex is represented by better made flaked stone tools than that of the La Jolla complex. The use of pressure flaking is more common in the latest phase of San Dieguito. The scraper-planes of the complex appear in two basic sizes, the smaller ones averaging about half the size of the larger ones. Concerning the use of this implement Rogers (1966: 158) stated that "It is not known if size had any effect on the function of the tool." It appears that the primary regard was to form a desired edge angle of approximately 90 degrees.

There is substantial evidence indicating that the San Dieguito people hafted their point/knife blades. Two specimens of these types that were recovered from the Harris type-site in San Diego County "bore a brownish-black stain on both sides of the basal third of the artifact" (Ezell 1977:306). Upon thorough analysis conducted by S.R. Silverman of the Chevron Research Company at La Habra, California, it was found that the stains were produced by a resin similar to natural asphaltic or tarry bitumen, thus indicating they were hafted. Due to C.N. Warren's work at the Harris site a C-14 date of 9,030±350 B.P. was yielded from the deposit from which the artifacts were recovered.

Some evidence from southeastern California (Weide and Barker 1974) indicates that a San Dieguito element was adapted to arid and semi-arid economic areas, and a highly seasonal and diversified economic base is implied. Whether this representative population group shared an affinity with the coastal counterpart is not known.

San Dieguito sites of the three phases invariably follow a pattern according to physiographic zones (Kaldenberg 1982; Rogers 1966). In San Diego County, San Dieguito I and II camps occur mostly on ridges and mesas which framed valleys and are absent from river and stream margins. San Dieguito III people seemed to have preferred camping in valley bottoms, river channels, and associated low terraces. This settlement pattern seems to temporally co-relate with topographical areas that were initially habitable, and others that later became habitable (e.g. river channels and valley bottoms) as climate became more arid and intermittent desiccation of certain water courses occurred. That is, the settlement pattern that has been spatially and temporally documented (Rogers 1966; Warren 1967b) seems to have a systematic connection with geological evidence relating to precipitation patterns.

The geological evidence indicates that when sea levels were lower there was greater discharge along major drainages and into the Pacific Ocean, which was an effect of abundant precipitation (Curray 1965). High discharge rates created fast-moving streams and supplied local marshes, ponds, and lakes with runoff. As climate changed rising temperatures and decreased available moisture were accompanied by glacial retreats and sea level rise (Shepard 1965). Consequently, stream and river channels began to accrue alluvium from lessened runoff force and local water systems began to desiccate. Presently in San Diego County the San Diego, Tijuana, and San Dieguito River systems are mostly dry, except in times of high precipitation rates. This condition is likely analagous to what the local population was exposed to during the impetus of the Thermal Maximum. Changing climatic patterns are also suspected as being responsible for cultural change on the south-coast at the terminus of the Thermal Maximum (Crabtree, Warren and True 1963; Kaldenberg and May 1975). These cultural changes are specifically attributed to silting of lagoons and estuaries which became less able to support previous abundant marine faunal populations which the local inhabitants relied upon for so long. This change is understood to have had a significant impact upon the existing biotic system and Kaldenberg and May (1975:5) emphasize that:

> "One would expect cumulative stress upon those human populations attempting to exploit the resources. As the environmental stress factors of decreased water availability, lagoon faunal depletion, and the rising sea

level, the old exploitation pattern would be expected to change ... The evidence for the environmental stress-induced cultural change is very convincing ... Large shell middens characteristic of pre-5,000 B.P. became increasingly scarce and inland settlement patterns along well-watered drainages became far more common."

As recently as 1972 there had been very few stratified sites located with a San Dieguito component. The Harris site in west-central San Diego County is the type-site for the coastal manifestation of the San Dieguito tradition. It is considered to be a transient campsite and quarry used intermittently through a long period of time and has provided the typology for their lithic classifications. With the exception of the Harris site and the lower occupation at Ventana Cave, developmental sequences and chronological relationships of the San Dieguito complex "have been inferred from the spatial distribution of surface localities with respect to geomorphic features, a presence-absence analysis of tool assemblages, and the degree of desert varnish on implements" (Hume 1975:1-2). Within the past decade some buried sites with both San Dieguito and La Jolla components have been excavated, mostly through Cultural Resource Management projects, which have afforded more thorough and accurate information about these traditions (May, personal communication 1983).

It appears evident that the La Jolla tradition is a temporal cultural stage rather than a regional variant or activity facies of San Dieguito. This is substantiated by undisturbed deposits in which La Jolla materials are superposed over San Dieguito (cf. Kaldenberg 1982). There are no doubt San Dieguito and La Jolla sites south of the United States border that would yield more information about these traditions. However, little work has been done in the area other than the initial surveys of Malcolm Rogers from the 1930s to the 1950s. More must be known of the temporal and topographical distribution of San Dieguito settlements. The need for intensive surveys combined with an excavation sampling strategy that would allow 'diachronic characterization' of littoral zones is obvious. It is certain that the San Dieguito, who clearly relied on a somewhat nomadic lifestyle, had a more broadly defined resource zone than the La Jolla who were partially oriented to aquatic resources. Although the San Dieguito seem to have not been coastal oriented, the close proximity of the coastal mountains to the shoreline (Figure 13) probably limited their seasonal rounds to no farther than their hinterland.

Although Rogers (1966) includes house sites (circular boulder structures) as a trait of the early inland San Dieguito complex, no remains of house structures or distinct living floors have been evidenced from their coastal manifestation. It remains questionable whether Roger's interpretation of 'house sites' is accurate (cf. Richardson 1976).

The main source of raw material used by the San Dieguito for manufacture of lithic implements is the Poway

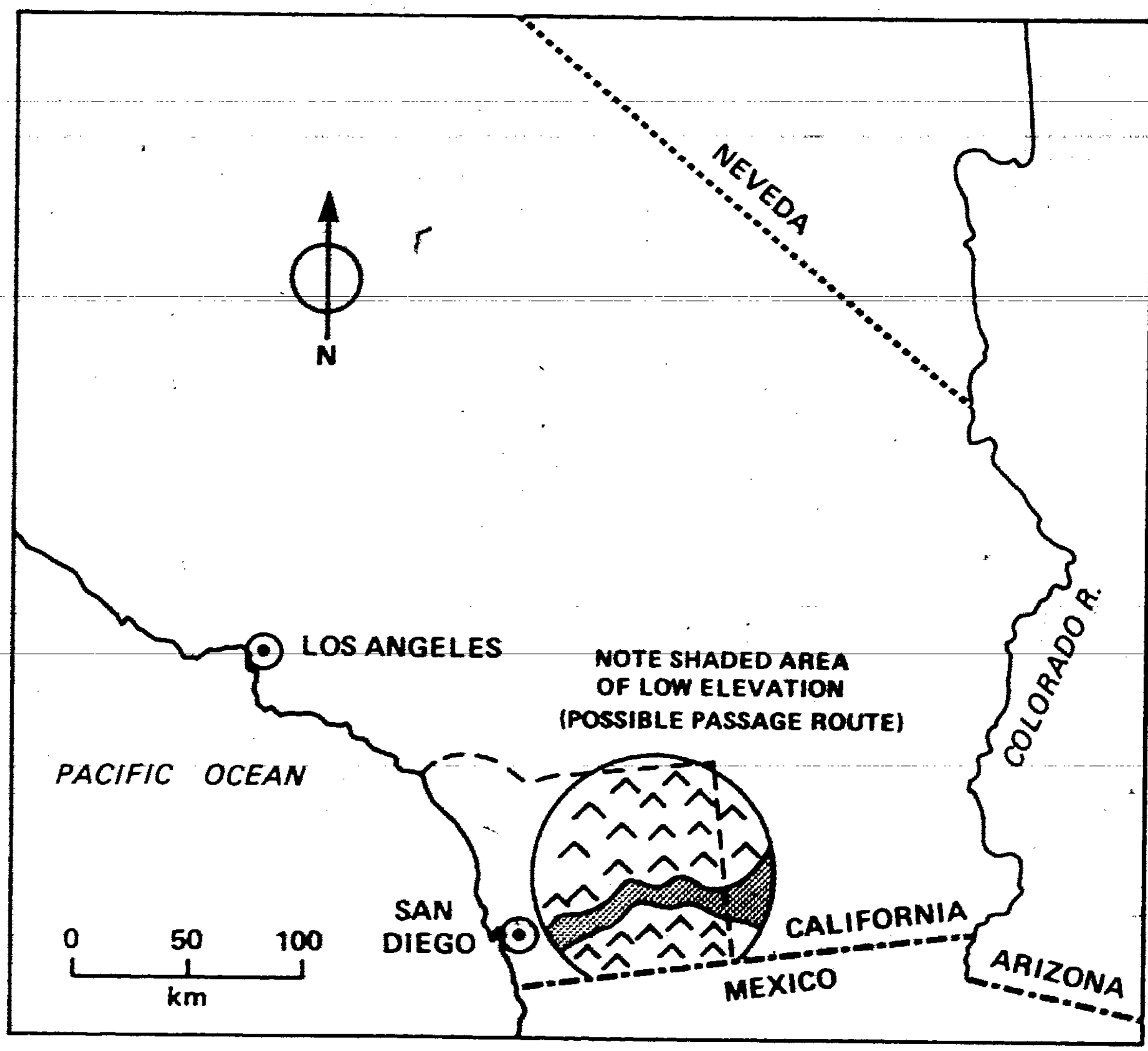


Figure 13. Map showing proximity of San Diego county coastal mountains to coastline

Conglomerate, a geological formation which provided fine-grained volcanics for the areas' inhabitants (Kaldenberg and Ezell 1974). This formation is relatively limited to the mesa area throughout western San Diego County. The transition from San Dieguito III to La Jolla I culture is indicated in one way by a change from volcanic material, especially felsite, to the more local meta-quartzites for tool manufacture (Kaldenberg 1982). After San Dieguito the local culture seems to have relied more upon minerals that could be easily obtained in close proximity to individual coastal sites rather than transporting fine-grained volcanic materials from quarries further inland.

The La Jolla culture is identified as a coastally adapted tradition that immediately succeeds the San Dieguito in the same general geographical region. Although not strictly considered to have had a significant maritime economy until the later phase (Bull 1977), the exploitation of mollusc resources was a practice characteristic of the initial phase.

From studies of the most reliable evidence it is generally agreed that the La Jolla incipience occurred approximately 7,500 years ago. Radiocarbon samples from the La Jolla component at the Harris site were assayed and indicate that the date for the initial La Jolla phase should be placed between 7,500-8,000 B.P. (Kaldenberg and Ezell 1974). This temporal ordering is important because there is a San Dieguito component at the site which stratigraphically and radiometrically predates the La Jolla deposits.

The apparently undisturbed Agua Hedionda Lagoon site in San Diego County has provided evidence in support of this initial occupation date. Radiocarbon dated samples from throughout two meters of continuous cultural deposits temporally place the emergence of milling at the site at 7,450 B.P. (Hubbs, Bien and Suess 1965:109), and an underlying component, presumably San Dieguito, predates 9,000 B.P.

In southwestern California the San Dieguito culture exhibited a slow change throughout the period ca. 9,500-7,500 B.P. In the archaeological record this change is observable by the greatly reduced frequency of some, and the possible incorporation of new tool types. Projectile points and crescents seem to have had a decreasing role of importance as the San Dieguito tradition progressed through time (Cressman 1977; Warren 1967b). If milling stones can be shown to be clearly associated with the San Dieguito III phase, a distinct modification in subsistence strategy would be indicated. It is postulated that a change in economic focus resulted from increasing aridity and environmental change which altered the availability or variety of biotic resources in the coastal area, and caused an extreme of desert conditions in southeastern California. Evidence indicates that as the climatic regime became warmer and drier agave vegetation spread into the formerly more moist coastal region. Kowta (1969:53) believes that "the development of agave exploitation in the coastal province marked the introduction of the traits characteristic of the Milling Stone Horizon."

It is possible that during the duration of increasing aridity groups of people were compelled to migrate from the desert to the California littoral environment, resulting in demographic diffusion or displacing the local residents. However, the evidence more strongly supports alternate explanations of cultural change in the area of the coast. The environmental change that occurred which inaugurated the Thermal Maximum should not be considered as having forced the more inland residents to the coast. Rather, it is likely that the shift may actually have attracted people already near the coastal area, who then established settlements in a linear pattern along the shoreline, as opposed to an inland planar pattern, and became participants in an ecotone food network.

The San Dieguito people whose antecedents are indicated to have come from far inland (Davis 1969) were adapted to a very different environment than was characteristic of the Thermal Maximum. As is evidenced in their tool inventory, their subsistence was based mostly upon hunting probably supplemented with some gathering. Approximately 7,500 years ago the generalized economic orientation of the tradition underwent a transition. The San Dieguito complex which was dominated by tools characteristic of a hunting economy was apparently replaced by a complex associated with a milling and seed grinding subsistence base. There are a limited number of feasible explanations as to why this occurred. The available evidence implies that this was a reflection of an adaptive response to climatic and environmental stimuli. Baumhoff and Heizer (1965) suggest that the San Deiguito people chose to adapt their technology to the changing environmental conditions rather than migrate to environs that favored continued hunting. Just as the early Playa-Flake complex of southeastern California underwent a transition contemporaneously with the terminal phase of the Wisconsin glaciation (Davis 1965), the transitional San Dieguito-La Jolla occurrence seems to coincide with a pattern of another marked climatic and environmental shift. There is evidence suggesting that the San Dieguito were in a transitional stage during the latter segment of the last phase. For instance, Kaldenberg and Ezell (1974:28) state that the archaeological record at the Harris site "suggests that the gathering of shellfish was also part of the subsistence pattern of the coastal manifestation of the San Dieguito Complex. Evidence from the Agua Hedionda site seems to verify that the San Dieguito were exploiting shellfish to some degree before 7,500 B.P. (Hubbs et al. 1965:109).

It is hypothesized that the San Dieguito, after occupying the coastal area for at least two to three thousand years, were confronted with an environmental shift of sufficient degree as to warrant a readaptation both economically and socially. This inference will be later discussed in detail. The La Jolla pattern may represent a reorganization of the San Dieguito culture resulting from a change in their accustomed habitat. It seems that the La Jolla tradition can be viewed as an adjustment in response to a changing environment which occurred as the population encountered what King and Graham (1981:130) refer to as a "habitat stress line." As the moist phase of the terminal Pleistocene graded into the warm-dry phase of the Thermal Maximum the oak and pine woodlands that were once abundant were generally replaced by chaparral-type vegetation that proliferated in more arid conditions. The northeastward movement of the oak/pine ecotone has been demonstrated by radiocarbon dated pollen sequences. Other biotic elements including fauna followed their customary niche (King 1976).

La Jolla lithic technology is characterized by a high frequency of retouched flakes and milling stones, with beach-cobble choppers representing a lower proportion of their assemblages. Large, crude projectile points occur in their complex but they are rare (Kaldenberg 1982; Cressman 1977) and seem to have been of tertiary importance in a techno-economic capacity. It is noteworthy that decorative elements appear in the initial La Jolla phase. Most notably, olivella shell beads are the common ornaments that occur in their deposits, and they are sometimes found as burial offerings.

Although dwelling structures are not evidenced for either the San Dieguito or the La Jolla traditions, the diversity between their respective artifact assemblages seems to suggest different populations with contrasting behavior patterns. It is noteworthy that there is no evidence of human burials from San Dieguito deposits while the La Jollans are known to have flexed burials and small cemetary areas that appear with the incipience of the tradition. Rogers (1963:7) describes the La Jolla culture type as represented by a "rather simple technology of crude stone work and indications of a seafood-seed-gathering economy, along with the interment of the dead in prepared graves." However, burial practices should not be discountd as a possibility among the San Dieguito. The majority of San Dieguito sites are surface assemblages and the absence of burials may be due to taphonomic effects such as water erosion, deflation, or poor preservation conditions. Also, the San Dieguito are known to have been more transient than La Jollans with very few sites representing sedentary occupations. Their nomadic inclination may account for the difficulty in potentially locating any of their burials.

Researchers who have investigated the early cultural patterns of lower California have generally agreed that grinding stone and milling implements do not appear until the La Jolla I industry at ca. 7,500 B.P. (Cressman 1977; Rogers 1966; Warren and True 1961). However, there remains some question whether milling stones form a part of the San Dieguito complex. Relating specifically to the San Dieguito, Kaldenberg (1982:10) states that "Little evidence of grinding technology has yet been found in association with the complex." At a few sites close stratigraphic superposition or slight mixing of La Jolla and San Dieguito material complicates establishing whether milling was practiced by the earlier tradition. In any case, if it was, it seems that it would be only in the terminal phase when it might have become a practice of secondary importance. The San Dieguito site at Otay mesa offers some evidence indicating that the later San Dieguito people may have practiced some milling, and the assemblage presents an interesting study of possible transitional importance.

4.2 A Site Study

The Otay site is located three kilometers due north of the Mexican border and 15.6km due east of the Imperial Beach shoreline in San Diego County (Figure 14). The site is approximately the same distance from the County coast as is the San Dieguito type site located 53km north of Otay Mesa, however it is not located on a river channel-terrace as is the Harris site. It is situated on a mesa at an elevation of 160m a.s.l. The vegetation is sparse and is dominated by chaparral base species and short grasses with a high proportion of these plants clustered in mima mounds. The site is represented by a surface assemblage, the significance of which should become clear from the literature pertaining to this topic.

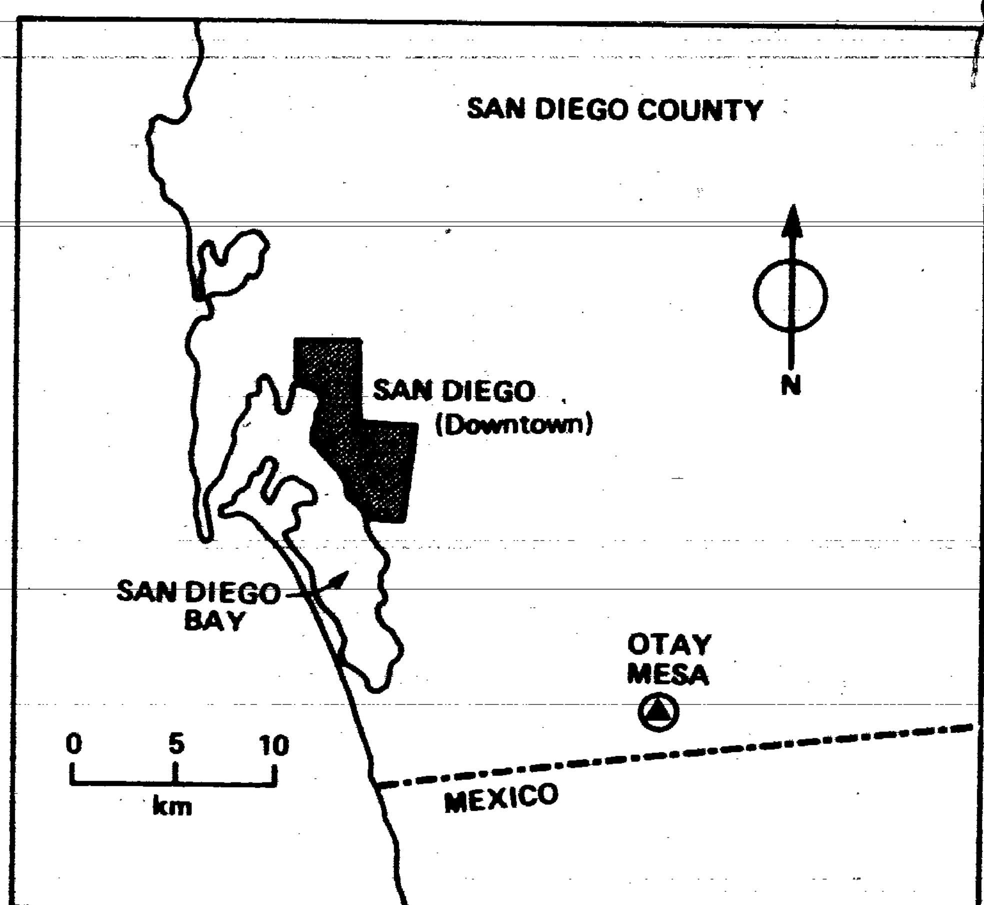


Figure 14. Map of Otay Mesa site location

The systematic collection of archaeological surface materials, other than being a cost-efficient data generating technique, is important for numerous reasons. Lewarch and O'Brien (1981:297) emphasize the basic tenet "that surface artifacts are useful in more situations and for more kinds of research problems than might commonly be appreciated." It is believed that archaeologists should consider a more expanding role for surface materials in their own research.

Although the natural formation processes that create surface phenomena are not an issue, and excavation procedures were not carried out on the Otay site, it is expected that its surface deposits might be an indicator of discrete cultural dynamics.

In 1976 Richard Cerutti (personal communication 1982), an associate of the Museum of Natural History, San Diego, surface collected artifacts from the site with permission of Mr. J. Pepper, the landowner.

Laboratory analysis of the Cerutti material, undertaken by myself, demonstrated that all of the specimens in the assemblage conformed within typological characteristics of the general San Dieguito lithic industry, with one essential exception -- the presence of milling stones. The specimens were classified using Davis (1969:75) typical San Dieguito artifact types list (Table 2), Rogers (1966) attributes of the southwestern San Diéguito aspect, and by comparison with the San Dieguito type collection housed at the Museum of Man, San Diego. Following are general observations about

TYPICAL San Dieguito artifacts

1) Heavy, "horse-hoof" planes

2) Rounded end-scrapers, retouched by light percussion and probably hafted

3) Side-and-end scrapers, probably hafted

4) Ovoid scrapers, probably hafted

5) Choppers, made on large and heavy primary flakes

6) San Dieguito Type 1 knife/points (Warren and True 1961) with one end pointed and the other round. Cross section is lozenge shaped. These tools are narrow and thick rather than wide and thin.

7) San Dieguito Type 2 knife/points (Warren and True 1961). These are large, thinned bifaces; rather wide

8) Long-stemmed point/knives with weak shoulders

9) Crescents (rare)

10) Hammerstones

11) Macroflakes

12) Thick primary flakes

13) Thin trimming and finishing flakes

Table 2. (After Davis 1969:75)

the recovered artifacts, and a detailed description of the specimens is presented in the Appendix.

Discounting the milling tools in the assemblage the remaining elements appear to be, in the terms of Mosely and Mackey (1972) "ethnically pure" with no intrusion of material from succeeding cultural traditions. The preference of using felsite and porphyry for the manufacture of tools is apparent as the entire assemblage, other than milling implements, is fashioned from these materials.

The functional aspects of the assemblage, with slight overlap allowing for uncertain purposes of some knife and piercer-type specimens, seem to fall within three categories: 1) tools used in hunting, such as projectile points, knives and some scraper forms; 2) those used in the gathering and preparation of food, such as scraper-planes, cutting and piercing devices, and milling stones; and 3) stones used for shaping and resurfacing grinding slabs (metates).

The milling component in the assemblage is represented by 20 manos made of beach-type cobbles and five large metate fragments, two of which were found to be from the same original object (Figure 15). All of the manos are symmetrical and well shaped (Figure 16). In all cases both faces exhibit wear (Figure 17) but on a few specimens one side has been much more flattened and smoothed by rubbing. Two specimens are composed of gritty sandstone while the remaining ones are granite or feldspar material.

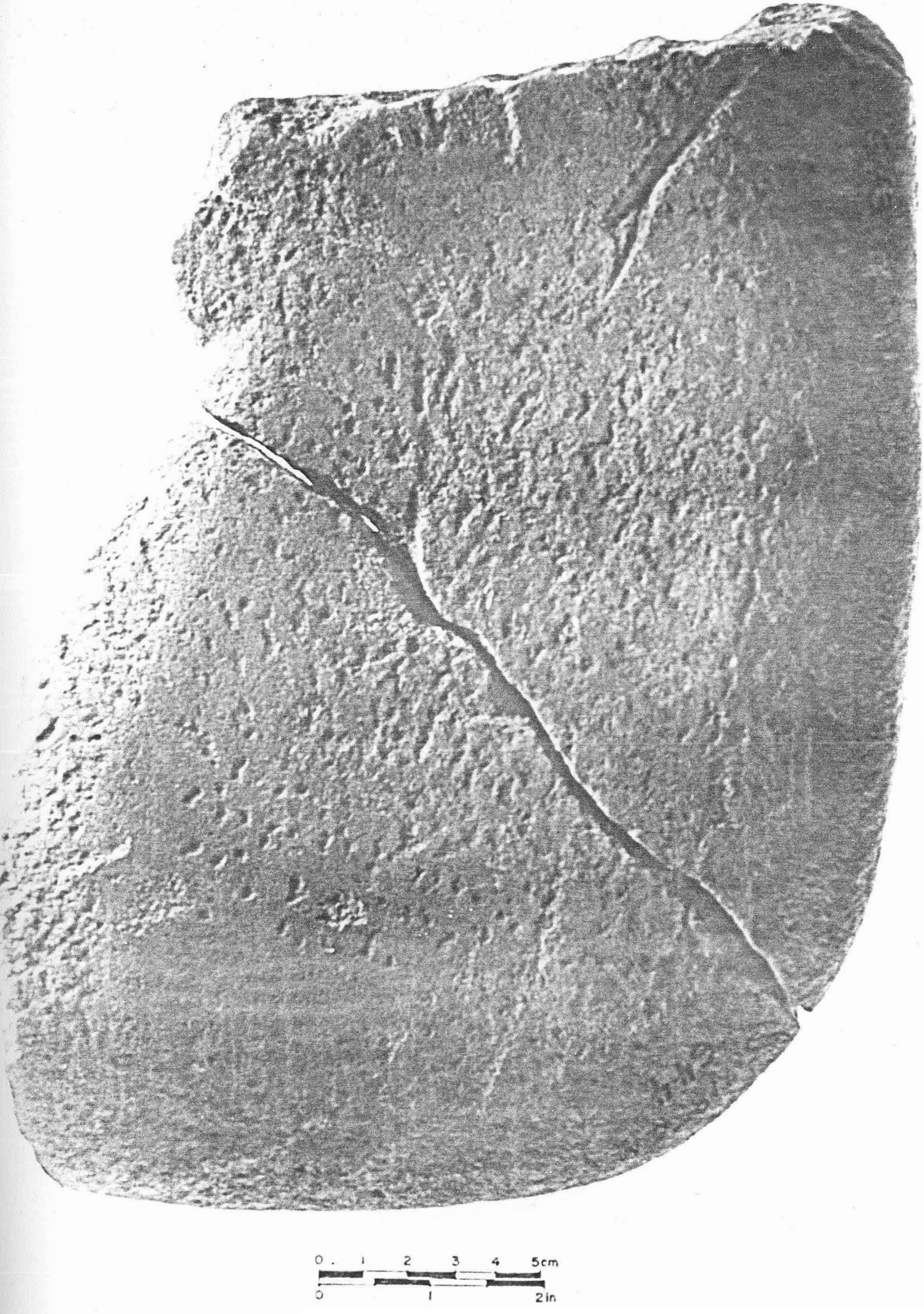


Figure 15. Metate fragments

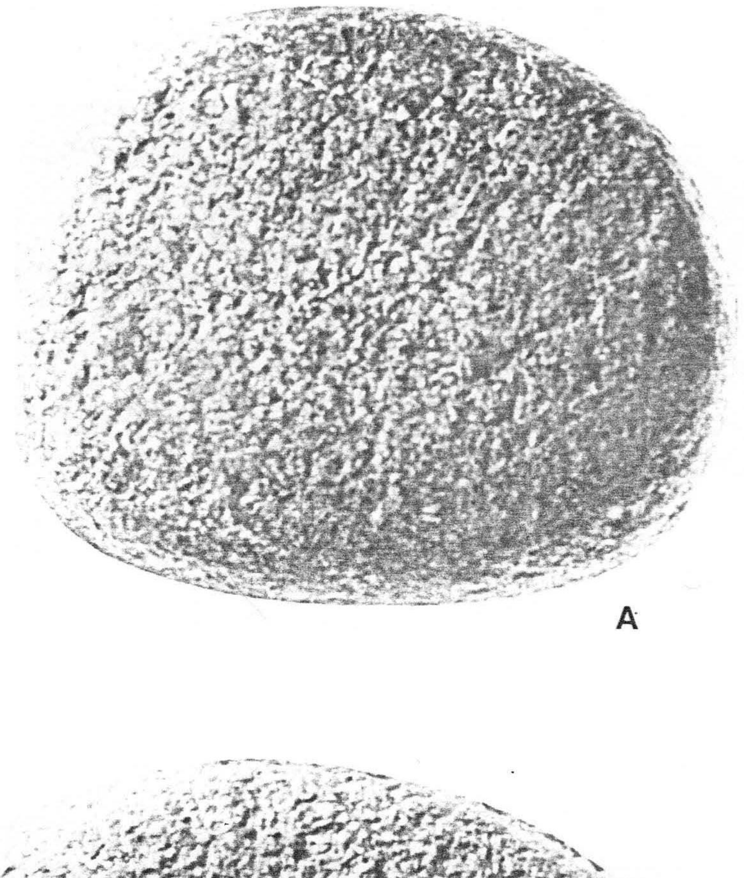


Figure 16. Manos

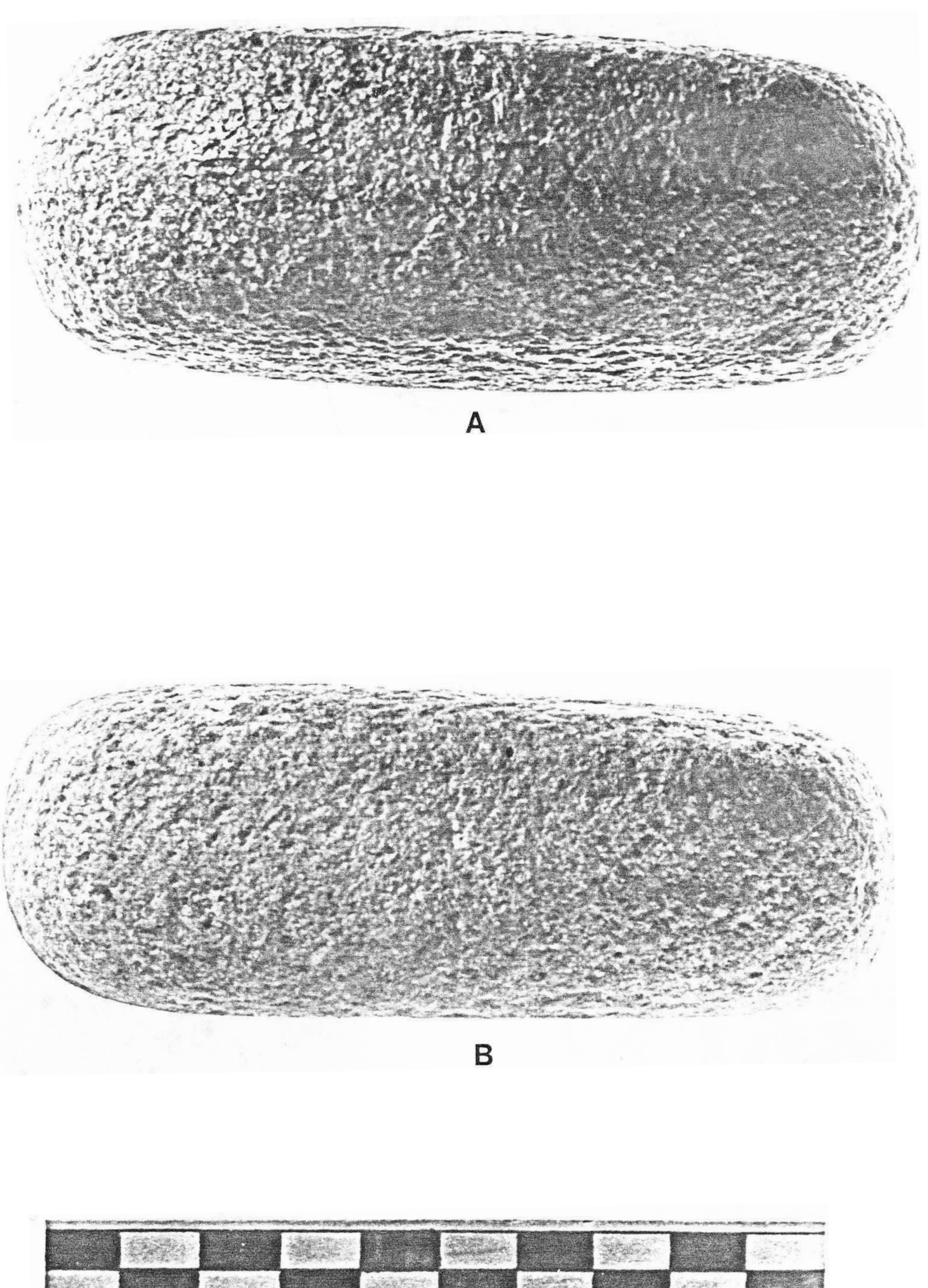


Figure 17. Manos (side view)

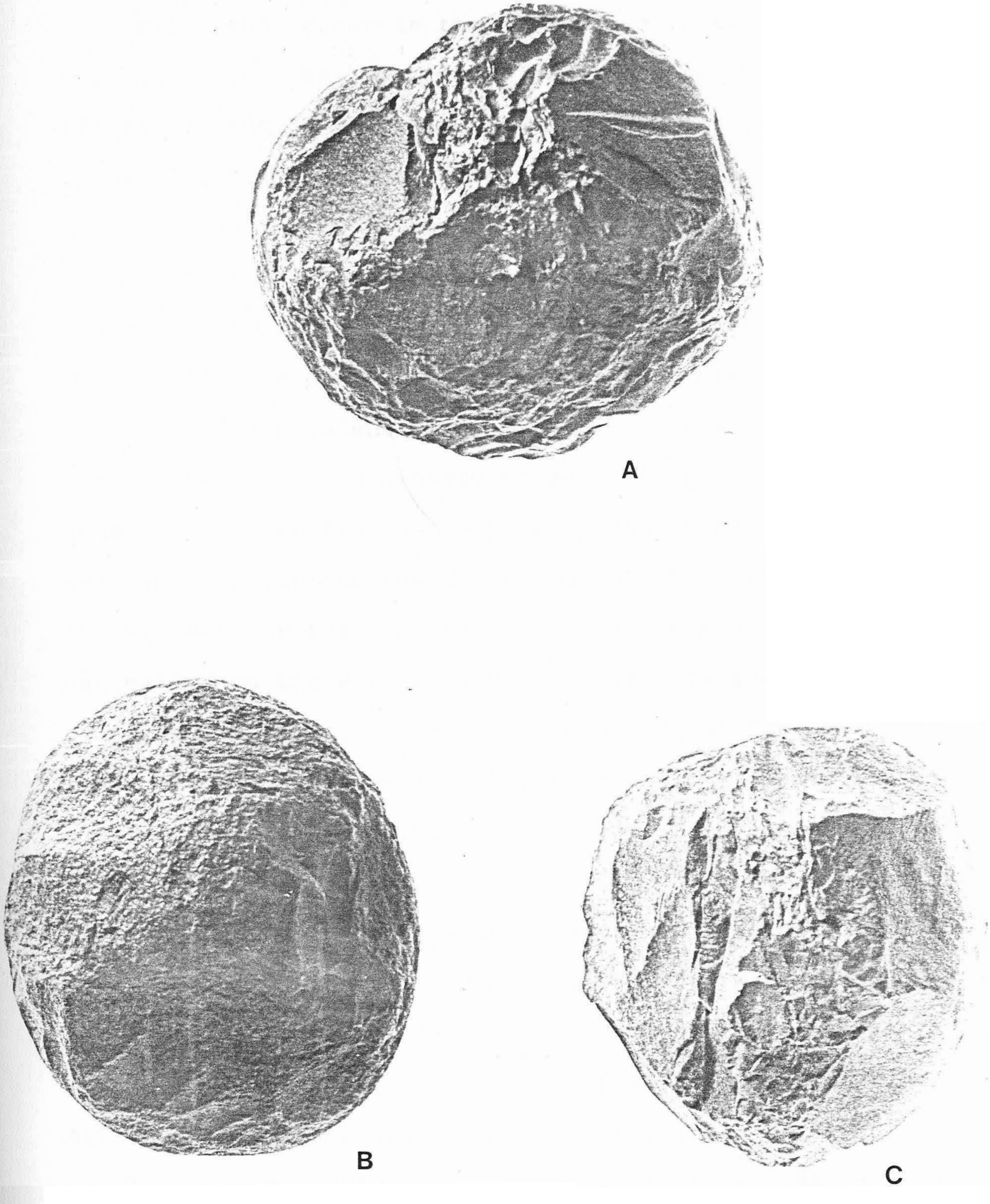


Figure 18. Hammers

0 1 2 3 4 5cm
0 1 2in

While they occur in the assemblage in association with milling stones, the implements considered as hammers (Figure 18) should not be confused with hammerstones in the traditional sense. They were likely used to sculpt and work the metates -- not only to roughly shape them, but probably also to resurface the grinding area for increased friction between plant material and rock surface as is suggested in Dodd's (1979) report which describes this practice.

Since independent means of dating the assemblage are inadequate, it was necessary to rely on typological comparisons in order to fix the temporal position of the site as well as to determine the directions of its cultural affinities. Most of the assemblage demonstrates a high degree of patination on the worked surfaces, which is suspected to have resulted from a long duration since manufacture of the implements and is generally characteristic of early south-coastal cultural materials made of felsite or porphyry (Reeves, personal communication 1982).

The San Dieguito complex incorporated technological changes throughout its phases (Rogers 1966; Warren 1967b), albeit these changes were slight and presently are visible mostly in comparative frequencies of individual tool types. Although the phases are somewhat difficult to differentiate, the low frequency of projectile points (Figure 19) and presence of milling stones in the Otay assemblage suggests the late phase of the tradition. The scarcity of both side-struck flakes and flakes with a high percentage of cortex

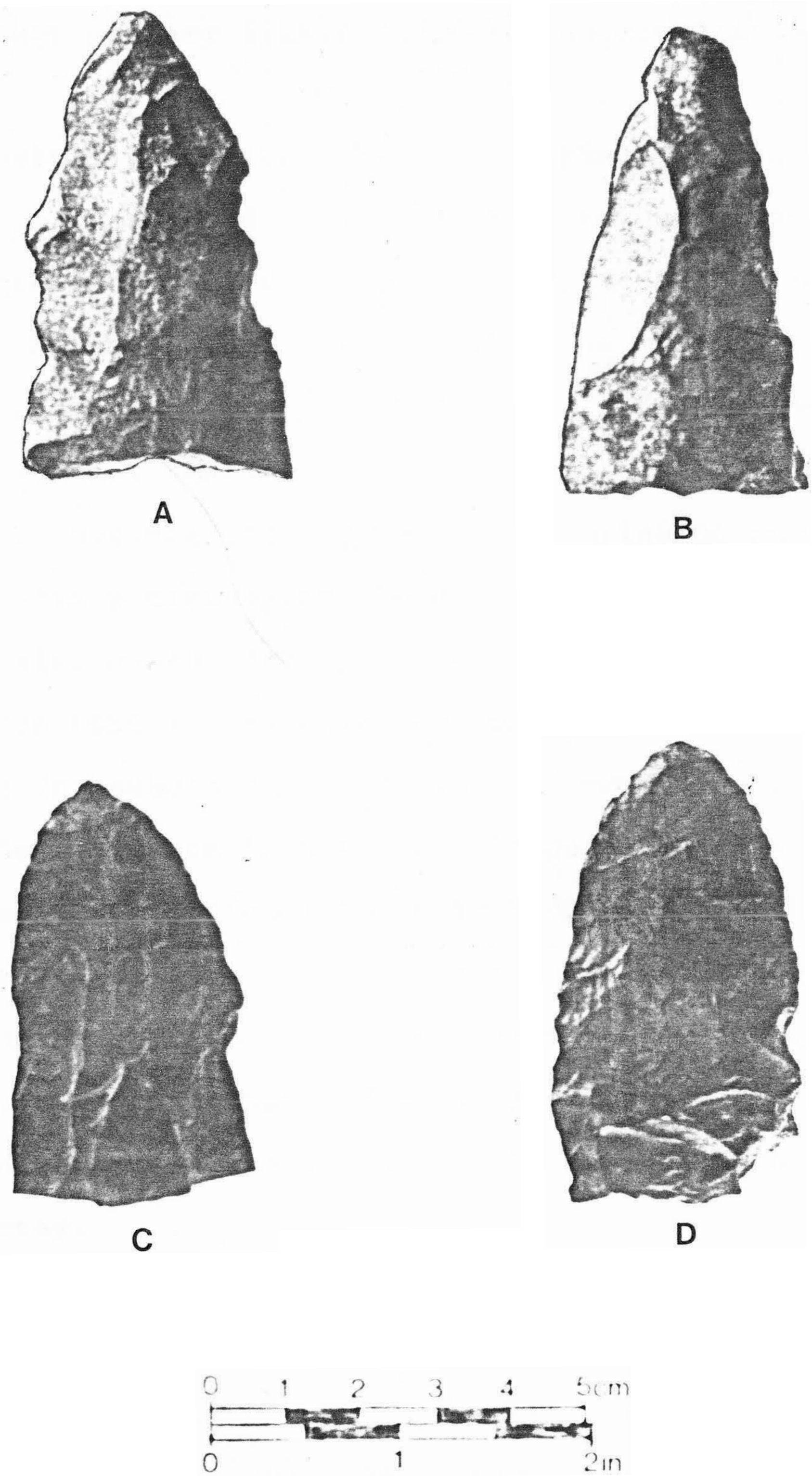


Figure 19. Points

indicates that primary lithic reduction occurred at another location.

In previously mentioned literature the San Diequito complex is characterized as a flake industry with well-made knives, a great diversity of plano-convex scrapers, and crescents. Although the Otay collection is morphologically representative of this Complex there is a total absence of crescentic stones. As is generally suggested the Complex is probably not characterized by the use of grinding tools. Again, there is a discrepancy between this consensus and the Otay materials, as the frequency of manos and metates suggests more than a peripheral economic dependence upon plant foods for subsistence. It is proffered that the Otay site provides evidence that the San Dieguito had likely incorporated some milling into their technology in the late phase. The general presence of milling devices suggests that processing of seeds, nuts or grains was becoming important for sustenance as opposed to earlier phases of San Dieguito in which hunting is assumed to have been the economic mainstay.

The absence of crescents and the presence of grinding implements can be interpreted as representing a period in which the San Dieguito complex was undergoing an alteration of cultural patterns. This was likely induced by the environmental transformation that is demonstrated in the paleoenvironmental literature.

The reddish polish that appears on approximately 20 percent of the manos seems to reveal either the grinding of ochre, which was recovered from the site, or plant material having a similar ironlike pigment (Broderick 1983).

The bifaces that are considered projectile points are mostly broken specimens and are likely to be ends of elongate knives which are represented in various sizes in the assemblage (Figure 20). One specimen of a possible knife blank or pick was recovered (Figure 21). The remainder of finished tools in the assemblage include the scraper-planes diagnostic of the San Dieguito industry (Figure 22) and a relatively high frequency of borer/engravers (Figure 23) and discoidal scrapers (Figure 24).

A recurring notch pattern that was observed by this researcher during two seasons fieldwork and subsequent laboratory analysis of collected artifacts may be relevant to tool function. This pattern seems to have been intentionally produced for a desired purpose, as it appears on a number of tool types including scrapers, planes, borer/engravers, and modified flakes. This pattern was observed in both the San Dieguito and La Jolla industries and is present on many of the Otay Mesa artifacts (Figure 25).

Succeeding the analysis of the artifacts from Otay Mesa it was concluded that all of the specimens of finished tools are typologically and dimensionally within the criteria delimiting typical San Dieguito implements (see Table 2). Based on the extensive descriptions of the San Dieguito

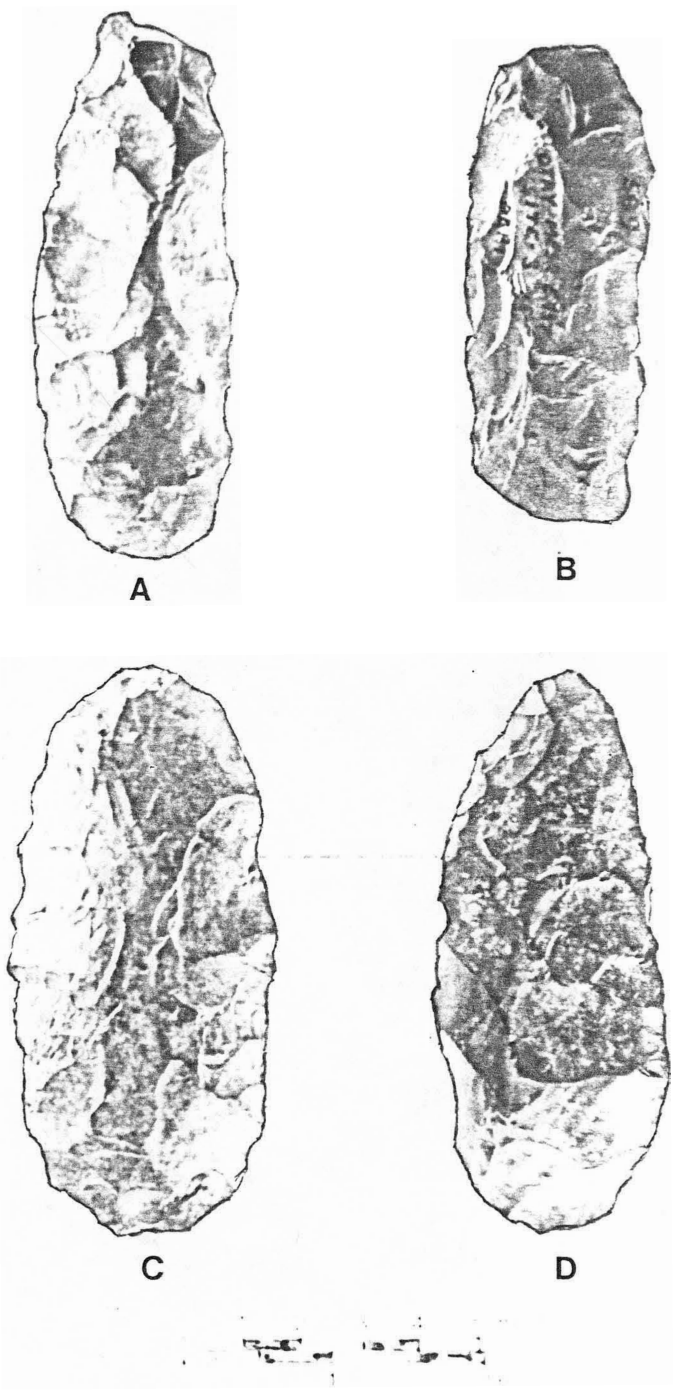


Figure 20. Knives

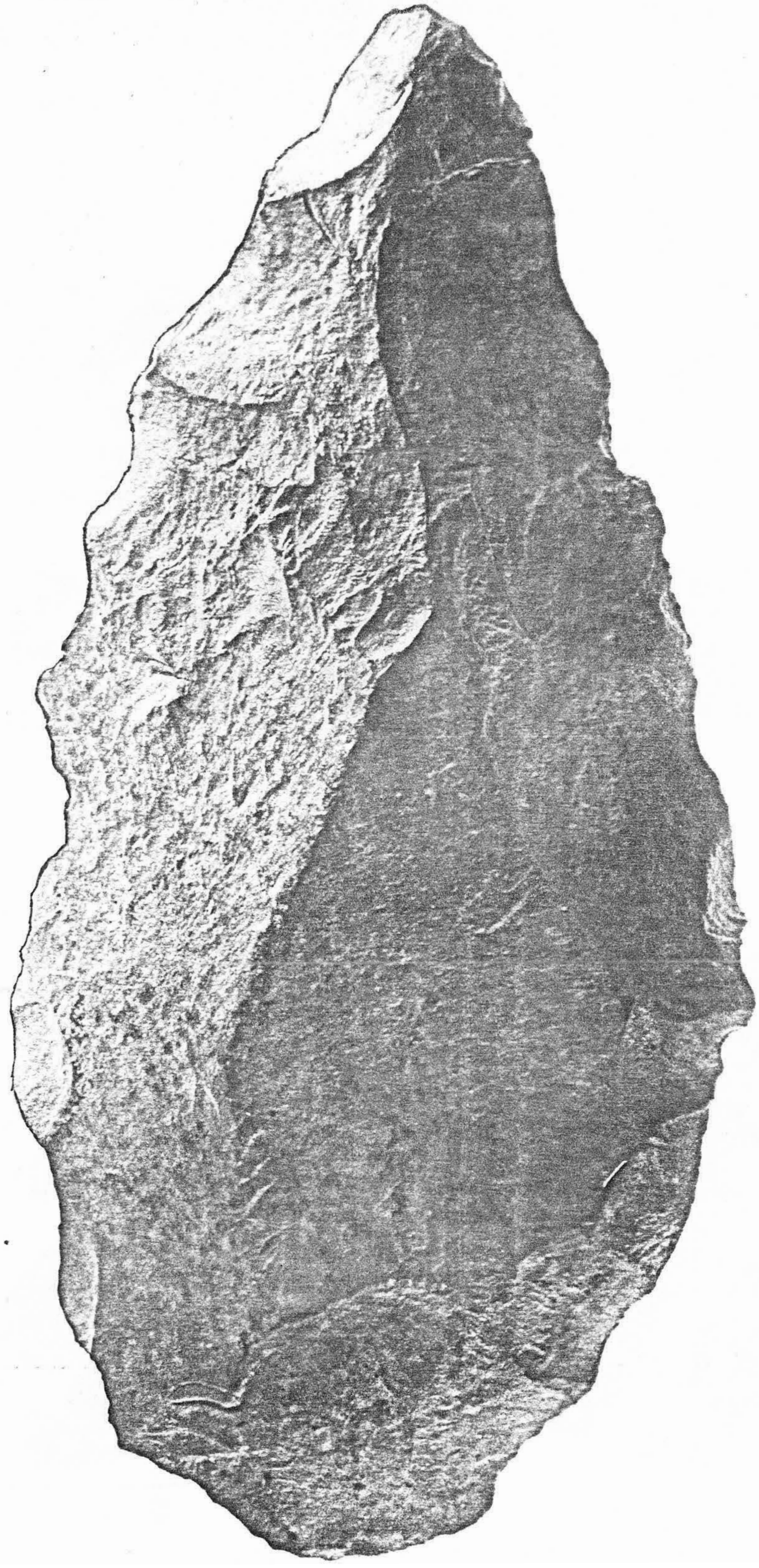
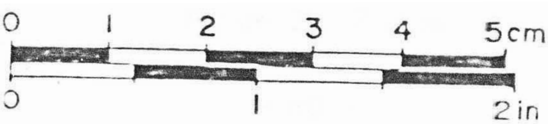


Figure 21. Preform / pick



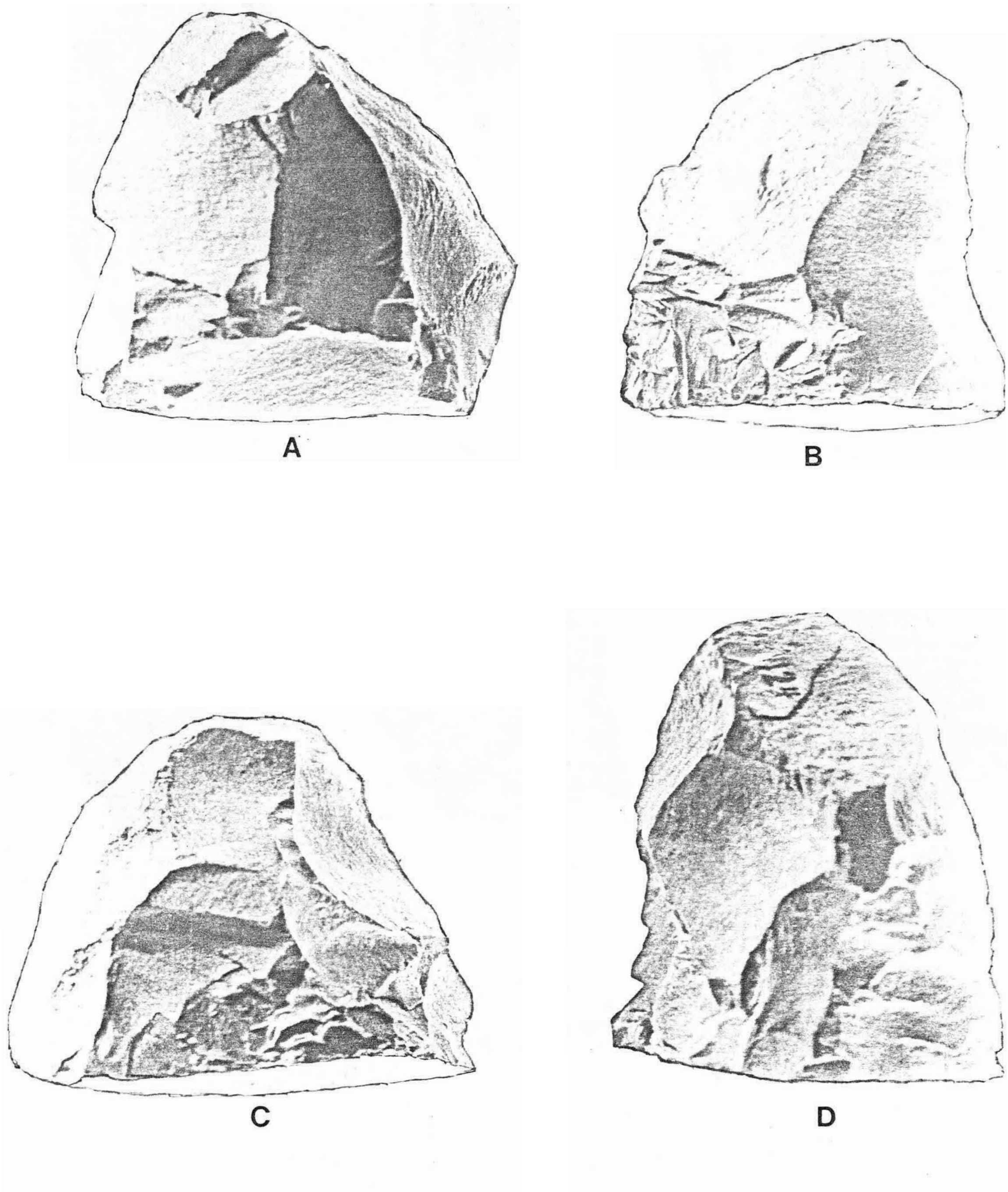


Figure 22. Planes

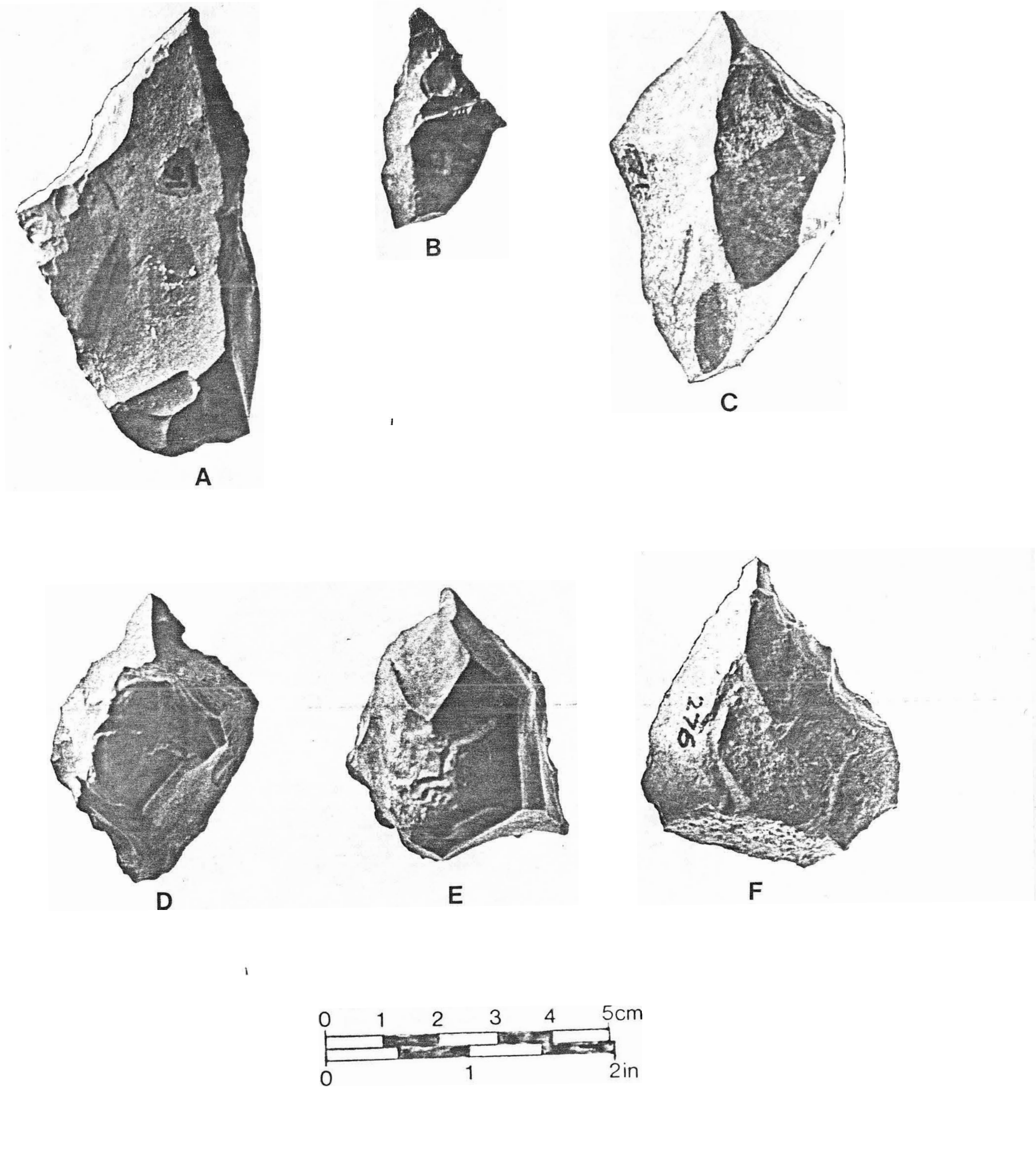


Figure 23. Beaked borer/gravers

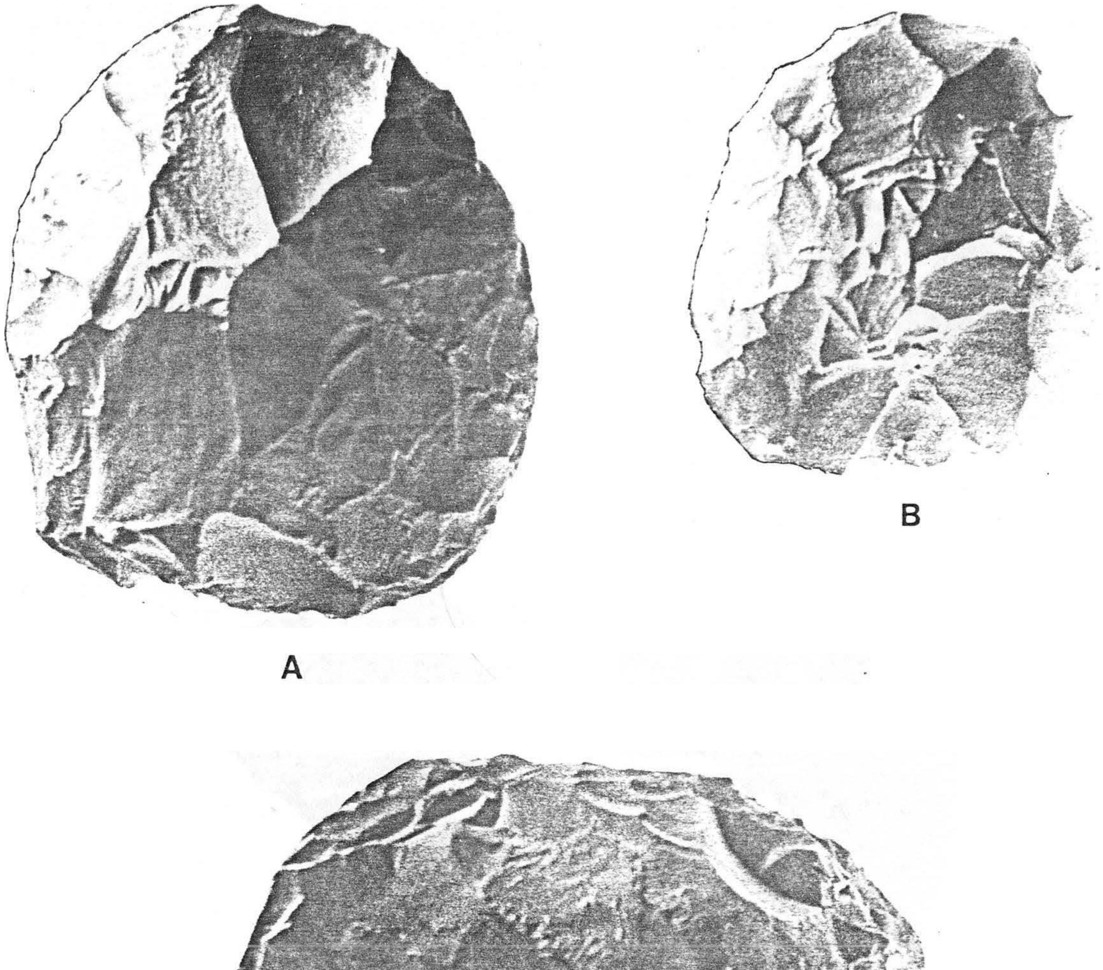


Figure 24. Discoidal Scrapers

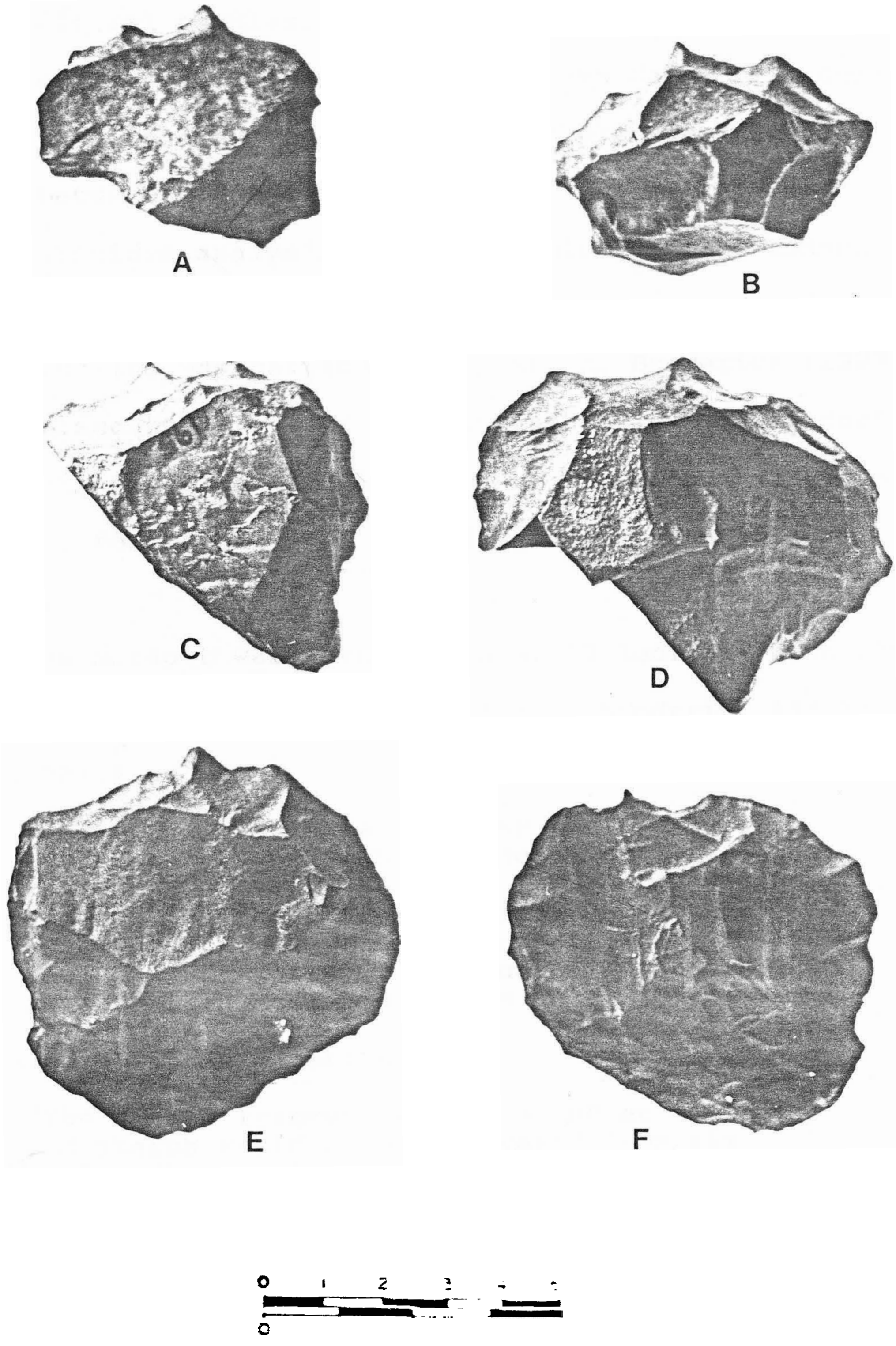


Figure 25. Notched pattern

lithic industry, including that of the type site, the Otay assemblage can be confidently placed into the late phase of this cultural complex. From radiocarbon dated sequences of San Dieguito occupation in southwestern California correlated with tool typologies, it is likely that the Otay site dates between 8,000-7,500 B.P.

A residue analysis of three tools (a plano-convex discoidal scraper, a mano, and the largest metate fragment) from the site was carried out by Mr. M. Broderick (1983). The implements were subjected to the following standard examinations: 1) the benzidine test for blood; 2) the Sudan III test for fat and resin; and 3) the Iodine test for starch.

The scraper was scrutinized at 19 loci and both blood and fat were recovered from 11 loci. Broderick (1983:9) found that:

> "This would indicate that the tool was used on animal tissue. The residues were ... restricted to both sides of the narrow angled edge of the tool. Lack of residue on the opposing [thick] edge may indicate that the tool was not hafted. One would expect a residue such as resin on the tool if hafted."

The author (p. 12) continues:

> "The metate fragment was examined at 16 loci and starch residue was recovered from six loci. The remainder of the tool was barren of residues at loci sampled. It appears that one surface of the tool had been used for processing starchy plant matter such as grain by grinding. This is suspected because the area of the tool containing starch residue is in the depression of the surface."

The mano, made of a feldspar beach-type cobble, was tested at 16 loci and both fat and resin residues were recovered from all but two loci which were sampled from the rounded edge of the tool. This is an interesting observation because there is a deep reddish-brown stain on both flat-ground surfaces, and under high magnification the stain appears to have been absorbed by the cortical material. It would seem that the presence of both resin and fat suggests the tool was used on both plant and animal tissue, however further consideration is necessary. Hematite presence was suggested as the benzidine test detected significant amounts of iron from the surface and a subsequent X-ray diffusion analysis revealed that the iron content was restricted to that surface. Broderick (1983:15) summarizes with this hypothesis:

> "The tool may have been used for the purpose of grinding a hematite pigment in a mixture of plant and animal tissue. It may have been used on a mixture of hematite and plant material, as an oily plant part may have been selected to act as a hematite vehicle. The tool may also have been used exclusively for the preparation of plant tissue for some ethnobotanical purpose. Here, an iron-rich oily plant or plant part would have been selected."

4.3 Ecofacts as Indicators of Environment and Subsistence

The problem of reconstructing paleoenvironments and also social lifeways of prehistoric populations can be partially solved by various studies with ethnobotanical orientation. As Yarnell (1970:215) explains:

> "Analyses of plant remains from individual archaeological sites and groups of sites can be highly instructive of local patterns of technology and subsistence (and perhaps ultimately of economics and other aspects of the extinct socio-cultural systems under investigation)."

Among the types of information that can be obtained by these studies are local contemporaneous environmental conditions and preparation and uses of plant products.

The great quantity of milling stones in the La Jolla complex is evidence of the importance of wild-seed collecting and processing. They also utilized <u>Pinon</u> and <u>Malvaceae</u> resources as witnessed in the recovery of a "roasting platform" associated with these species, dated 6,300 B.P. (Warren and True 1961). No remains of this type have been found at San Dieguito sites. As Meighan (1965: 713) has observed:

> "By about 7,500 years ago, at least part of the coastal region was widely settled, and a shift took place to a more varied and diversified kind of economy, with close adaptation to the resources of the numerous ecological niches of the western coastline."

The major changes distinguishing the La Jolla tradition (i.e. new technology, slight shift in habitation area, appearance of shell middens and milling devices) were likely adaptive interactions to augment exploitive capabilities.

There are few data available relating to Holocene terrestrial faunal distributions in the pre-7,500 era of southern California, even in a non-archaeological perspective; especially the faunal sequences for coastal sites are very incomplete (Lippold, personal communication 1984). Because of this it is difficult to speculate how a period of increasing aridity affected migrations of land species. As McCrossin (1983:138) has pointed out, "one must realize that faunal remains are but very abstract representations of habitat unless large samples are available" for study. However, it can probably be assumed that the larger species of mammals either became extinct or followed their customary ecological niches into higher elevations.

The most common land mammals occurring in the early La Jolla deposits are California mule deer, rabbits, gophers and woodrats; although the proportion of these compared to molluscan remains is small.

It has been evidenced in early La Jolla sites such as Green Valley Knolls (Kaldenberg and Hatley 1976) and Monument Mesa (Bingham 1978) that reptiles such as lizards and small rodents became important in the economy through time.

The archaeological record of the San Dieguito tradition, other than lithic implements, is sparse. There is no association with extinct fauna and relatively little with extant species (Kaldenberg 1982). The appearance of some indicator species can aid in the formulation of San Diequito ecology. As Birks and Birks (1980:27) have noted:

> "It is unlikely that all species of a ... community will be preserved, recovered or recognized in the fossil assemblage. However, certain species will be identified which

because of their known modern niches and the ways in which they are associated, can, by inference, be used to indicate the past occurrence of a particular community."

From research undertaken at the transitional San Dieguito-La Jolla site at Rancho Park North, Kaldenberg (1982) has determined a shift of animal food resources through time. His data are summarized in Table 3.

RANCHO PARK NORTH SITE

LEVEL VIII-IX (ca. 8,300 B.P.)	LEVEL IV (ca. 6,900 B.P.)
woodrat	jackrabbit
cottontail	cottontail
deer	bird
	fish
	deer

(number of specimens not indicated)

Table 3. Representative fauna through time (summarized from Kaldenberg 1982:59,188)

Berryman (1974) collected and analyzed pollen samples from stratigraphically controlled units from archaeological sites A and C, Rancho Park, San Diego County, and noted a shift from the domination of oak and pine pollen to that of chaperral species. This was determined to have occurred sometime between the earliest occupation of the site (ca. 8,300 B.P.) and the deposition of matrix which contained samples C-14 dated between 7,400-7,100 B.P. This particular shift of vegetation suggests that a wetter, less arid climatic condition existed during the early occupation of the area. Also, pollen samples from these sites indicated that the climate during San Dieguito presence was more steppe-like than during the La Jolla residency. The early presence of pine, sea blithe, deer grass, and lace-pod indicates an environment with more groundwater in the form of marshes, ponds, and seasonal creeks than existed during the later occupation (Kaldenberg 1982).

According to Warren, True and Eudey (1961) and Cressman (1977) the La Jolla complex differs from the San Dieguito by its dependence upon shellfish and the gathering of vegetable foods. The San Dieguito are considered to have relied much more upon hunting for their subsistence than the La Jolla. The absence of shellfish remains in San Dieguito deposits and the accumulation of shellfish middens during the onset of La Jolla culture is meaningful. Warren (1966:7) suggests that "the San Dieguito seem to have been traditional avoiders of shellfish resources." However, data extracted from geophysical and paleoenvironmental studies have provided some information relevant to this apparent subsistence change. Moratto, King and Wolfenden (1978:147) stated that:

> "Scholars have long been concerned with relationships between environmental and cultural change (cf. Butzer 1964), but most such studies have endeavored to account for the latter with reference to the former. One may reverse the equation, however, using archaeology to test and amplify the paleoenvironmental record ... archaeology can indicate what the past conditions meant to human societies and thus show more precisely the magnitude and nature of the changes."

If the shifting climate, as postulated by recent research, resulted in significant changes in the environment and fauna of the bays at the mouth of the rivers on the south coast, such changes should be reflected in the ecological adaptation of the prehistoric cultures of the area.

4.4 Cultural Importance of Marine Species

It is interesting that shell middens do not appear in the early Holocene Paleo-Indian Stage in southern California, and in fact do not appear in any sites of such age in the Americas. Evidence indicating that easily obtainable shellfish were nonexistant in the region at that time seems to be apparent. Temperature and aridity seem not to be the only factors that influenced shellfish presence on the shoreline. Southern California has been in somewhat of a Mediterranean-type clime throughout most of the Holocene

(Johnson 1977) and various mollusc species are presently found throughout the Northwest Coast climates of high latitudes. Therefore, other physical factors may be relevant.

As Braun (1974) has shown, a combination of temperature fluctuation and sea level rise can be responsible for changes in mollusc habitats and availability. As the Holocene sea level rose on the coast estuaries began forming in areas where land semi-enclosed a body of water, which merged as an arm of the sea meeting an inland river mouth. Therefore, the estuaries were composed of saline and fresh water which results in an extremely productive ecosystem. As Desgrandchamp (1976:46) describes, this is caused by:

> "chemical and physical changes which affect suspended particles when salt and fresh water mix, resulting in increased deposition of sediments and organic detritus to the extent that estuaries contain more minerals and nutrients than either the fresh or saline water sources which feed them."

Estuaries were uncommon geological features throughout most of the pre-Holocene and it was not until the post-glacial rise in sea level that estuaries developed on the shoreline of North American continental shelves (Emery 1967; Russell 1967). The particular features of the California shelf with associated riverine drainage systems allowed a heydey for estuary and lagoon development between 8,000-5,000 B.P. Specifically, the marine shelf of the southern California coast is configured such that the Holocene sea level rise created and destroyed estuaries and lagoons in relatively short geophysical time intervals (Bickel 1978).

This is not only considered in geological interpretation, but is also witnessed in the archaeological record as shellfish do not appear as an exploited resource until during this period (Warren 1967a). Molluscs and certain plant species represented resources in a biome newly opened to human adaptation in the coastal region. Warren (1966:12) suggests it is during this period that the "San Dieguito people were compelled to overcome their traditional avoidance of shellfish in order to supplement their normal diet with it to some extent." Recent evidence shows that the San Dieguito people were at least marginally exploiting mollusc resources by ca. 8,000 B.P. at the transitional Rancho Park North site in San Diego (Kaldenberg 1982).

It is not known to what degree the La Jolla exploited estuaries as few quantitative studies of this nature have been made. However, it seems reasonable to assume that this tradition was highly dependent upon them, judging from the size of some of their shell middens (cf. Shumway, Hubbs and Moriarty 1961). Also, as many mammalian populations of the larger species probably became depleted in the early Holocene it became necessary to exploit alternate food resources to compensate for a decrease in the available meat supply. Estuaries and lagoons seem to have provided this alternative. From the distribution of incipient La Jolla sites it is indicated that this population preferred estuaries as habitation areas (Figure 26). The catchment area of an estuarine locale provides many different ecological

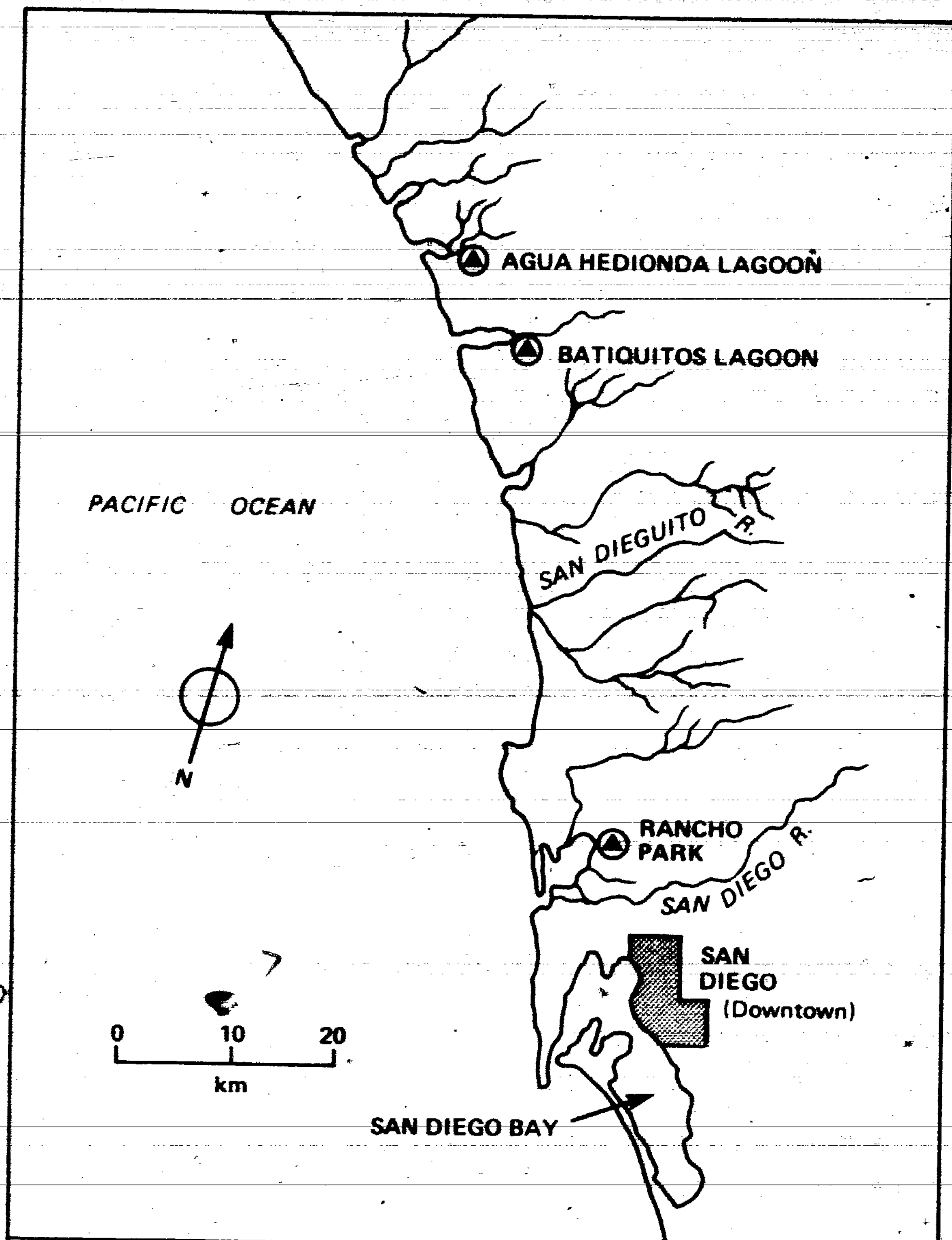


Figure 26. La Jolla Estuary and Lagoon sites

zones for simultaneous exploitation (Odum 1971). This is especially so in southern California because "the coastal watershed is short and steep due to the proximity of the coastal ranges and this condition allows for a diversity of communities ..., an estuary centralizes these ecological zones" (Desgrandchamp 1976:6).

Although less land may be available under the circumstances of sea level rise, in some areas such as the south coast there was an increase in number and size of intertidal water sources (Bingham 1978). This condition lasted for perhaps 3,000 years before silting in of these sources finally degenerated the habitat of the mollusca. The presence of Chione californiensis from the Batiquitos Lagoon site, a La Jolla occupation, revealed shellfish utilization over an extensive duration. Samples of this mollusc species were radiocarbon assayed and yielded dates encompassing 7,300 B.P. and 3,900 B.P. (Hubbs, Dien and Suess 1960:207, 209). These dates fall within the period delimited for the duration of lagoon and estuary abundance along the coast. Hubbs et al. (1960:209) comment that the date of 7,300 B.P.

> "is conformable with several others along the coasts of southern California ... that pertain to the early shellfish gatherers. It bears an inferred Holocene rise in sea level and on past estuarine condition in the lagoon, which is now silted up and incapable of supporting the molluscs that existed here between three and eight millenia ago."

It is suggested that the San Dieguito cultural system, which as a whole was dependent upon a certain level of production or energy intake, was affected by a depleted main resource, or the increased quantity of alternate resources. If it was resource depletion, Warren (1971:200) suggests that the level of "energy loss must be compensated for by greater production in another substractive subsystem or the population and/or the general complexity of the cultural system will be decreased." If other resources increased in abundance (e.g. molluscan species in newly formed estuaries and lagoons), they may have been selected for, as an increase in productivity and a source of protein intake. It seems that the La Jolla cultural system was the manifestation of newly integrated economic strategies and social organization within the San Dieguito tradition.

The reliability of molluscs as a dietary mainstay has been argued for decades. Koloseike (1969) has pointed out that most archaeologists that have calculated flesh/shell ratios for mollusc meat quantities, and protein/flesh ratios for the calculation of mollusc protein quantities have grossly underestimated the food resource value of these species. He discusses parameters of proper meat/shell weight reconstruction and other problems of translating shell sample weights into correlated weight of meat. A consideration that is often overlooked in the estimation of molluscan meat and shell weight reconstruction is the season of collection. Meighan (1972) estimates that as much as 125 percent more live meat can result because of gonadal ripening during the spring spawning season. It is noteworthy that there is no nutritional value in the mollusc juice as this is basic sea water that has been filtered by the animal (Fankboner, personal communication, 1984).

The question centering upon the value of shellfish as a reliable and staple resource has been mostly concerned with nutritional aspects. This should not always be the primary consideration, unless detailed demographic patterns of population size and dispersal are known. Since very little demographic data are available for early south-coastal prehistory attention must be focused upon the importance of shellfish on other levels. As Wessen (1982:41) stresses, "adaptive value is not reducible to nutritional value. Thought must be given to how shellfish resources are integrated into the adaptive strategies of cultural systems."

Ethnographic information from coastal California reveals the importance of shellfish exploitation in a gathering economy. While observing numerous tribes Krober and Barrett (1960:110) found that:

> "Those living along the immediate coastline had an abundant supply of shellfish at all times and dried them, not only for use in the winter, but also as an article of barter with the people living farther back in the mountains."

The paucity of shellfish remains in San Dieguito deposits may be due to causes other than preference. Tartaglia (1976:27) suggests that:

> "an observed shift to prehistoric marine subsistence practices might reflect a replacement of temperature sensitive species by better adapted molluscan species; therefore,

a recorded change in molluscan subsistence may not be directly attributed to human predation."

This point in conjunction with the fact that estuaries and lagoons were not representative elements in the early Holocene coastal physiography, might well be the reason that the San Dieguito did not exploit shellfish.

On the North American east coast there is evidence of archaic terrestrial hunters and riverine fishermen "that applied their skills in a maritime setting when on the coast, but overlooked the potential productivity of unfamiliar shellfish populations" (Snow 1972:211). The eventual appearance of shell middens in later coastal components in this region is explained by Snow to have been an effect of internally initiated cultural evolution. However, Braun (1974) has demonstrated from paleoclimatic, ecological, and paleoecological evidence that patterns of shellfish exploitation were induced by changing environment.

The fact that there are rarely fish or sea mammal remains found in early La Jolla shell middens indicates that this population was probably in the initial stages of maritime resource exploitation. If there is evidence of earlier cultural antecedents of a maritime economy under the present sea level there should be evidence of more thorough marine exploitation in the unsubmerged middens. It is not until nearly 3,000 years after the appearance of La Jolla culture that significant amounts of shark, stingray, seal, sea lion and vertebrate fish seem to have been incorporated into their subsistence economy (Kaldenberg and May 1975; Shumway et al. 1961). It is probable that they existed quite effectively with shellfish as a dietary supplement until the molluscan communities were greatly reduced due to a change in habitat (i.e. rising sea levels silting in lagoons and estuaries).

Since most shellfish species, at least in southern California, are available on a year-round basis, sedentary occupations would have been possible. Also, a reduced seasonality in marine resource availability, which may also have been the case for some plant communities, would obviate the need for storage (Binford 1980). In agreement with this concept there is no evidence of storage practices in the La Jolla tradition.

A convincing indication that the major durational occupation of the San Dieguito tradition did not exploit shellfish resources is that at some of the sites where both San Dieguito and La Jolla elements are found, the San Dieguito lacked shellfish remains. For example, at the Monument Mesa site, San Diego County, excavated stratum #4 contained a typical San Dieguito assemblage devoid of shellfish remains (Bingham 1978). This component was below a radiocarbon date of 7,260$\pm$80 B.P. yielded from the base of an overlying La Jolla shell midden. The significance of this occurrence is that this is a mesa site that was not exposed to rising sea levels during the Holocene. The argument that the San Dieguito people may have routinely exploited shellfish but the sites that would indicate this are now inundated, is not reinforced by sites such as Monument Mesa. Since the site is located near the beach it is unlikely that this site would not reflect their general subsistence economy due to their seasonal rounds in the immediate proximity. It seems that the San Dieguito, at least for most of their temporal duration, subsisted without the necessity of gathering shellfish. Among the La Jolla component at the site, as well as mollusc remains there were manos and metates characteristic of that tradition.

Evidence from the Glen Annie Canyon coastal site near Santa Barbara indicates that by 7,300 B.P. a tradition adapted to marine resources and milling existed (Owen, Curtis and Miller 1964). Remains of sharks, seals, rays and shellfish were recovered during excavations. Although the early tradition associated with the site is not defined as La Jolla, many cultural traits are comparative (e.g. flexed burials with similar offerings, very comparable chipped stone, grinding and milling technology, and decorative elements). There is no evidence of an earlier culture occupying this area, so it seems that grinding nuts and seeds began here at relatively the same time as in the La Jolla tradition, coinciding with climatic changes.

The Scripps Estate site which was extensively researched by Shumway, Hubbs and Moriarty (1961) is a typical coastal La Jolla occupation in many ways. The occupation sequence was radiocarbon dated between 7,370-5,460 B.P. and contains at least 46 burials. All of the burials that were in a sufficient state of preservation to reveal skeletal orientation were in flexed positions and a number of the remains were accompanied by offerings such as metates, shell beads, scraperlike quartzite flakes, and one item classified as a shell 'cup' or 'dipper'. None of these items are characteristic of the San Dieguito tradition. Although the site is located at an elevation of approximately 100m a.s.l. on the edge of a small mesa, there is an extensive area of shell midden that is over 300 meters in length (Shumway et al. 1961:63-65). The lithic tools from the site indicate manufacture by percussion flaking (in rare cases refined) and these authors state that "pressure methods (if used at all) were of little importance." This technology contrasts with the well-executed technique of controlled pressure flaking of the San Dieguito tradition.

The faunal remains from the site offer bases for inferences concerning the environment and dietary habits of the aboriginal population.

> "The faunal relationships of the 56 species of pelecypod and gastropod molluscs found on the site indicate, on detailed analysis, that the temperatures were as warm as at present and very probably somewhat warmer; the remains of animals in other groups confirm this indication" (Shumway et al. 1961:97).

Some of the shell material from the site was assayed for isotopic content and yielded paleotemperature measurements that confirm the deduction stated above. It is intimated by

Shumway et al. (p. 97) that:

> "The type of molluscs eaten, the abundance of tools for grinding plant food, and the great scarcity of vertebrate remains all indicate a simple food gathering culture, with little hunting for larger animals, either on land or on the high sea."

Among the sparse vertebrate remains are birds and mammals (unidentified) and three species of fish: Roncador stearnsii, Genyonemus lineatus, and an unidentified small shark.

4.5 Seasonal Periods of Occupation

The archaeological evidence indicates that the San Dieguito were very transitory making almost continual rounds in an attempt to provide for their sustenance, mainly through hunting and some gathering. It is hypothesized by Curtis (1965:5) that "permanent village life was not only possible but entirely feasible in certain favored natural environments of coastal southern California as far back as the Milling Stone Horizon." The sedentary life does not preclude leaving the village area altogether, but Curtis believes that the gathering rounds were possible without abandoning the living site. It is suggested that no inland area could offer the plentiful resources that the coast supplied, especially during arid conditions.

The degree of sedentariness of early La Jolla society has been a problem of interest. La Jolla sites are nearer the coast than those of the San Dieguito, and are especially evident in proximity to coastal water sources such as lagoons and small estuaries. It is indicated that such sites were more continuously occupied although their subsistence depended heavily upon gathering.

Previous studies on the daily and annual growth lines of certain clam species have allowed estimations on seasons of occupations (shell gathering) at shell midden sites (Coutts and Higham 1971; Deith 1983; Drover 1974; Koike 1975; Weide 1969). Studies of this nature have been applied to south-coastal sites but most of them deal with Late Horizon cultures. However, Bingham (1978) has been able to offer some hypotheses as to seasonality of La Jolla occupations on the San Diego coast. A sample population of Chione undatella shells from the Monument Mesa midden were analysed to determine the season of death of each clam. This "provided an indication of the seasonal exploitation pattern of the areas' shellfish gathering occupants" (Bingham 1978:12). The sample population used for this study was taken from a limited excavation area, therefore a statistically valid representation of the entire site cannot be provided. However, the data indicate that a peak occurred in the gathering of clams during the winter months (Figure 27). Essentially, none of the specimens examined were collected during the summer, with slight representation from fall and spring. The implications, although tentative, are that the site may not have been occupied in summer, or

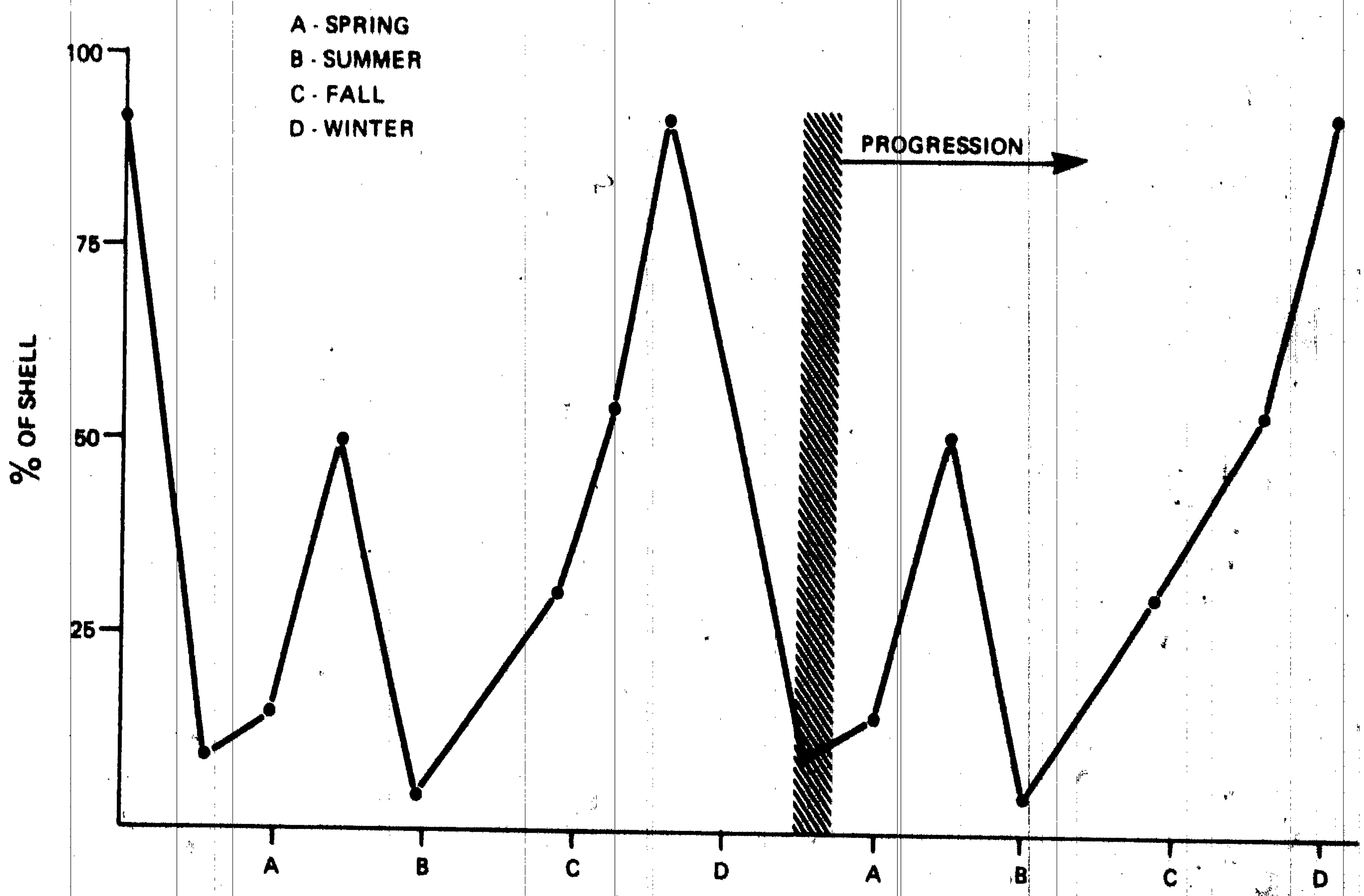


Figure 27. Shell Seasonality Graph; Monument Mesa Site
(Modified from Bingham 1978:11)

shellfish collection was refrained from during this season possibly due to the presence of red tides that prevail in summer months. The fact that the lowest tides of the year occur from October to March "permitting optimal shellfish gathering conditions, provides an explanation for winter collecting" (Tartaglia 1976:63). It may be that since most west coast clam species mature sexually for spawning in the spring (Meighan 1972), these species were avoided by the dictates of La Jolla procurement strategies during this season. For example, although the meat weight of a clam is at its peak during spawning, Keen (1979:10) relates that "spawning cycles...cause deterioration in clam quality." After the spring spawning "sexual development begins again and proceeds throughout the fall and winter" (p. 12). Therefore, it seems that the La Jolla may have purposely harvested the clam crop when it was in prime condition for use in the late winter before spring spawning. Other dietary resources, especially plants such as agave, erigonum, mesquite, grasses, seeds and nuts (Kaldenberg 1982), may have been available during the remainder of the year which would preclude the necessity for shellfish gathering on a continuous basis.

By 7,000 years ago climatic conditions in the area were similar to the temperate clime of today. The vegetation covers offered numerous food plants of which acorns of several varieties were likely a very important diet element (Gifford 1973). There is paleontological evidence that oak

(*Quercus agrifolia*) occurred continuously along the south coast, although in varying quantity, since the Pleistocene (Axelrod 1981).

The study of prehistoric subsistence practices becomes more problematic with a decrease in preserved dietary remains. As stated previously, San Dieguito deposits have virtually none of these remains. Shell deposits characterize many La Jolla sites, however new quantitative methods of midden analysis need be developed in order to properly formulate hypotheses concerning the cultural importance of molluscs.

V. ARCHAEOLOGICAL INTERPRETATIONS

If the average date for maximum Holocene climatic change were taken from the paleoclimatic and paleoenvironmental data presented in this report, it is intimated that a well-defined transformation occurred at approximately 7,500 years ago. The data indicate, among other things, that there was a vegetation shift from pine and oak woodland to chaparral base species and coastal sage scrub occurring within the period 8,000-7,000 B.P. An environment with pine, deer grass, sea blithe and lace-pod, indicating a relatively cool climate with substantial precipitation and ground water, shifted to chaparral based species such as Artemisia and Erigonum (Kaldenberg 1982) indicating a warmer and drier environment. This would likely cause a response from the occupying population, either to migrate or to adapt to the new ecological niche.

The differences between the behavior patterns of San Dieguito and La Jolla, as ascertained from the archaeological record, suggests adaptations to different environmental conditions and that their cultural affinities might be different. Not only are the lithic tool kits manufactured in dissimilar patterns but a wide spectrum of other activities which include burial, ritual/ornamentation, subsistence strategies and settlement movements seem to reinforce this indication. However, archaeologists must not adhere to pretenses concerning this problem lest they may become biased about the matter. There is also evidence suggesting cultural affinities between San Dieguito and the later Milling Stone Horizon. For example, the seeming occurrence of eccentric (i.e. not to standard form) crescentic stones (Figure 28) in both of the complexes (Wallace 1965; Warren, True and Eudey 1961) is significant.. If this unique implement was used by both traditions it may indicate that they shared an affinity with each other.

The crescentic stone is somewhat of an archaeological enigma at present. Although the function of this object is unknown, many ideas have been advanced concerning its temporal distribution and purpose. They have been documented as appearing in the San Dieguito complex as well as other early cultures; for example in the Western Plurial Lakes tradition between 11,000-8,000 B.P. (Davis 1969). Strong (1969:88) recounts that "crescents seem to be limited to the proximity of lakes and rivers and the [west] coast" and are found in only six western states. In reference to the crescents Tadlock (1966:672) accepts that the crescent has "a possible range of dates between [9,000 B.P.] and [7,000 B.P.] and are associated with an unidentified combination big-game hunting and food-grinding culture of the Proto-Archaic Stage." This may indicate that they were utility elements of a pre-Desert tradition that were introduced into the coastal area with the initial migration of the San Dieguito who no longer had need for its services as archaic patterns were adopted. The following views have been

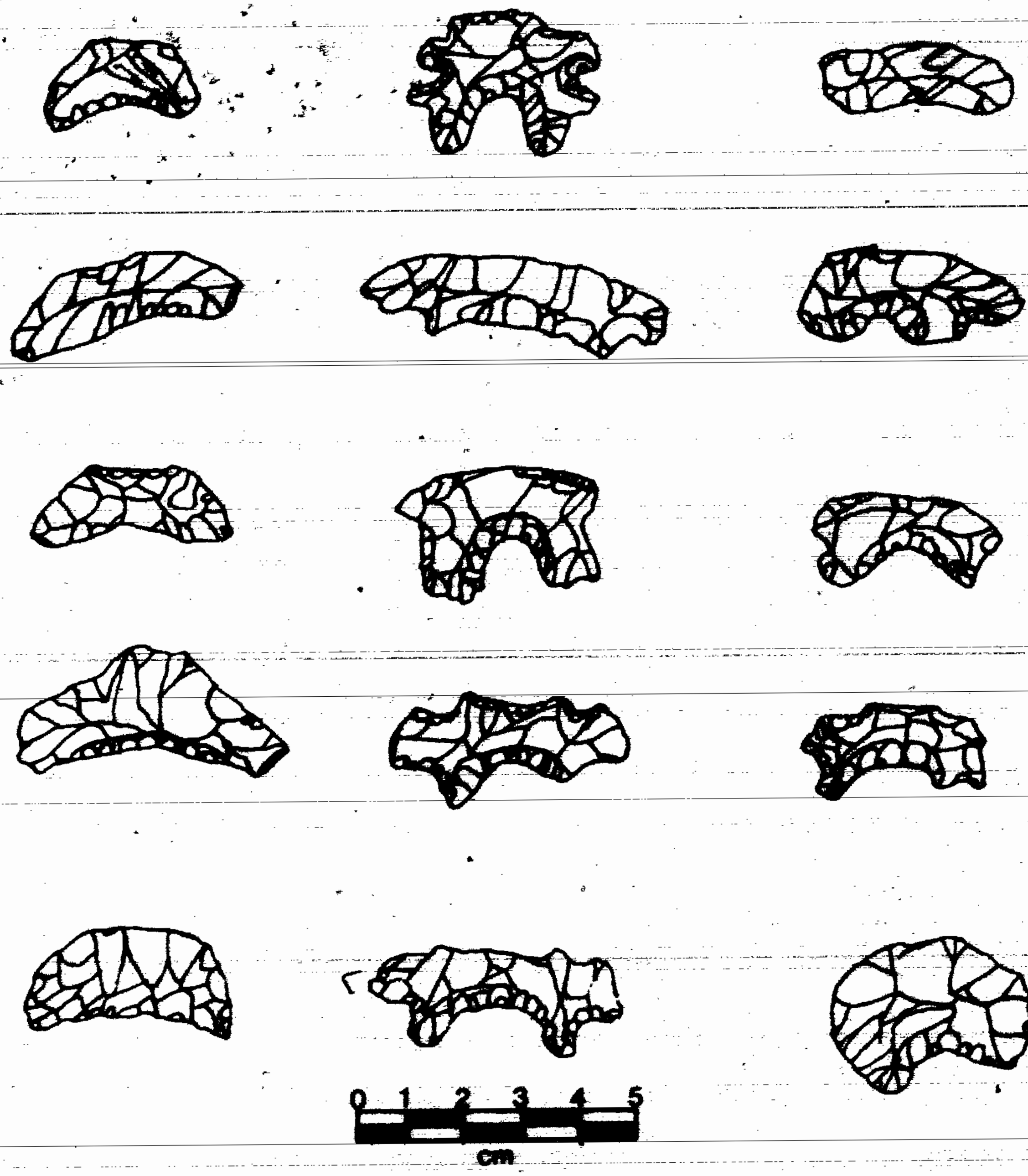


Figure 28. Crescentic stones; two columns on right were recovered in San Diego County (from Rogers 1966:62)

expressed as to what the crescents may represent:

1) transverse projectile points to hunt waterfowl (Clewlow 1968)

2) stunning points (Strong 1969)

3) surgical instruments (Tadlock 1966)

4) symbolic or talisman objects such as hunting amulets (Rogers 1966)

5) fish scalers/knives or net measurers (Strong 1969)

6) functionally-specific projectile shaft smoother-finishers (Carbone 1982)

7) tattoo knives or scarifiers (Strong 1969)

Although information regarding past environment cannot be ascertained from the morphology of crescents, an analysis technique that has been developed by Loy (1983), which identifies species-specific residue adhering to tool surface, can be applied to specimens and may reveal primary functions of the objects. Results of this type of testing might at least provide implications as to whether the crescent was used in a hunting associated function or if it was used for another specific purpose.

The Hollywood Rivera site on the south coast comprises an early Milling Stone Horizon (Wallace 1965). Although the site assemblage is typical of the early La Jolla (i.e. a high frequency of grinding/milling stones, a few large, crude "projectile points", and flake scrapers), a well made crescent was among the lithic specimens recovered. The earliest occupation of the site is estimated to be at least

7,000 B.P. and the virtual absence of marine shell suggests "a lack of interest in this abundant and easily obtained nutritive material" (Wallace 1965:426), although the encampments are located in the sand dunes along the beach. Other than a few fragments of marine mammal bone, faunal remains are nonexistent at the site. Were it not for the high frequency of milling stones there would be an unappreciable amount of evidence indicating the type of diet composition of the occupants.

There is presently no evidence that suggests a population decrease in south-coastal California during the Thermal Maximum as has sometimes been suggested for this time period in the Great Basin and the Central Plains. Although there are some sites which present sterile layers between San Dieguito and La Jolla materials, such as the Harris site (Warren 1967a:17), there are a sufficient number of undisturbed transitional sites (Bingham 1978; Kaldenberg 1982; Hubbs et al. 1965; Moriarty 1967; Wallace 1973) which indicate the San Dieguito diversion was relatively contemporaneous with the La Jolla incipience. In these transitional sites there are no sterile layers within the stratigraphy between San Dieguito and La Jolla deposits. Instead, there seems to be a slight overlap or mixing of cultural remains which may be representative of a cultural continuum. These occurrences will be later dealt with.

The varying degrees of emphasis placed upon some elements of economic importance by the San Dieguito and La

Jollans is difficult to establish from the archaeological record. As Warren (1967a:234) commented, "It is extremely difficult to weigh the relative importance of food collecting as opposed to hunting and fishing because of the difference in preservation of remains." Because of this, archaeologists are sometimes restricted to evaluating prehistoric economies by certain artifactual materials exclusively. Most suppositions relating to early south-coastal economic strategies have been proposed with this limitation.

The explicit cause of the behavioral transition which occurred in the time period concerned in this study is presently unclear. It is also not known whether the change is representative of a new human population entering the area who might have brought with them a unique society, or whether it was the existing population that changed their mode of adaptive interaction.

The philosophy that climate was the main influence upon hnman adaptation in prehistory may seem determinist, however this concept is becoming more prevalent in archaeological research. The cultural changes that occurred in the early Holocene can be regarded as the first of a number of identifiable changes that occurred throughout the Recent period in the coastal region which seem to be concurrent with climatic and environmental change. Hopefully, as more evidence is accumulated archaeologists may be able to "help validate models of environmental change developed in other sciences; [and also] independently discover environmental trends and conditions" (Moratto et al. 1978:147).

Alluding to cultural change, it has been argued that most such events are likely to have been the results of social, political, demographic, economic or other factors, more so than climatic variation. However, the relative degree of sophistication of a population, both socially and technologically, must be recognized when considering the causes of events such as introduction of new economic resources, abandonment of a region previously occupied, occupation of a region presently uninhabitable, sudden changes in population size, etc. The alternatives that were available for dealing with environmental change must also be considered. It is possible that climatic change could affect an alteration of tool kits, subsistence strategies, and site locations. Davis (1969) believes that morphological changes in Paleo-Indian lithic technology were due to local adaptations to changing environment. This pattern supposedly continued as the early industries were replaced by the tools of the Milling Stone Horizon. However, climatic factors are not as easily explained as a causation of the adoption of more complex practices such as burials, the depositing of grave offerings, and ornamentation. Nonetheless, these cultural advances occurred in other prehistoric cultural groups and may have been a result of organizational and social structuring emerging from new economic activities and increased sedentism initiated by environmental change.

5.1 Social Organization

Determining the past existence of varying social organization and/or value systems in early prehistoric societies and how they might be observed in the archaeological record is very difficult. Of course it must be recognized that when hypothesizing about early prehistoric social organization and its observable manifestations there must be a distinction between raw data and interpretation. The following premises are speculative and were derived largely from inductive reasoning rather than concrete evidence. However, if previous postulates concerning Californian hunter-gatherer societies and social organization (cf. King 1978) are valid, then there is evidence suggesting a process of transformation from an egalitarian society to one of non-egalitarian status organization. When a number of elements and factors are considered in conjunction, some interpretations of social dynamics that might have affected patterns of social organizations can be offered.

It is probable that a climatic shift influenced changes in and relationships between not only subsistence, settlement, and population, but social organization as well. Exotic raw materials which are often indicators of special value or status are absent from San Dieguito and early La Jolla deposits. The crescentic stone is the single artifact type observed in the San Dieguito complex that might be considered as a decorative or symbolic element (Rogers 1966).

After a long duration as an element in the complex it seems to survive for only a short period in the initial coastal Milling Stone Horizon (Wallace 1965; Warren, True and Eudey 1961), however none of these late specimens are made of quartzite which was the primary raw material used by the archaic inhabitants.

The rudiments of ornamentation seem to have progressed through shell material in the La Jolla tradition. Items of shell such as beads and drilled pieces present some evidence of the significance placed upon artistically modified raw material for possible aesthetic, social or ritual value. The occurrence of worked shell, especially olivella beads, and other crudely made decorative elements in the La Jolla tradition (Cressman 1977; Shumway et al. 1961) represents a poorly understood pattern of values. Also in the initial La Jolla phase there is the first concrete evidence of burials on the coast, a number of them accompanied with mortuary offerings such as beads and broken or 'killed' metates (Shumway et al. 1961). Whether these traits are effects of a more sedentary lifestyle is not clear. The implications suggest that concentrations of sites along the coast resulted in more sedentary conditions than were previously possible. As this occurred, social groups were likely compelled to bury the dead in designated areas. Thus flexed burials occur in small cemetaries as a trait of the early La Jolla tradition (Cressman 1977; Rogers 1963; Shumway et al. 1961). Some of these burials are deposited with grave goods and are overlaid with a cairn which may signify some form of status position of the deceased. In itself, the presence of cemetaries suggests sedentary life and the fashioning of non-utilitarian objects indicates that the early coastal population was not continuously on the move (Curtis 1965).

The early prehistoric coastal ecology of southern California can be assumed to have been rich in primary plankton production, the base of the marine food chain (Yesner 1980), especially after the onset of the Thermal Maximum (Bickel 1978). This condition would have been ideal for the propagation of large communities of shellfish.

As previously discussed, a rise in the Holocene sea level created estuaries and lagoons on the southern California coast at a time of ideal geological context (Emery 1967). This would have generated a habitat conducive to shellfish proliferation and shellfish gathering which presented an occasion for increasing the human population density, especially in more sedentary La Jollan occupations of the littoral area. As explained in Carneiro's (1970) model, an increase in population may be a prime mover or precondition to the evolution of a more complex society. The La Jolla tradition is evidenced as a relatively more complex society than San Dieguito; possibly not because they were a different population group but because the San Dieguito people may have developed elements of increasing social organization due to: 1) exploitation of new resources necessitating a reorganization of the economic system, and 2) population pressure initiated by a shift in environment and settlement area followed by a population increase. Relating the latter case to the California coast Bickel (1978:9) emphasizes that "The effects of changing sea levels over the last 15,000 years provide a mechanism independent of human cause which led to increase in population density." This was possible because the coastline is a unique boundary which then furnished economic resources while limiting settlement expansion.

Many La Jollan sites are located in proximity to previous highly productive estuarine zones that, as Odum (1971) explains, offer a higher degree of exploitational resources than other coastal zones. An increase in the requirements for economic and social organization, as well as the effects of new demographic features may have led to more of a potentiality for social complexity to develop in the La Jolla than in the San Dieguito tradition. The conversion to the linear settlement pattern instituted by the La Jollans, as oppósed to the planar pattern of San Dieguito, likely afforded conditions suitable for social change.

It is possible that after the linear pattern of site clustering was established the population increased to the extent that their previous social system was no longer viable. Dumond (1965:313) for instance indicates that subsistence and society are directly interdependent, and if there is "alteration of subsistence patterns, this alteration could be expected to be observable in social organization. Such a connection between subsistence patterns and social organization is, of course, the major tenet of cultural ecology."

He also stresses that population increase if often concomitant with the adoption of more effective and efficient subsistence strategies. Following within this theme Yesner (1980:730) states that:

"In any maritime society in which shellfish or other invertebrates are an important resource, dependency ratios tend to be lower, population pyramids broader, life expectancies higher, and potential for population increase consequently greater."

It is hypothesized that energy expenditure is greater and comparative energy harvest ratios smaller for extensive gathering than for game hunting practices, depending upon group formation and optimal group size (cf. Smith 1983). Following a depletion in the available game resources in the coastal area the time and energy requirements that likely became necessary for almost exclusive gathering may have created a situation whereby a hierarchical system of labor tasks was necessitated. This would likely have led to the imposition of a social order with some degree of stratification.

Some ethnographic data imply that there was a population increase associated with the incipience of the La Jolla tradition. For instance, Yesner (1980:730) notes that:

"Birdsell (1968) has calculated that, for Australia, coastal hunter-gatherers exhibited

> population densities 40 times those of the interior groups. Similarly, Kroeber's (1939) data from aboriginal California show a decrease in population from coast to interior."

An increasing La Jolla population may have caused an institution of social complexities that are evidenced in their decorative elements, and burials with offerings and associated cairns. The ideational aspects of the La Jolla flexed burial trait is not known, yet the social dimensions of the practice might be revealed through studies such as those advanced in Brown (1971), which offer documented observations about how social dimensions interlock with mortuary practices.

5.2 Correlated Data

It is probably unwarranted at present to commit oneself to the postulate that climatic transition was exclusively the cause of culture change on the southern California coast. However, any variation in a past natural environment must be considered when determining factors of changing culture in the archaeological record. In reality this circumstance is not always reckoned with in the research designs of the professionals who are investigating such problems. McMillan and Klippel (1981:240) point out that:

> "Unfortunately some of the models most widely employed in interpreting culture change ... are those which hold the environment constant while attributing variation in the archaeological record to cultural dynamics in a seemingly stable environment."

It should be noted that at the hypothesized terminus of the Thermal Maximum and onset of a cooling trend (ca. 4,000 B.P.) another cultural tradition appeared on the coastal strip that was "markedly different from the cultures that preceded" (Meighan 1965:716). This adaptation involved a shift in subsistence patterns toward the greater use of marine resources, and fishing was the primary economic activity. There is supplementary evidence indicating that a climatic change leading to displacement of some fauna [and floral species can cause a shift in emphasis of economic resources. Nance (1972:169) submitted data for central Mexico suggesting that there was:

> "an economic shift in emphasis from the pre-Altithermal hunting, to gathering, and back to hunting at the end of the Altithermal. This pattern may extend north and west to coastal southern California."

At Coxcatlan Cave in central Mexico it is indicated that at ca. 7,500 years ago a pattern begins in which "the ratio of projectile points to food-grinding stones decreased during the Altithermal from earlier site levels, then increased at the period's end" (Nance 1972:186). This is analogous to the archaeological record in southern California.

An interesting statistical analysis using two independent techniques correlating climatic shifts with cultural discontinuities was executed by Wendland and Bryson (1974). Concerned strictly with the Holocene epoch, they used over 800 C-14 dates associated with geologic and botanic ep-sodes (maxima and minima) and:

> "simultaneously analyzed them to identify times of globally synchronous environmental discontinuities. Some 3,700 C-14 dates associated with 155 cultural continua of the world were collectively analyzed to identify worldwide synchroneities in appearance and termination of the cultures" (Wendlandd and Bryson 1974:9).

Their results indicated that there was a variation in the probability of a culture's continued existence across climatic discontinuities. The dates of environmental and cultural discontinuities form a similar pattern and it is suggested that:

> "... perhaps when the environment changes, such a change could be found recorded in the history of Man's activities. The record of his hunting, agricultural and housing practices may well contain information on environmental history. That is, the culture history of Man may be a proxy record of environmental history. This is not to suggest that Man fully or socially responds to his environment and its changes, but rather that initial conditions may be established by the environment. Man, plants and other animals function within that biased field." (Wendland and Bryson 1974:14).

It seems that the synchronism, or nontime-transgressive covariation of cultural discontinuities and the palaeobotanical record, "suggests a geophysical cause rather than migration or diffusion, probably climatic change" (Wendland and Bryson 1974:23).

In the case of the La Jollans the exploitation of shellfish may have been an adaptation to a general drying climate and the decline of faunal species which had been previously hunted. Environmental factors brought about a biotic and geomorphic change in the southern California coastal area that was well suited to the technology and production technique of a basically collecting economy. Bingham (1978:28) explains how:

> "The general rise in post-Pleistocene sea level caused the formation of rocky foreshores, bays and lagoons with flourishing populations of clams, mussels and oysters. With a subsistence system based primarily on collecting, people of the La Jolla culture could be more or less sedentary."

It is possible that groups of people migrated westward to the littoral environment when an increase in aridity caused an extreme of desert conditions in southeastern California. If the La Jollans came from inland and were already based mainly on a gathering and milling economy it seems that they could more easily adapt to the drying trend on the coast; more so than the game-hunting San Dieguito. Warren (1966:12) suggests that it is during this period that possibly the "San Dieguito people were compelled to overcome their traditional avoidance of shellfish in order to supplement their normal diet with it to some extent."

In one of Rogers' (1945:171) initial observations regarding the early cultures of the South Coast he stated that "immediately after the disappearance of the San Dieguito peoples with their excellent stone flaking technique, a new stock with a seafood-seed-gathering complex and no ability to work stone moved in." This was a surprisingly accurate statement at that time considering that very little excavation had been undertaken, radiocarbon dating had not been invented, and most of the cultural remains were surface materials. Yet, despite Rogers' foresight he never explained what was meant by "a new stock ... moved in." When considering whether the La Jollans may have been the same cultural group as the San Dieguito, there is very limited evidence to work with. The occurrence of a new technological industry (i.e. the appearance of milling stones, a marked reduction in projectile point frequency, retouched flakes generally replace scrapers in a tool kit, use of an alternate raw material) does not necessarily indicate a new population group. As Kaldenberg and Ezell (1974:11) imply, the introduction of possible transitional implement forms "does not necessarily connote a cultural change or the coming of a new people" in the prehistory of a given region. The transition from one cultural tradition to another in the same general region may have been an effect of being culturally and technologically out of balance with a shifting environment. There seems to be no archaeological evidence of the La Jolla migrating from inland. The characteristic tools of their lithic industry as well as their burials (Figure 29) are limited to a close proximity of the coastline with little evidence further inland.

A rise in Holocene sea level has many implications. Not only did the heightening of the mean tide level allow for the proliferation of coastal marine species -- it also became the medium which obliterated much evidence of the early populations along the coastal strip as illustrated in Figure 30 which delimits the submersed area. The paucity of

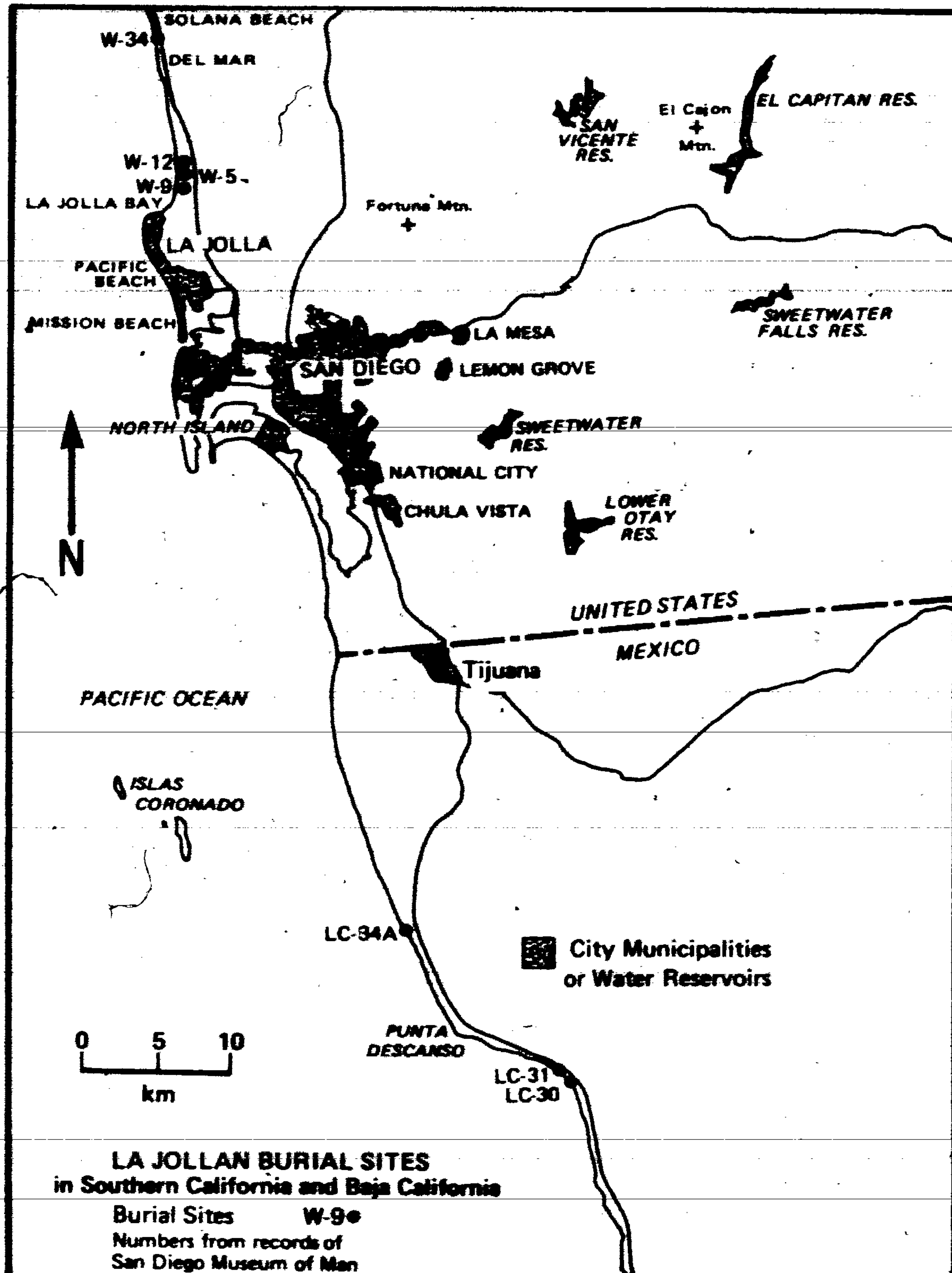


Figure 29. (From Rogers 1963: frontispiece)

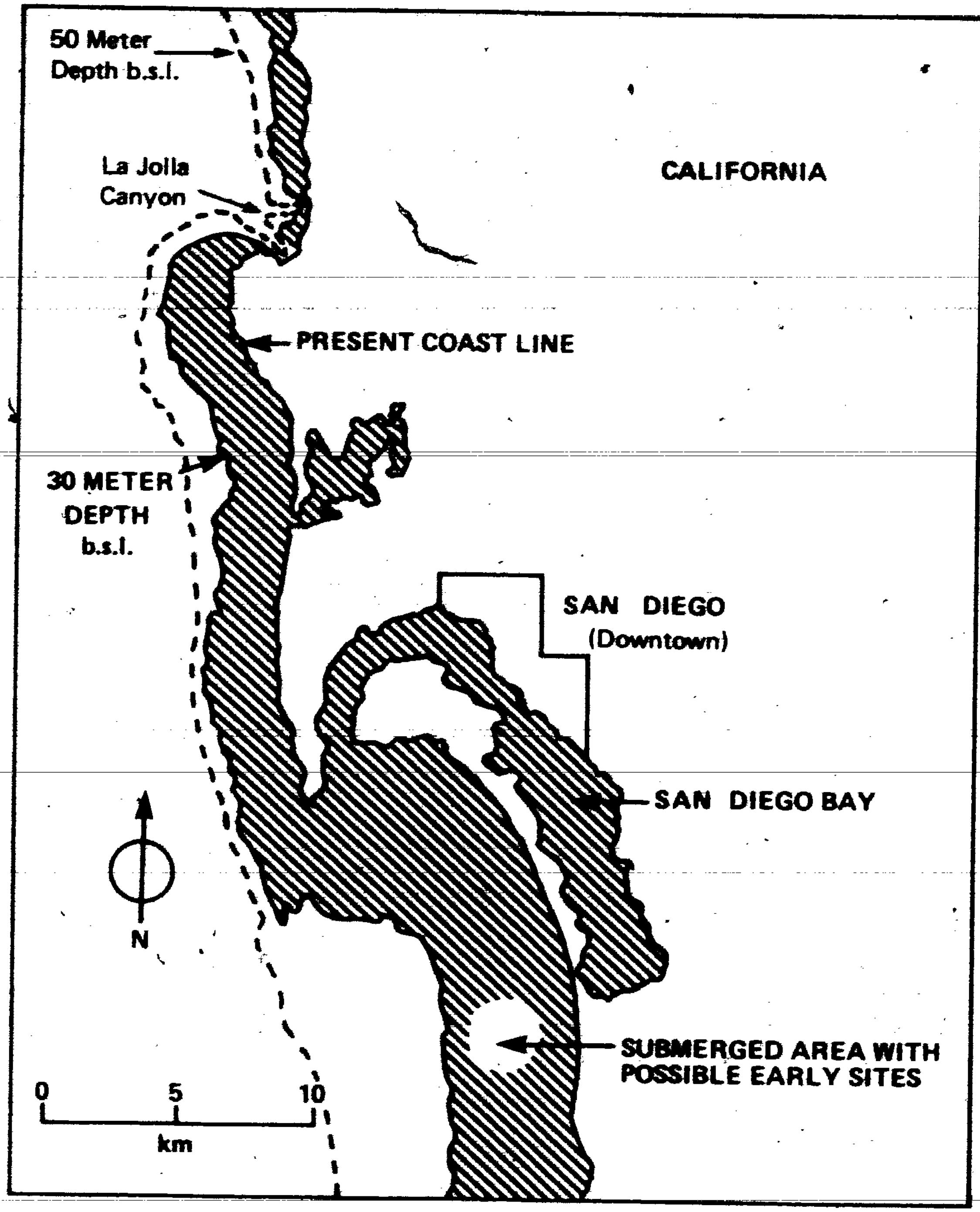


Figure 30. Land area submerged since 9,000 B.P. in coastal area of San Diego County (Sources: U.S. Geological Survey map No. NI - 11 - 11; synthesized with sea level changes from Milliman and Emery (1968);Shepard (1964)

San Dieguito sites associated with La Jolla components (Kaldenberg 1982) seems to confirm that many late phase San Dieguito and early La Jolla sites were affected. Sea level curves for the Holocene period are depicted in Figure 31. In Hudson (1976:preface) it is noted that dated evidence indicates that sea level rise inundated occupation sites and:

> "there was a general landward retreat of coastal dwelling people all along the southern California coast. This retreat continued up until the recent or present sea level stand about 2,000 years ago. There is no question that the near-shore waters of the worlds' maritime coastline constitute a vast repository for artifacts relating to man's history from the earliest times to the present."

If there is evidence of earlier La Jolla antecedents they may be below the present sea level. For example, ground stone vessels have been found distributed at various depths in the near offshore area of San Diego County (Hudson 1976:41). Curray (1965) stresses that there was a considerable landward movement of the shoreline between 9,000 and 7,000 years ago, and Clark, Farrell and Peltier (1978) have predicted a change in sea level of 80m in southern California since the Late Wisconsin maximum (16,000 B.P.). The San Dieguito-La Jolla transition has been discussed by Bingham (1978:28) who proffers that:

> "The subsequent La Jollan complex may have rudiments in, or have evolved from, the coastal San Dieguito. It could represent a maritime adaptation of the inland Millingstone tradition or have cultural affinities as yet unsuspected. Obviously, present knowledge of the origins and dynamics of early

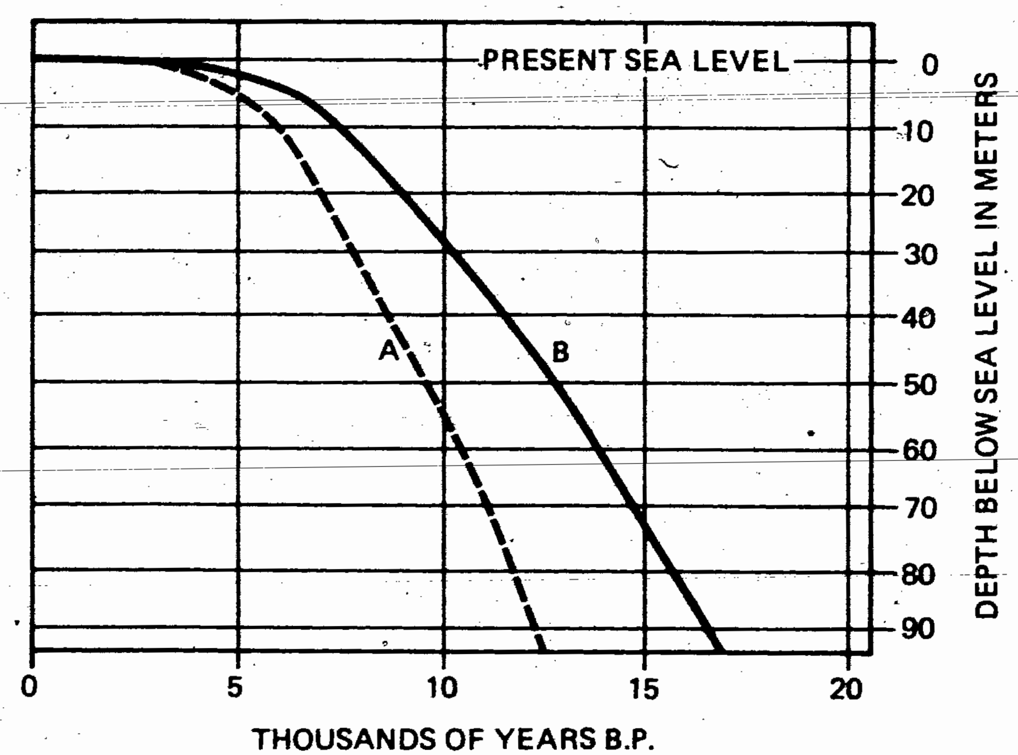


Figure 31. Graph showing sea level changes for the past 17,000 yrs.
"A" denotes the ME curve of Milliman and Emery (1968:1122, Fig.2)
"B" represents the S curve of Shepard (1964:575, Fig.2)

prehistoric cultures in southern California is in a state of flux. Insufficient data (especially for the coastal San Dieguito sequence) dictate that the current body of theory must remain highly speculative."

The problem concerning the impaction of climatic changes upon prehistoric populations is not impossible to deal with. Although there is no real 'archaeological' evidence of climatic fluctuations of the Holocene in southern California, and archaeologists have used climatologist's delineations without contributing much evidence of importance, further investigations are necessary. Future studies relating prehistoric populations to sea level changes, lake and marine terraces, lagoon silting, deposition of stream gravels etc. should shed light upon cultural adaptation strategies in response to changing environment.

The influences upon cultural systems in the early Holocene are not clearly understood. It is likely that the restricted distribution, or localized occurrence of the La Jolla tradition may have been due to ecological dictates that cannot be perceived today. It is probable that cultural changes transpired more rapidly along the coast than inland because inland climatic and environmental changes are slower (Ford 1982). The evidence here presented relating to climatic and cultural change within a delimited time period strongly suggests that: Environmental modification brought about by decreased available moisture resulting in biotic displacements and geophysical restructuring was likely responsible for [illegible] change in subsistence activities, technology, and possibly social behavior. Irwin-Williams and Haynes (1970:59) aptly declare that:

> "The effect of climate change is felt through the actions and reactions of the economic subsystem and its linkages with other subsystems. These reactions reflect not only the character of the climatic stimulus but also the existing state of the cultural system. Alternate reactions include direct systemic readaptation to the changed environment (through changed technologies, methods of population control, etc.), or small scale or large scale relocation of populations in different local niches, regions or areas whose character most closely approximates the conditions to which the cultural system was initially adapted."

The network of linkages and relationships between man's activities and environmental modification is extremely complicated, and the linkages and relationships that have been identified during the course of this report are only a portion of those that could be detailed. It is obvious that cultures change through time, often parallel to environmental changes. However there is no unequivocal evidence that the latter caused the former. "The problem is that of linking mechanisms which are far from well understood in addition to the known randomizing effects of human conscious choice -- often seemingly illogical" (Fladmark, personal communication 1982).

The nature of the mechanism that is ostensively most significant to cultural change in early south-coastal prehistory seems to have been a noncultural stimulus. As illustrated by the model in Figure 32, the environment seems to have influenced cultural development at this time in the study area.

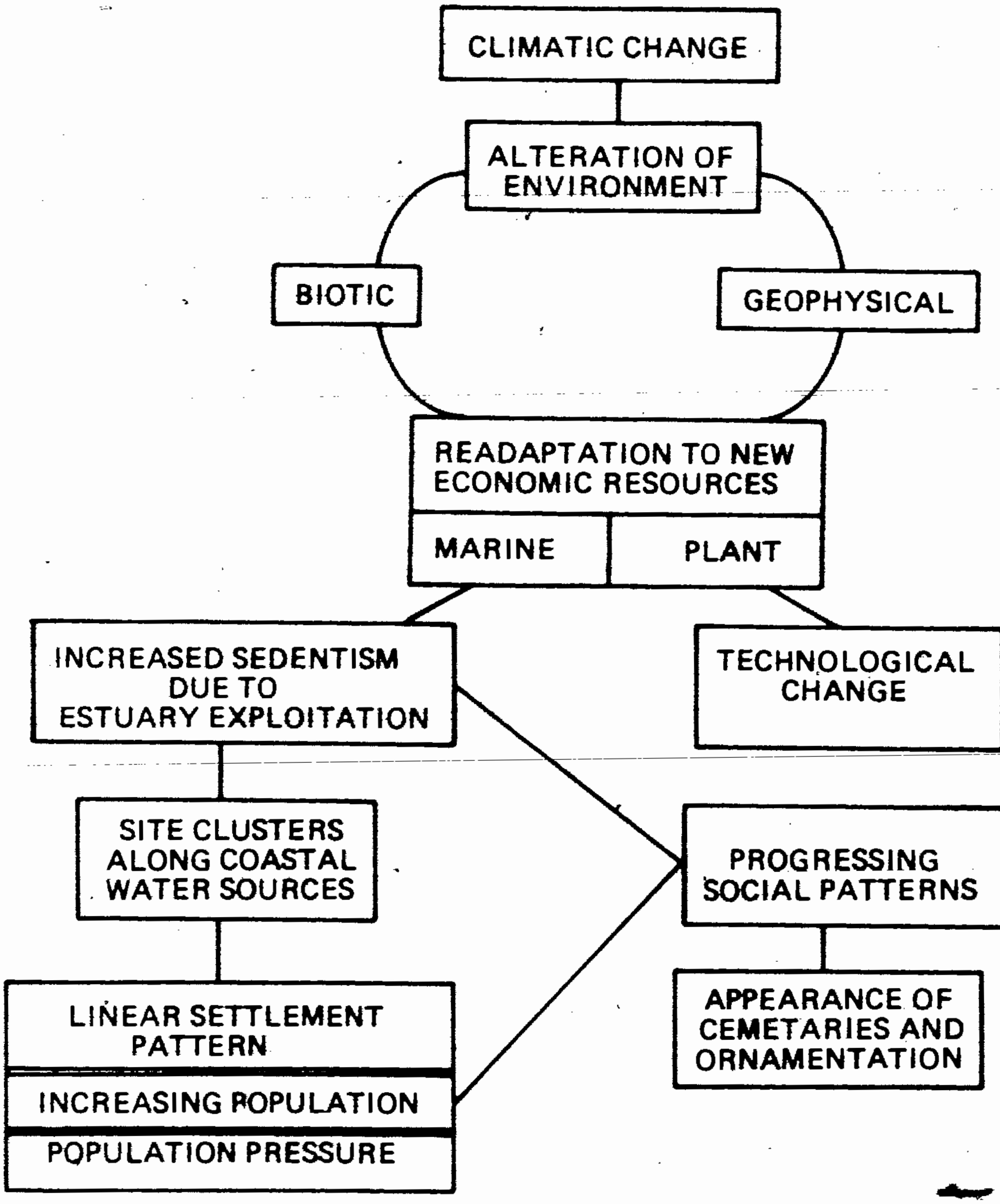


Figure 32. Proposed model explaining the San Dieguito-La Jolla transition.

VI. SUMMARY

It is clear from the evidence available that pronounced changes in the natural environment occurred in the early mid-Holocene, especially along the coastal strip of southern California. Studies in palynology and geomorphology have shown that climatic regimes had a marked influence on both biota and landscape erosional patterns, while fluctuations in precipitation, humidity and temperature regulated floral, faunal, and water distributions. Understanding these complex biophysical variables is critical in order to explain the evolution of early prehistoric cultures. Environmental changes that restructured different components of the ecosystem through time and space appear to have had a direct influence upon cultural adaptations. That is, cultural and technological changes "were precipitated by environmental and ecological systems adjustment" (Kaldenberg and May 1975: 3). It may be within these stimuli that the San Dieguito cultural system progressed.

VII. FUTURE RESEARCH

The settlement-subsistence system associated with the early cultural traditions of southern California has been a subject of uncertainty. Therefore it is important that future research designs be concerned with gathering data relevant to explaining the patterns of group dynamics and subsistence strategies of the early Holocene. Data reflecting local environmental conditions associated with cultural activities is most important. As Hume (1975:5) suggests, it is necessary "to explicate the intrasite variability for the San Dieguito and to explain this variability in terms of ecological and socio-cultural variables." The most important factors that should be considered within these parameters are: 1) physiographic features; 2) hydrological features; and 3) vegetation elements. Intensive investigations with strict control of criteria that delineate extent of variation is necessary.

9 Successions of cultural traditions must be better understood in order to accurately perceive the ways they may have been influenced by environmental change. It has been proposed by Bull (1977) that the Middle and Late Horizons of Southern California represent occupations of distinct cultural groups. Although there is more evidence from the later cultural horizons to work with, an interpretive framework with the intent to distinguish the Early from the Middle Horizon should be applied and critically evaluated.

This would aid in determining whether the San Dieguito was the antecedent of the Milling Stone Stage in the coastal area.

It is difficult to determine whether cultural and technological change was manifested by movements of ethnic groups. Ideally, if human skeletal remains were recovered from San Dieguito deposits a comparison could be made with the existing La Jolla skeletal material. This would provide a necessary test for determining whether all specimens would fall within the range of morphological diversity for the area.

Determining the degree of temporal distinctness between the San Dieguito and La Jolla traditions would be a method of testing for separate populations. A long duration of contemporaneity would indicate different cultural groups more than would a short coeval interval. If dual component sites with long temporal associations of elements from both traditions were identified, the postulate presented in this report, which proposes that the same ethnic population represented both traditions, would become less tenable. Explaining the intricacies of early cultural adaptations is not an impossible problem to solve, as new analytical methods continue to afford more promising results and interpretations.

The paleoclimatic record for lower California is not yet complete. Future research, such as that undertaken by Smith (1976), should be directed toward comprehensive examinations of laminated lake sediments that contain at least a substantial post-Pleistocene history. As Kutzbach (1975:4) explains:

> "Because precise dating is possible from varved lakes, the climatic reconstructions from varve thickness and pollen counts can be used independently to verify climatic reconstructions from [other variables] as well as extending the climatic record in areas where tree-ring chronologies are relatively short."

Further pollen analyses such as the previously mentioned study by Berryman (1974) need be applied to components which might reveal cultural behavior and economic status as well as paleoenvironmental conditions.

VIII. CONCLUSIONS

In an attempt to offer more accurate interpretations of the prehistoric record of cultural change, this report has explored the dimensions of human populations as active components in a dynamic system composed of various environmental aspects, both biotic and geophysical in nature. It is increasingly evident, as time and attitudes progress, that "human populations form a living ecosystem, tied to their environment and responding to the same types of external regulatory mechanisms as other organisms" (King and Graham 1981:128).

The interrelationship of culture, biome and habitat cannot be overemphasized in a thorough archaeological interpretation of prehistoric cultural adaptations. While difficult to prove, in my view, climatic change was a causal factor in modifying the technological, social, and settlement patterns of the San Dieguito-La Jolla transition. Assuming that the San Dieguito did not migrate from the coastal region, the evidence convincingly demonstrates that climatic and environmental fluctuation was a/the primary influence upon the change in subsistence practices. Therefore the other cultural elements discussed above, which are systematically related, were also likely affected, even if indirectly.

The archaeological evidence supports the explanation that: Significant cultural changes were taking place in the study area ca. 7,500 years ago, and these changes occurred in the context of environmental shift and may be interpreted as adaptive in nature. For example, the sharp decrease in the frequency of projectile points and knives and the coincident introduction of a high proportion of grinding stones for milling reveals that dramatic cultural adjustments to ecological changes were occurring.

The most striking cultural feature that came about at the onset of the Thermal Maximum was not so much the change in technology, but a change from a nomadic way of life to more sedentary settlements. Whether or not this was caused by a climatic change or other stimuli, the occurrence signaled a major cultural orientation for the area. It is necessary to consider as many plausible explanations as possible to account for this variance.

In order to explain, from the available evidence, the change in cultural tradition that occurred during the time period being studied, there are four practicable models: 1) The La Jolla migrated to the coastal strip from inland and dis- placed the San Dieguito population occupying the region; 2) The appearance of the La Jolla tradition was a result of cultural diffusion by which the San Dieguito incorporated new cultural patterns which were sufficiently distinct to be defined as a succeeding tradition; 3) The La Jolla were an established marine adapted culture on the coast, contempora-neous with the near-inland San Dieguito people well before 7,500 B.P. In this case the La Jollans would have gradually moved their settlements with the rise of the Holocene sea level; and 4) The La Jollans were the same population group as the San Dieguito who responded to climatic change through adaptations that are observable in the archaeological record.

Any of these models could explain the cultural responses to changing environments, although one seems more plausible than the others. The first model, which assumes the migration of a new population into the area, is not reinforced if Haury's (1958:1) criteria for the minimum set of conditions required for a probable migration are applied. He states that "if the products of the immigrant group not only reflect borrowed elements from the host group, but also, as a lingering effect, preserve unmistakable elements of their own pattern" a migration is likely. The second model necessitates an established cultural system inland which acted as the core from which the diffusion originated. This possibility is refuted by further consideration of Haury's basis for evidence of outside groups. An external influence is established:

> "1) If identification of an area is possible in which this constellation of traits was the normal pattern, and
> 2) if a rough time equivalency between the 'at home' and the displaced expressions of the similar complexes can be established." (p. 1)

This is not the case for the La Jolla pattern as neither their technology nor their burials are evidenced in early 'inland' sites. The third model is not substantiated for the following reasons: a) if a maritime adaptation existed perhaps 9,000 years ago, the middens deposited 1,500 years later should reflect a more thorough adaptation to sea resources than is evidenced. For example, remains of sea mammals, rays, and vertebrate fish should be present in the 7,500 year old La Jolla middens as they are in the later La Jolla patterns (Kaldenberg and May 1975), b) evidence indicates that estuaries were very uncommon before 8,000 B.P.

I believe that the weight of evidence supports the fourth model. That is, the San Diéguito evolved into the La Jolla tradition, as there is no present indication of later San Dieguito patterns elsewhere in California. Also, there are transitional sites where a tight cultural continuum is witnessed. The Agua Hedionda site demonstrates a cultural continuum between San Dieguito and La Jolla phases. When excavated it was noted that a distinct La Jolla component was deposited from surface to a depth of 1.3m when "a distinct change of its mineralogical content as well as its topology" was shown (Moriarty 1967:555). Felsite flakes and a well made projectile point or biface appeared. Moriarty (p. 555) continues that:

> "The technique and pattern appeared similar to those of San Dieguito material, a resemblance confirmed by laboratory comparison with San Dieguito material recovered from the type site. Intermingled with these artifacts were choppers, scrapers, and hammerstones typical of La Jolla phase I. No variation in the profile occurred and there appeared to be an unbroken continuity of occupation from the lowest level up through the overlying midden to the surface."

Additional evidence of a San Dieguito-La Jolla continuum is apparent at the transitional Rancho Park North site. A radiocarbon dated sequence shows a transition between 8,000-7,000 B.P. represented at levels 4 to 5. The undisturbed deposits indicate, from various factors, that San Dieguito was not displaced but evolved to La Jolla during this period. Kaldenberg (1982:187) states that this continuum "makes the exact demarkation between the San Dieguito and La Jolla complexes difficult to discern." It also appears that the La Jolla continued using felsite for some tools although to a lesser degree than the previous San Dieguito tradition.

This report does not profess to detect the explicit cause and effect processes relating to the San Dieguito-La Jolla transition. It is intended to stimulate an awareness of the difficulty and the possibility in archaeologically assessing the role of environmental change as the causal factor of prehistoric human behavior. Caution is required when postulating that climatic oscillation was responsible for triggering the events evidenced in the archaeological record.

It has been noted that "When archaeologists identify and define distinct cultures in the same spatial locality, one succeeding the other, it is too often assumed that separate populations were responsible for each tradition" (Carbone 1984:11). It is suggested here that the evidence supports the probability that the La Jolla tradition represented the same population group as the San Dieguito people. Of course, researchers must be mindful not to over-extend paleoenvironmental reconstruction or the assessment of human responses beyond the limits of the data base.

While it cannot be stated unequivocally that cultural change was a direct result of climatic influence on a large regional level, the evidence is strong in this direction. The fact that numerous traditions representative of the Milling Stone Horizon, where there were none before, appeared contemporaneously in southern California, argues for climatic factors being responsible for the readaptation. This model will be supported if paleoenvironmental reconstructions can be developed for adjoining local areas, and if it is shown in these areas that environmental change occurred with concomitant cultural transformation in most cases, the hypothesis proposing that cultural change was caused by climatic shift will be strengthened. The need to establish further correlations of this nature is evident, especially for determining the basis of cultural variations on a systemic level in a prehistoric society.

Although no data were found that are contradictory to the interpretation offered in this report, the conclusions must be considered with the hope that future studies will clarify the model suggested above. Nonetheless, it now seems that unless new paleoclimatic data come to light to refute the apparent impact of the climatic shift on culture in the study area, the Thermal Maximum cannot be ruled out as a primary impetus of change in the cultural patterns from

San Dieguito to La Jollan in south-coastal California prehistory.

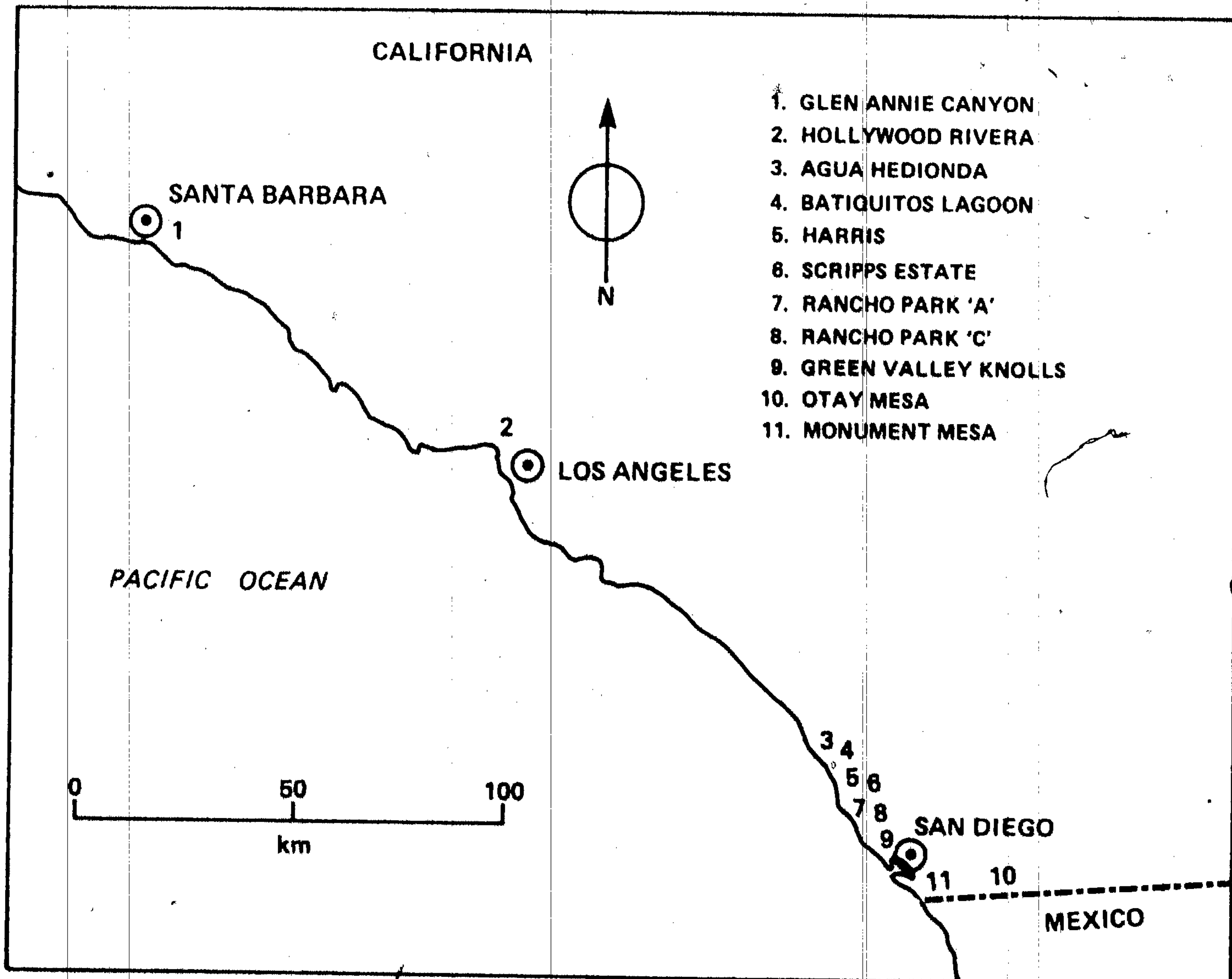


Figure 33. Location of sites mentioned in text

APPENDIX

The following appendix contains the dimensional analysis of all lithic assemblage specimens from Otay Mesa. An attribute variance study or percentage analysis is not intended. Descriptions of each representative tool type are given previous to the tabulational data in order that a perspective of each classification can be presented beforehand.

Discoidal Scrapers - Virtually all of the discoidal scrapers are made from large flakes which have been reduced by varying degrees. They are ovoid in outline and plano-convex in cross-section. The top surfaces are usually trimmed off by percussion flaking and all are retouched around their perimeter, either partially or completely, sometimes by pressure flaking. Some of these specimens are domed and/or beaked. (see Figure 24).

Horse-Hoof Scrapers - These scrapers follow the same general morphology as the discoids, however there is usually a more pronounced dome and some specimens are semi-circular in perimeter. The working edge-angle on horse-hoof scrapers is not as acute as on the discoids, and often approaches 45 degrees. These specimens are more commonly broken than other scraper types.

Planes - The push-plane or scraper-planes are one of the most characteristic tools in San Dieguito assemblages of all phases. They are all percussion flaked core tools, and as stated in Rogers (1966:163) "Some may actually be cores which were put to secondary use as planes. Their working edges are usually about 90 degrees. The bottom is flat with the sides and top forming a highly arched convex surface (see Figure 22).

Beaked Borer/Gravers - The gravers in the assemblage occur in various shapes (Figure 23), the most common being plano-convex in cross section. The majority are made from amorphous flakes by percussion technique and pressure flaking was apparently employed to form a sharp point on one end. Some of the specimens may have been used for scraping as well as engraving as it appears that other edges were worked besides the beak which suggests a compound tool.

Hammers - These stones are generally spheroidal shaped with a high degree of battering on their previously angular edges. They may have been used as cores or chopping tools before their use as hammers which resulted in rounding of the edges (see Figure 18). It is unlikely that these implements were used as hammerstones for the purpose of knapping. They seem to have been used for a pecking function. The dimensions of these tools are fairly standardized, most of them being fist-size. Some of them suggest prolonged use.

Ovate Bifaces - These specimens are more or less discoidal to slightly elongate in outline and are lenticular in cross-section. They are made with a well-controlled percussion flaking technique. None of these objects seem to be derived from thick flakes, but appear to be core tools. Since they occur in association with knives it may be assumed that they were probably used for scraping rather than knife-like cutting.

Knife/Points - It is difficult to determine whether any of these bifaces may have been used strictly as projectile points. The specimens in Figure 19 might be considered as points because of their thin cross-section, although none of them are complete. The pieces in the collection that are decidedly knives are generally thick in cross-section and rounded on at least one end (see Figure 20). They are made by a well-controlled percussion flaking technique with pressure flaking used for retouch in some cases. Almost all of the complete specimens exhibit some remnant of a striking platform at one end demonstrating that they were fashioned from large flakes as opposed to a core preform.

Cores - The cores are represented by two basic shapes; amorphous cores which have flakes removed from a number of faces, and prepared-platform cores. A few of the prepared-platform cores may be classed as tortoise cores because of the sophisticated pattern that was followed while removing flakes. This technique produced a form that resembles a hemisphere-shape in the outline of the flaked sides meeting the side opposite the platform. A few of the specimens are entirely devoid of cortex.

Chopping Tools - All of the choppers from the Otay site are bifacially flaked. They appear to have been made from either angular river cobbles or macro-flakes by percussion technique. The specimens made on flakes often display flaking around the entire perimeter and virtually all of these objects have some percentage of cortex present.

Manos - All of the manos are made from well rounded cobbles of granitic, feldspar, or gritty sandstone material. They are bifacially ground in all cases with varying degrees of smoothness on the faces. They are remarkably uniform in size and weight. There is a distinct reddish stain on five of the specimens which may suggest the type of material that was worked.

Metate Fragments - The five large metate fragments show a high degree of smoothing on the surface that exhibits a depression. Four of the fragments are from tabular shaped metates while the remaining piece seems to be from a deep basined object. Four specimens are made from hard sandstone and the fifth, deep basined fragment from feldspar. All of the pieces suggest prolonged use.

Retouched Flakes - These flakes show varying degrees of retouch, mostly by well controlled percussion flaking and in some cases pressure flaking. A large percentage of these pieces have an observable amount of use-wear that has rounded some of the edges. Although many of the specimens have edges that were purposely re-formed, none of them have morphological taxanomic characteristics represented by the finished tools. They vary is size from small thin flakes to macro-size.

Flakes - This artifact type is by far the most numerous in the assemblage. A high percentage of the flakes are without cortex (see Appendix tabulations), which suggests secondary or trimming stages of lithic reduction. There is a wide size range represented within this category. Blades and "Teshoa" flakes are uncommon while most of the specimens appear to be amorphous pieces resulting from percussion flaking for trimming purposes. Many of these flakes have a pronounced bulb of percussion produced from striking at a high angled platform.

Flake Fragments - These are identifiable by the presence of either a striking platform, bulb of percussion, or a diagnostic form of step, hinge, or feather fracturing. The variation in size is similar to that of the complete flakes and retouched flakes.

Shatter - Unidentifiable as to artifact class but was probably produced by cultural activity such as smashing a core or cobble with sufficient force to detach some debris.

Hammerstone - One specimen of this type was recovered which seems to be a rather small, well-rounded river pebble which exhibits pitting around its entire perimeter.

For the purpose of the following tables:

$\bar{X}$ = mean s = standard deviation

All dimensions given in centimeters

All weights given in grams

DISCOIDAL SCRAPERS

Artifact #	Length	Width	Thickness	Weight
132	6.7	5.4	2.0	65.2
31	8.4	7.2	2.0	132.6
334	6.1	5.6	2.0	70.2
10	6.4	5.3	2.4	82.1
540	7.2	5.6	1.6	72.9
41	6.0	4.7	2.7	63.8
559	5.1	4.9	1.4	36.0
131	4.5	4.0	2.1	41.6
43	7.2	6.7	2.7	125.9
2	5.2	4.1	1.8	44.2
134	4.3	4.1	1.5	30.6
64	6.1	5.5	1.8	67.4
600	3.8	3.0	1.0	13.5
28	6.6	6.5	2.2	89.7
267	5.4	4.9	2.0	50.3
575	2.9	3.9	1.4	22.2
175	5.5	4.7	1.4	45.5
220	4.8	4.3	1.6	35.9
11	6.6	4.7	1.8	65.9
227	6.6	4.7	1.9	69.2
222	5.8	4.6	1.5	42.5
73	5.7	5.4	1.7	53.0
9	5.3	4.2	1.7	27.1
42	5.9	4.9	1.5	40.4
65	5.7	4.3	2.3	64.6
174	6.1	4.7	2.1	49.7
210	5.3	4.2	1.4	24.6
109	8.7	8.3	2.1	145.0
235	4.9	4.5	2.1	51.4
52	5.9	4.9	2.4	66.7
6	4.3	3.9	1.5	25.2
215	7.0	4.8	1.4	55.3
183	5.0	4.3	2.3	47.5
674	5.9	4.8	1.5	44.8
122	5.2	4.4	1.6	41.3
188	5.6	4.0	1.9	44.9
196	7.7	5.0	1.3	64.6
561	7.1	5.4	2.1	71.6
94	6.7	4.4	1.5	40.6
35	5.5	3.8	1.8	33.8
89	9.2	5.1	2.5	139.8
23	10.5	9.3	3.5	377.0
232	6.2	4.0	1.9	47.3
597	6.7	3.6	2.5	58.6
100	6.0	5.4	2.3	88.2
	$\bar{x}$= 6.12 s= 1.31	$\bar{x}$= 4.93 s= 1.17	$\bar{x}$= 1.90 s= .47	$\bar{x}$= 66 s= 56.03

'HORSE HOOF' SCRAPERS

Artifact #	Length	Width	Thickness	Weight
182	6.3	4.9	2.8	109.6
66	5.5	3.5	4.0	96.7
207	10.2	7.7	3.8	308.8
57	6.2	6.1	3.8	184.5
51	5.7	4.8	2.6	97.6
14	6.0	5.0	2.9	75.3
217	7.1	5.1	3.1	101.6
591	7.0	6.2	2.9	137.0
214	6.0	3.8	3.5	96.6
45	7.3	5.4	3.3	119.8
211	6.9	6.0	2.2	94.7
49	6.8	3.8	2.6	61.8
219	4.8	3.8	2.4	48.0
62	5.4	4.3	3.6	80.3
154	8.3	7.3	4.8	331.2
47	6.3	3.7	3.1	63.6
171	5.7	3.5	1.4	33.1
673	8.1	5.4	3.2	126.5
98	6.7	5.7	3.7	154.1
218	7.9	6.1	3.6	221.0
13	7.0	5.4	2.7	124.0
130	6.0	5.9	3.9	175.5
90	7.7	6.7	3.4	183.0
193	8.3	5.7	4.1	205.8
36	6.0	4.1	2.2	71.4
661	8.2	6.2	2.1	166.4
202	6.5	4.8	3.2	101.3
	$\bar{x}$= 6.81 s= 1.17	$\bar{x}$= 5.22 s= 1.15	$\bar{x}$= 3.14 s= .74	$\bar{x}$=132.19 s= 72.57

PLANES

Artifact #	Length	Width	Thickness	Weight
135	5.4	4.8	5.0	146.7
120	5.4	5.2	5.2	163.6
124	8.0	5.2	6.5	309.7
169	8.2	5.1	4.8	254.4
123	6.7	5.3	5.2	227.4
48	5.2	2.6	3.0	63.0
59	6.0	4.7	3.5	114.3
115	7.0	5.5	3.8	162.4
136	5.0	4.4	2.8	66.1
127	7.8	5.8	5.5	278.0
568	6.7	5.2	3.8	149.0
119	8.3	6.5	5.3	331.9
587	6.4	5.8	3.7	145.4
46	4.9	3.6	1.9	41.2
181	5.9	4.7	5.1	179.8
22	5.0	3.8	3.3	73.0
3	7.0	5.0	4.0	169.5
450	4.9	3.5	3.1	49.4
118	8.5	6.1	4.0	267.9
176	6.4	5.7	5.3	243.7
277	4.3	2.9	3.6	46.9
435	5.6	5.3	3.3	111.2
117	6.6	5.0	5.3	217.6
159	5.3	4.3	4.2	113.0
25	5.4	4.1	3.2	77.8
145	6.6	6.0	4.6	207.2
162	4.8	4.3	4.1	96.9
79	5.2	6.8	8.7	377.1
91	6.4	5.4	2.4	99.1
239	6.6	5.4	6.4	211.6
223	4.8	3.3	5.8	92.4
68	3.8	3.7	5.2	119.1
224	4.5	3.5	5.9	101.0
	$\bar{x}$= 6.02 s= 1.23	$\bar{x}$= 4.8 s= 1.03	$\bar{x}$= 4.47 s= 1.38	$\bar{x}$=160.83 s= 88.41

<u>**BEAKED BORER/ENGRAVERS**</u>

Artifact #	Length	Width	Thickness	Weight
54	8.0	6.4	2.1	101.2
56	7.1	6.4	3.5	140.4
268	6.8	4.4	4.4	109.7
236	5.1	3.7	2.8	40.6
570	8.2	8.2	3.4	198.7
86	5.7	4.2	2.0	44.7
429	6.8	6.8	4.2	137.1
537	11.4	5.4	2.0	138.4
71	6.5	4.1	2.0	46.0
187	6.8	5.0	3.7	131.0
204	8.3	5.2	2.9	130.7
33	6.7	4.3	2.6	84.1
612	7.0	5.6	1.7	58.5
40	5.8	5.6	2.5	77.9
203	4.9	3.9	3.4	67.7
463	5.9	4.5	3.5	96.8
108	8.2	7.4	4.4	211.0
16	8.0	4.2	1.2	41.3
209	8.5	3.5	2.3	83.6
398	8.0	5.1	1.8	74.3
29	6.0	5.4	2.7	83.5
63	6.4	3.8	2.1	49.1
276	5.5	4.5	1.8	37.4
400	5.4	4.3	1.2	19.1
213	4.8	4.5	1.3	27.2
349	3.9	2.3	0.9	6.9
433	4.8	4.4	1.2	24.8
509	3.5	3.1	0.5	6.7
275	6.0	5.2	3.0	66.4
165	4.6	4.5	3.0	80.6
82	5.4	3.9	3.5	60.2
	$\bar{x}$= 6.45 s= 1.63	$\bar{x}$= 4.83 s= 1.25	$\bar{x}$= 2.5 s= 1.05	$\bar{x}$= 79.86 s= 51.02

HAMMERS

Artifact #	Length	Width	Thickness	Weight
149	7.0	6.4	5.2	365.5
99	5.6	4.8	3.2	114.3
563	6.0	5.1	4.0	164.3
121	7.1	5.2	6.2	393.3
15	8.0	7.7	4.8	353.3
161	7.4	6.3	6.8	472.3
128	6.5	5.3	6.2	301.1
212	6.9	5.3	4.5	198.9
567	6.5	5.1	4.4	217.6
167	5.5	5.1	5.4	231.9
147	5.5	3.8	3.6	115.0
83	6.4	5.9	4.8	234.3
240	6.0	5.2	3.3	129.4
55	6.5	5.1	4.3	209.8
583	5.3	5.3	3.3	111.4
61	6.5	3.5	4.4	123.2
87	7.6	5.5	3.9	199.0
166	6.8	5.5	2.0	89.5
88	6.1	5.0	2.1	79.1
257	6.3	4.7	1.8	49.8
125	7.3	6.1	4.9	298.5
92	6.3	5.1	2.2	94.9
153	5.6	5.0	4.0	141.7
571	5.5	5.1	3.0	134.5
156	5.5	4.9		115.2
	$\bar{x}$= 6.39 s= .74	$\bar{x}$= 5.28 s= .81	$\bar{x}$= 4.12 s= 1.33	$\bar{x}$=197.51 s=110.8

ELONGATE BIFACES

110	9.2	3.5	1.7	56.2
78	7.5	5.9	2.3	119.8
39	6.6	4.6	2.2	81.7
361	8.3	3.5	2.6	65.8
594	6.2	3.3	0.9	23.2
589	8.0	3.1	1.4	38.4
467	5.1	4.3	1.2	31.6
576	5.6	3.3	1.0	18.1
24	6.9	7.4	2.8	114.0
76	15.5	7.1	2.6	314.9
97	9.5	4.4	1.9	97.4
12	5.0	4.7	2.2	62.3
93	9.6	4.1	1.5	61.8
70	4.6	4.6	1.4	35.6
593	3.2	2.4	0.6	5.9
184	4.9	5.0	1.3	43.9
579	3.2	3.1	0.8	8.1
590	6.3	3.3	1.2	24.2
269	5.8	3.2	1.5	24.7
164	5.2	4.1	2.5	49.6
596	6.2	3.6	1.0	23.0
675	4.8	4.0	1.7	32.3
588	1.8	3.8	0.7	5.2
266	5.4	3.1	1.3	23.9
111	6.2	2.3	0.8	13.1
150	5.1	5.7	3.5	130.4
	$\bar{x}$= 6.37 s= 2.66	$\bar{x}$= 4.13 s= 1.27	$\bar{x}$= 1.64 s= .75	$\bar{x}$= 57.89 s= 63.36

CORES

Artifact #	Length	Width	Thickness	Weight
177	6.6	5.9	4.2	163.3
221	7.4	6.2	4.5	184.4
168	7.6	6.6	3.4	142.0
144	6.4	5.8	4.2	126.1
280	6.4	5.2	2.7	81.1
96	6.9	5.9	4.6	141.9
81	6.0	5.6	4.1	131.1
146	5.7	5.2	4.2	151.7
226	6.9	6.1	3.8	142.0
157	5.9	5.0	3.9	108.5
152	8.4	7.4	3.7	209.9
143	6.4	6.2	2.8	112.9
237	6.8	4.6	2.9	78.3
80	6.9	6.1	5.6	165.5
138	8.9	6.1	3.9	189.2
565	7.0	5.1	2.4	72.1
	$\bar{x}$= 6.89 s= .86	$\bar{x}$= 5.81 s= .69	$\bar{x}$= 3.81 s= .82	$\bar{x}$=137.51 s= 40.33

SHATTER

Artifact #	Length	Width	Weight	% of Cortex
401	8.2	4.3	108.1	20-30
519	9.0	6.0	132.3	0-10
446	7.3	2.7	31.0	20-30
541	6.5	5.5	101.5	10-20
604	3.0	2.8	8.0	0
462	4.7	3.6	36.2	0-10
458	8.3	3.1	55.8	40-50
142	6.3	3.3	50.1	40-50
	$\bar{x}$= 6.66 s= 2.01	$\bar{x}$= 3.91 s= 1.25	$\bar{x}$= 65.38 s= 43.52	

MANOS

Artifact #	Length	Width	Thickness	Weight
626	9.2	8.0	5.3	548
628	11.5	10.2	4.3	834
627	11.7	9.4	4.1	742
621	10.9	9.0	6.3	965
630	9.3	8.3	5.5	621
629	12.2	10.2	4.1	812
623	9.5	8.1	4.1	498
632	10.2	7.8	5.4	687
622	10.9	8.6	5.9	826
637	0.6	9.6	5.2	853
638	12.6	11.3	4.8	1111
639	12.9	9.0	5.1	955
633	12.8	8.1	5.1	704
635	9.5	7.8	5.1	752
636	12.8	8.3	5.6	932
631	10.6	9.4	5.5	981
634	12.8	9.6	6.0	1123
625	11.6	7.8	5.0	700
620	11.7	9.7	4.3	792
624	12.0	8.9	4.5	811
	$\bar{x}$=11.26 s= 1.28	$\bar{x}$= 8.96 s= .97	$\bar{x}$= 5.05 s= .66	$\bar{x}$=812.35 s=166.83

METATE FRAGS

Artifact #	Length	Width	Thickness	Weight
643	23.0	16.0	5.1	1603,5
644	18.5	14.3	4.7	1434.0
642	23.5	14.5	3.7	1532.0
641	18.5	11.0	7.8	1917.5
640	10.6	8.4	3.5	455.2
	$\bar{x}$=18.82 s= 5.18	$\bar{x}$=12.84 s= 3.08	$\bar{x}$= 4.96 s= 1.72	$\bar{x}$=1388.44 s= 552.22

HAMMERSTONE

Artifact #	Length	Width	Thickness	Weight
158	5.2	4.4	3.7	130.7

RETOUCHED FLAKES

Artifact #	Length	Width	Thickness	Weight	% of Cortex
298	6.7	6.1	2.1	68.0	0
331	5.5	6.7	1.5	49.0	0
234	7.0	6.3	1.8	87.8	0
467	4.3	5.1	1.3	31.6	0
530	7.2	5.5	1.2	40.8	0-10
378	6.7	7.3	1.6	64.1	0
592	6.3	5.1	2.6	86.5	0
362	4.1	5.0	1.8	41.6	0
453	4.9	4.3	1.1	25.0	0
357	4.9	4.4	1.3	32.5	0
372	4.4	4.4	0.9	15.4	0
493	4.3	3.7	1.0	12.9	0
5	8.2	8.0	2.9	208.7	0
296	5.9	5.4	2.3	75.6	0
522	2.4	4.1	1.0	10.0	0
249	5.3	3.4	0.7	14.0	0
496	3.7	2.9	0.8	8.5	0
265	2.4	3.2	0.7	4.0	0
180	4.7	6.4	1.2	38.5	10-20
586	7.3	6.3	1.8	76.0	0-10
8	5.7	3.4	1.8	38.4	40-50
520	7.5	7.7	2.5	139.6	20-30
421	5.2	5.6	1.2	22.2	0-10
185	8.7	14.0	3.1	301.2	10-20
	$\bar{x}$= 5.55 s= 1.66	$\bar{x}$= 5.6 s= 2.29	$\bar{x}$= 1.59 s= .69	$\bar{x}$= 62.16 s= 68.89	-

FLAKES

Artifact #	Length	Width	Thickness	Weight	% of Cortex
461	5.6	4.4	1.5	29.8	30-40
315	3.7	3.7	0.8	8.7	40-50
241	4.2	5.1	1.2	21.9	0-10
245	4.2	3.2	1.0	15.7	10-20
500	3.9	3.1	1.2	16.5	0-10
179	4.0	3.3	1.6	19.3	0-10
553	4.3	4.0	1.2	17.4	10-20
448	4.9	4.5	1.2	25.9	20-30
447	4.7	5.2	1.2	27.9	10-20
499	4.7	2.8	1.0	12.8	0-10
573	4.5	2.7	0.7	9.0	50-60
605	4.6	3.7	1.5	22.6	0
465	4.4	3.6	1.2	15.7	50-60
243	5.3	6.4	1.6	41.6	50-60
309	3.2	3.5	0.8	10.1	20-30
250	3.2	5.2	1.0	12.1	30-40
651	3.2	4.0	1.0	10.9	0-10
197	4.2	3.1	0.8	9.8	0-10
533	2.2	2.8	0.8	7.2	30-40
482	3.1	3.1	0.7	6.1	20-30
477	3.1	2.6	0.8	6.5	0-10
335	3.2	2.4	0.5	4.7	0-10
598	2.9	2.4	0.5	3.8	0-10
335	3.1	2.2	0.5	4.6	0-10
572	3.0	2.0	0.8	4.2	0-10
106	5.9	12.2	1.7	127.6	90-100
281	5.1	6.2	1.8	55.9	70-80
338	10.9	9.3	2.8	223.5	0-10
198	9.6	6.6	1.6	99.8	30-40
74	7.2	8.2	2.5	194.0	60-70
101	10.6	5.5	1.8	117.9	30-40
615	6.5	5.0	2.0	76.5	90-100
75	9.5	13.0	3.0	304.6	60-70
230	5.4	5.4	1.0	40.9	90-100
547	4.7	3.9	1.1	21.5	90-100
208	4.9	3.7	0.8	17.3	90-100
341	3.3	3.4	0.7	8.5	90-100
44	11.8	10.5	2.0	206.5	30-40
285	4.8	5.3	1.3	26.7	0
290	4.5	4.5	1.3	24.5	0
307	5.4	5.4	1.4	40.4	0
303	5.3	5.5	1.8	52.9	0
288	5.1	7.2	1.4	43.0	0
26	4.8	5.9	1.9	62.9	0
297	5.6	4.9	1.2	43.6	0
291	5.1	5.6	2.3	63.8	0

FLAKES (Continued)

Artifact #	Length	Width	Thickness	Weight	% of Cortex
440	10.8	6.3	2.1	123.1	0
544	7.5	5.7	1.1	55.9	0
317	4.7	4.9	1.4	29.0	0
262	9.0	8.5	2.4	109.4	0
254	4.8	5.3	1.4	36.6	0-10
328	6.0	5.0	1.2	32.6	0
646	4.9	4.6	1.3	34.3	0
319	6.2	5.2	1.7	56.5	0
332	7.7	5.7	1.5	59.8	0
284	5.6	4.3	1.7	46.5	0
412	4.9	4.5	1.8	35.2	0
271	3.8	6.5	1.1	30.1	10-20
259	4.8	4.1	1.3	28.2	0
283	5.7	5.0	1.3	27.3	0
321	4.7	3.9	0.9	18.1	0
312	4.3	4.2	1.4	27.2	0
298	5.0	4.5	1.9	20.3	0
320	5.0	4.5	1.0	22.7	0
649	4.3	4.0	1.3	21.4	0
655	5.3	4.2	0.9	21.1	0
114	3.4	4.9	1.8	16.8	0
327	3.5	3.4	1.3	17.3	0
524	4.1	3.6	1.5	17.9	0
666	3.4	4.0	1.0	14.4	0
242	5.3	4.1	1.8	23.4	0
603	4.5	4.2	1.0	18.0	0
263	4.4	5.2	0.9	17.2	0
676	5.1	3.5	1.5	22.6	0-10
324	5.0	4.5	1.2	31.0	0-10
325	3.9	3.6	0.8	11.6	0
501	5.0	3.5	1.0	17.7	0
652	4.0	3.0	1.1	12.8	0
336	5.2	4.2	1.0	23.1	0
606	2.9	4.5	0.8	9.6	0
311	5.3	3.5	0.6	10.2	0
247	5.5	4.1	1.3	20.4	20-30
314	3.8	4.0	1.2	11.0	0
342	5.4	3.1	1.4	18.4	0
300	3.5	3.4	0.8	11.9	0
512	3.7	4.1	0.7	9.8	0-10
304	3.7	2.8	1.1	11.7	0
497	4.0	3.9	1.0	11.7	0
647	4.3	3.0	1.0	11.5	0
658	3.0	3.8	0.9	10.9	0
661	3.7	2.6	1.0	10.6	0
344	3.2	3.5	0.4	6.2	0

FLAKES (Continued)

Artifact #	Length	Width	Thickness	Weight	% of Cortex
550	3.7	3.2	0.9	9.8	0
660	3.1	3.5	0.7	8.0	0
495	2.9	3.4	1.1	10.4	0
574	3.5	2.7	0.5	4.2	0
301	3.0	2.7	0.4	4.0	0
513	3.7	3.9	0.9	8.8	0
654	2.9	2.7	0.4	3.8	0
345	2.9	2.0	0.5	3.5	0
490	3.4	2.0	0.5	3.3	0
406	3.5	1.7	0.3	2.4	0
488	3.0	1.9	0.3	1.9	0
38	5.6	5.4	1.7	46.7	0
456	5.7	6.6	1.2	48.7	0
418	8.3	8.3	2.3	131.3	0-10
438	6.9	6.3	2.6	105.4	0
395	7.0	6.7	2.0	69.8	0
449	6.1	4.4	1.7	50.1	0
351	5.3	5.3	1.4	36.5	0
464	6.0	4.1	1.2	32.8	0
388	3.9	4.2	0.8	15.8	0
560	4.4	4.7	1.6	33.0	0
408	4.1	5.9	1.4	39.5	0
444	7.0	3.9	1.5	42.2	0-10
339	5.2	6.1	1.1	42.8	0
363	5.3	4.3	1.4	37.0	0
404	6.7	5.7	2.4	92.5	10-20
427	5.5	5.2	1.5	41.8	0-10
387	5.1	4.4	1.7	34.3	20-30
402	5.3	4.2	2.3	48.4	20-30
113	5.8	5.5	1.3	39.8	0-10
347	3.9	5.2	1.9	30.6	0-10
428	6.4	5.9	2.0	64.8	10-20
411	5.0	5.4	1.8	18.9	0-10
385	4.4	4.8	1.4	23.3	30-40
399	5.2	3.6	1.5	23.3	0-10
410	5.0	3.8	1.8	33.3	30-40
396	4.6	5.2	1.5	36.2	10-20
669	5.3	4.4	1.2	25.5	10-20
389	5.0	6.2	1.6	49.4	0-10
264	5.3	4.4	1.8	38.7	30-40
601	5.4	4.3	1.5	36.0	20-30
417	4.9	5.2	1.7	45.7	10-20
305	5.9	4.9	1.2	40.8	10-20
278	5.8	5.2	1.2	45.0	50-60
85	5.3	3.7	2.1	43.7	10-20
299	4.4	4.7	1.2	30.2	10-20

FLAKES (Continued)

Artifact #	Length	Width	Thickness	Weight	% of Cortex
158	4.9	4.2	1.3	26.7	10-20
137	6.1	5.1	4.5	110.9	40-50
394	7.3	6.0	2.3	92.4	10-20
229	6.5	4.4	1.5	46.6	10-20
390	4.0	3.7	0.6	10.5	0-10
610	3.3	4.4	1.6	25.0	30-40
368	4.2	3.8	1.1	17.0	10-20
617	5.8	8.5	1.8	83.2	0
607	8.5	7.0	2.1	95.8	0-10
525	6.1	3.0	1.3	28.2	0
261	8.1	4.0	1.8	68.0	10-20
190	5.2	5.6	0.9	19.5	0
576	4.3	3.0	0.7	7.9	60-70
471	4.0	1.9	0.5	4.1	0
354	4.9	3.0	0.8	8.4	0
528	7.3	6.5	2.8	97.2	30-40
445	5.4	5.1	1.8	54.0	0
671	4.9	4.3	1.5	25.9	0
386	3.5	5.6	1.1	14.6	10-20
255	7.8	6.0	1.5	44.5	10-20
555	5.9	4.4	2.0	52.7	10-20
538	4.1	4.4	1.0	20.5	0-10
228	5.0	5.8	1.1	35.8	0-10
527	5.2	4.8	1.3	37.0	0-10
258	6.4	3.8	0.9	27.5	50-60
178	6.8	8.1	2.0	102.2	0-10
256	9.3	4.7	1.6	71.7	0-10
19	5.4	5.0	1.2	24.8	10-20
273	5.7	6.4	2.1	78.8	10-20
252	5.6	3.2	1.8	37.5	20-30
323	4.9	5.5	1.2	36.9	0-10
442	5.6	5.5	1.8	47.5	20-30
551	5.4	5.7	1.6	50.2	20-30
609	4.4	4.2	1.8	30.7	20-30
611	5.0	4.3	1.1	23.8	10-20
543	6.8	4.2	1.0	25.3	0-10
318	6.7	6.6	1.9	63.7	0-10
431	5.5	4.5	1.7	41.6	40-50
282	5.8	5.8	1.1	38.2	0-10
546	7.8	5.0	2.4	80.6	10-20
279	6.7	6.2	1.3	52.5	0-10
582	1.8	4.6	4.4	54.6	0-10
536	5.1	5.2	2.2	46.2	10-20
419	5.0	6.7	1.6	54.7	40-50
34	4.9	5.3	1.9	57.3	10-20
107	6.8	4.4	1.5	34.2	0-10

FLAKES (Continued)

Artifact #	Length	Width	Thickness	Weight	% of Cortex
441	8.0	5.6	2.5	94.5	40-50
343	7.1	8.3	2.2	112.4	0-10
248	4.3	5.5	1.9	29.0	0-10
466	6.9	4.6	1.8	53.5	20-30
613	5.0	4.4	1.4	31.7	0-10
546	5.0	4.3	1.3	28.1	0-10
439	5.9	5.7	1.3	39.0	0-10
102	6.3	4.0	1.4	30.8	30-40
430	4.4	6.5	1.2	34.5	0
407	5.6	5.2	1.6	49.0	0
1	5.1	5.6	1.5	43.0	0
531	7.8	4.8	1.4	30.0	0
452	2.9	6.0	2.1	42.3	0
352	4.1	4.6	1.0	21.7	0
436	7.8	6.4	2.7	101.8	0
413	5.6	5.2	1.5	50.4	0
581	5.4	4.9	1.5	38.5	0
375	4.9	4.7	1.8	36.2	0
443	5.2	5.1	1.6	27.4	0
355	5.7	4.7	1.2	33.5	0
529	6.5	3.2	1.4	32.3	0
397	5.0	5.3	1.8	45.8	0
270	6.9	5.3	1.2	37.6	20-30
650	4.6	4.6	1.1	26.0	0
569	4.4	3.9	0.9	14.0	0
316	5.9	3.7	1.5	28.8	0
475	4.0	5.8	1.1	17.8	0
542	5.5	5.9	1.1	27.9	0
423	4.9	5.0	1.7	48.1	0
322	6.4	4.1	1.1	25.2	0
426	4.6	5.0	3.2	58.8	0
333	5.2	4.2	0.5	10.8	0
350	4.7	4.5	0.9	13.0	0
618	3.7	4.6	1.2	22.3	0
457	4.0	5.6	1.5	40.2	0
414	4.6	4.3	1.9	29.8	0
358	4.6	4.7	1.4	28.8	0
602	4.7	3.5	2.0	34.9	0
434	5.7	3.9	1.9	34.0	0
616	4.8	4.1	1.4	26.4	0
436	7.5	6.2	2.8	101.9	0
359	4.5	5.5	1.0	24.6	0
451	5.3	4.2	1.3	30.5	0
370	4.4	3.5	1.0	14.0	0
377	4.6	4.7	1.1	23.0	0
376	4.7	4.4	1.6	28.2	0

FLAKES (Continued)

Artifact #	Length	Width	Thickness	Weight	% of Cortex
416	5.8	4.6	1.4	32.9	0
424	4.6	5.1	1.1	22.8	0
302	5.4	4.2	1.6	37.6	0
409	6.0	5.5	1.2	34.7	0
112	5.8	5.1	1.1	38.5	0
526	4.3	4.6	0.9	19.9	0
371	5.3	3.6	1.2	18.4	0
580	4.8	4.1	1.2	27.3	0
391	4.9	3.4	1.0	15.2	0
369	3.7	4.5	1.3	18.2	0
383	3.0	5.2	1.0	16.8	0
293	4.2	4.2	1.0	15.8	0
189	3.7	4.9	1.0	22.3	0
340	4.1	4.2	1.8	14.6	0
481	3.6	3.4	0.7	7.6	0
173	3.2	3.8	0.9	11.9	0
653	4.4	4.4	1.6	22.5	0
645	3.6	4.6	0.8	13.7	0
469	4.7	3.6	0.9	18.8	0
549	3.7	4.0	1.4	22.2	0
373	5.0	3.4	1.1	15.7	0
546	3.5	4.1	0.5	9.6	0
484	4.4	3.1	1.2	13.7	0
503	4.9	3.5	0.5	7.8	0
454	4.0	3.8	1.0	15.7	0
619	3.3	3.5	1.0	11.7	0
554	3.2	3.8	0.8	11.1	0
508	4.0	3.5	1.0	12.5	0
356	4.0	3.6	0.9	11.1	0
614	4.5	3.5	0.9	11.7	0
306	2.9	5.4	0.7	13.6	0
491	3.3	4.4	0.9	11.8	0
172	3.2	4.5	0.6	8.0	0
483	3.4	3.4	0.5	7.6	0
480	3.5	4.3	0.7	10.4	0
539	3.5	2.7	0.7	7.5	0
535	3.8	3.1	0.8	8.8	0
272	2.9	3.4	0.8	7.8	0
504	3.4	4.1	1.2	11.4	0
515	3.7	3.3	1.0	12.7	0
160	6.4	6.0	2.5	83.5	0-10
599	4.0	2.7	0.6	7.3	0
564	3.4	3.3	0.8	8.5	0
492	3.8	2.9	0.5	5.8	0
393	4.4	2.5	0.7	7.8	0
474	2.8	3.4	0.7	7.3	0

FLAKES (Continued)

Artifact #	Length	Width	Thickness	Weight	% of Cortex
507	3.4	2.9	0.9	6.8	0
364	3.3	2.8	0.7	4.7	0
384	2.3	3.5	0.8	5.4	0
577	3.0	3.4	0.6	5.6	0
478	3.1	3.0	0.5	3.8	0
348	2.5	2.8	0.4	3.4	0
659	2.8	2.3	0.8	4.3	0
486	3.0	1.9	0.3	2.2	0
479	3.0	2.1	0.4	3.5	0
584	2.6	2.4	0.9	3.7	0
	$\bar{x}$= 5.33 s= 8.88	$\bar{x}$= 4.39 s= 1.67	$\bar{x}$= 1.3 s= .81	$\bar{x}$= 33.92 s= 35.22	

OVATE BIFACES

Artifact #	Length	Width	Thickness	Weight
558	5.4	4.4	3.4	58.5
648	6.5	4.8	2.0	59.2
133	6.5	5.8	4.0	120.0
557	6.4	5.1	4.1	110.3
170	8.7	7.8	3.8	185.6
231	7.0	6.6	4.1	161.4
	$\bar{x}$= 6.75 s= 1.09	$\bar{x}$= 5.75 s= 1.27	$\bar{x}$= 3.57 s= .81	$\bar{x}$=115.83 s= 51.93

CHOPPING TOOLS

Artifact #	Length	Width	Thickness	Weight
129	8.1	6.8	7.0	364.3
148	6.4	7.4	3.6	190.1
562	6.3	5.9	4.2	122.5
4	6.8	6.4	3.8	147.7
60	8.0	9.3	4.4	336.2
200	7.8	6.9	3.5	200.7
27	5.2	7.0	3.8	168.1
67	4.8	7.0	4.0	137.0
310	9.8	8.9	4.0	308.4
126	10.7	10.3	7.4	760.3
	$\bar{x}$= 7.39 s= 1.88	$\bar{x}$= 7.59 s= 1.42	$\bar{x}$= 4.57 s= 1.41	$\bar{x}$=273.5 s=191.8

MODIFIED FLAKES

Artifact #	Length	Width	Thickness	Weight	% of Cortex
105	7.1	8.5	2.7	170.3	0
151	5.3	4.1	1.8	47.1	0
50	6.1	3.9	2.3	56.2	0-10
308	4.8	7.1	2.1	91.4	0-10
233	5.6	5.1	2.0	75.3	20-30
422	4.5	4.4	1.2	28.8	0
30	8.8	5.3	2.4	106.8	0-10
103	6.5	6.5	3.1	147.3	50-60
191	6.3	8.1	1.4	92.8	20-30
18	6.0	8.5	2.1	112.0	10-20
194	6.2	5.7	1.3	58.0	0
186	5.5	7.4	2.1	97.3	60-70
95	7.4	5.4	2.1	77.6	0-10
84	7.2	6.2	2.3	154.0	0-10
238	5.1	5.2	1.8	62.4	0
206	4.3	6.9	2.1	76.0	60-70
420	4.5	4.4	2.4	55.3	50-60
521	5.9	6.2	2.1	106.5	0
69	3.8	7.5	2.0	65.3	0
72	5.9	6.2	2.0	105.5	60-70
21	7.3	4.3	1.9	68.2	0-10
17	4.7	7.2	2.0	57.2	0
216	5.2	5.0	1.6	52.5	80-90
205	8.4	5.5	1.3	99.4	0
578	7.0	11.9	2.9	253.0	80-90
104	8.4	7.2	2.4	137.4	0
32	6.3	6.1	2.7	107.9	0-10
155	7.5	6.0	2.8	114.1	0
163	10.8	7.6	2.3	260.6	0-10
20	7.0	3.9	3.2	72.0	0
534	3.0	5.3	0.7	13.3	0
53	8.6	11.5	3.1	326.0	60-70
139	5.6	4.4	1.9	47.9	0
585	2.8	7.6	1.5	23.3	0
295	10.9	5.6	2.1	108.3	0
140	6.7	6.4	2.4	103.1	40-50
595	7.2	6.0	1.6	75.5	10-20
522	11.1	3.9	1.9	75.3	0
260	6.4	5.7	2.4	79.6	30-40
201	5.6	7.5	2.6	149.6	0
	$\bar{x}$= 6.43 s= 1.91	$\bar{x}$= 6.28 s= 1.81	$\bar{x}$= 2.12 s= .55	$\bar{x}$=100.25 s= 63.34	

FLAKE FRAGMENTS

Artifact #	Length	Width	Thickness	Weight	% of Cortex
657	1.8	4.2	1.6	13.3	0
670	2.8	4.5	1.0	8.2	0
329	3.7	2.8	0.5	5.0	0
505	3.9	2.6	0.6	4.9	0
326	3.1	4.6	0.7	12.1	0-10
313	4.2	3.8	0.6	9.7	0-10
664	2.1	3.4	0.4	2.9	0
672	2.8	3.7	0.7	6.8	0
665	2.2	3.2	0.8	5.0	0
668	2.3	3.0	0.4	3.3	0
415	3.4	5.0	1.5	22.0	0
405	4.4	8.3	1.7	54.6	0
514	1.7	3.5	1.1	8.0	0
502	3.0	2.6	0.6	3.5	0
522	2.4	4.1	1.0	10.0	0
382	2.7	2.8	0.6	3.7	0
468	2.7	4.4	0.7	8.5	0
498	3.0	3.9	0.8	10.5	0
473	4.6	3.2	0.7	9.5	0
360	2.3	3.8	0.9	11.5	0
286	3.0	3.0	0.9	6.7	0
374	3.7	4.0	1.2	12.4	0
367	3.9	4.7	1.0	12.0	0
353	2.2	14.6	1.0	6.8	0
662	1.9	3.7	0.5	5.6	0
380	3.4	3.7	0.4	5.3	0-10
379	4.0	3.2	1.0	8.2	0
470	2.0	4.0	0.7	5.9	0
494	2.7	3.2	0.5	4.7	0
346	2.7	2.7	0.4	3.4	0
663	2.5	2.8	1.4	9.3	0
517	2.4	2.8	0.4	2.2	0
510	2.5	2.0	0.5	2.9	0
487	2.9	1.7	0.7	3.1	0
274	9.6	7.0	2.5	130.3	0
253	3.9	7.1	0.8	20.3	0
437	5.2	5.4	1.7	38.7	0
511	4.8	3.0	0.9	14.4	0
244	4.5	3.3	0.7	11.6	0
392	4.7	3.7	0.7	10.0	0
294	4.9	5.9	1.5	33.0	30-40
225	3.5	6.7	1.8	41.3	10-20
366	3.8	3.1	0.6	6.2	0
460	4.2	3.2	1.2	16.6	0

FLAKE FRAGMENTS (Continued)

Artifact #	Length	Width	Thickness	Weight	% of Cortex
365	3.6	3.8	0.7	12.1	0
532	7.1	4.8	2.7	72.2	10-20
292	4.8	2.7	1.2	16.1	10-20
566	5.6	6.2	1.0	47.0	0-10
455	5.8	4.2	1.2	30.3	0-10
523	3.1	3.5	0.7	8.6	0
667	2.8	3.6	0.7	4.4	0
251	3.7	4.4	1.4	20.7	0
485	3.6	3.1	0.6	5.8	0
337	3.5	6.2	0.7	13.5	0
459	6.6	6.4	2.8	88.8	0
287	4.1	5.1	1.9	36.7	0-10
425	6.8	4.8	2.6	89.5	30-40
472	1.6	2.6	1.3	5.9	0
330	3.8	3.8	1.8	10.6	0
489	2.6	2.5	0.4	2.7	0
656	1.8	4.1	0.7	4.3	0
403	3.5	6.4	2.0	48.3	10-20
432	3.4	4.6	2.1	36.6	0
608	3.6	3.0	0.9	8.7	0
506	3.9	2.1	0.7	7.1	0
246	4.9	6.5	1.1	30.4	0-10
381	3.5	3.7	0.7	8.9	0
7	4.3	5.7	1.1	36.1	0
476	3.0	1.9	0.6	4.0	0
	$\bar{x}$= 3.63 s= 1.41	$\bar{x}$= 4.02 s= 1.40	$\bar{x}$= 1.04 s= .59	$\bar{x}$= 18.58 s= 23.59	

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