Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions
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Chapter 15

Middle Holocene climate change and human population dispersal in western North America

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Abstract

Available climate records in western North America (7000–3800 cal yr BP) indicate a severe dry interval between 6300 and 4800 cal yr BP embedded within a generally warm and dry Middle Holocene. Dry conditions in western North America between 6300 and 4800 cal yr BP correlate with cold to moderate sea-surface temperatures (SST) and relatively high-marine productivity along the Southern California Coast evident in Ocean Drilling Program (ODP) Core 893A/B (Santa Barbara Basin). Based on archeological, linguistic, and genetic data, we argue for a movement of Uto-Aztecan people from western desert environments to the Southern California Coast, including the southern Channel Islands, and into portions of the Central Valley by at least 5500–4500 cal yr BP. We hypothesize that population dispersal from the desert interior was primarily in response to severe and prolonged drought and that people moved selectively to coastal and aquatic habitats because of the ameliorated effects of drought and their overall productivity.

1. Introduction

Multidisciplinary studies employing genetic, linguistic, and archeological data have revolutionized the study of past human migration. Mitochondrial DNA (mtDNA) and Y-chromosome DNA work on extant populations has redefined and focused our view of the original dispersal of anatomically modern humans from Africa between 200 and 150 thousand years (Stringer, 2002; Jobling et al., 2004) and the study of ancient mtDNA extracted from Neanderthal fossils from Europe and the

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Caucasus suggest that these Archaic *Homo sapiens* were a genetically distinctive population (Krings et al., 1997; Ovchinnikov et al., 2000). Recent genetic and archeological studies also indicate a single dispersal of anatomically modern humans along the coasts of southern and southeast Asia and into Australia (Mellars, 2006), followed by movement into East Asia (Jin et al., 2002), Europe (Sykes, 1999; Richards et al., 2000; Mellars, 2006), and the Americas (Merriwether and Ferrell, 1996; Bianchi et al., 1997), perhaps in multiple waves (Karafet et al., 1997, 1999), and ultimately to some of the most remote portions of our planet in Oceania (Deka et al., 2000). Creative analysis of multiple lines of linguistic, genetic, and archeological data have mapped subsequent movement, displacement, and re-organization of populations within these geographic areas, often associated with the transition to agriculture (Cavalli-Sforza, 1996; Bellwood, 2001; Diamond and Bellwood, 2003), and the extraction of ancient DNA from well-dated skeletal material has provided specific information about the timing of these migrations (Haak et al., 2005). This work has revitalized the study of human dispersal and its historical importance for understanding broad-scale cultural developments, moving beyond the extreme and reactionary anti-diffusionist paradigms of the late 20th century (Trigger, 1989).

Linguistic diversity and the patchwork distribution of language groups in western North America reflect a complex history of early settlement, *in situ* development, and periodic population movement. A large number of geographically limited language families were recorded along the Pacific Coast, a product of an early migratory history (Golla, 2000a,b) and great ecological diversity (Nichols, 1992). Larger, more linguistically homogeneous regions such as the desert interior reflect more recent population migration (Kaestle, 1995, 1997, 1998). Recent mtDNA work confirms that one coastal group – the Chumash of Southern California – exhibits a distinctive founding haplogroup D sequence that is rare and primarily found in populations that lived along the coasts of North and South America, supporting the idea of an early coastal dispersal during the colonization of the Americas (Johnson and Lorenz, 2006; Kemp et al., 2007). The Uto-Aztecan language family is widely distributed in western North America from in Southern California and adjacent southern Channel Islands, south of Chumash territory, and extend across Southern California desert areas through much of the Great Basin. This wedge-shaped distribution is interpreted, along with the broader distribution of related language groups down into Mexico, as representing a movement of people from the interior to the coast (Kroeber, 1925; Bright and Bright, 1976), a scenario supported by a recent study of modern mtDNA lineages in California (Johnson and Lorenz, 2006). Estimates for the spread of Uto-Aztecan people derived from glottochronology and archeology range from about 2000 to 7000 cal yr BP (Moratto, 1984; Vellanoweth, 2001; Raab and Howard, 2002).

In this chapter, we synthesize the available genetic, linguistic, and archeological data for the spread of Uto-Aztecan peoples from the desert western interior to the Southern California Coast and argue that this expansion occurred during the

Middle Holocene between about 5500 and 4500 cal yr BP. We also argue, based on genetic and archeological evidence, for an associated spread of Uto-Aztecan people through the Central Valley of California, possibly as far north as the wetland environments within the vicinity of San Francisco Bay. Speakers of Penutian languages later colonized this region and were the ancestral populations to people living in the valley at the time of European contact. We evaluate these data within the context of newly available climatic data for western North America (Fig. 15.1), and argue that the movement of Uto-Aztecan people was stimulated by severe drought conditions across western North America between 6300 and 4800 cal yr BP that reduced terrestrial productivity and drinking water availability. These dry conditions correlate with cold to moderate sea-surface temperatures (SST) and relatively high marine productivity along the Southern California Coast evident in Ocean Drilling Program (ODP) Core 893A/B (Santa Barbara Basin), conditions that would have been particularly attractive to people living in interior areas at this time. To build these arguments we first turn to the available paleoclimatic records and then to the genetic, linguistic, and archeological data.

2. Climate records

2.1. Santa Barbara Basin paleoenvironmental record

Changes in SST and marine productivity during the Holocene have been inferred using various marine sediment records from coastal California (Pisias, 1978, 1979; Heusser et al., 1985; van Geen et al., 1992) including an especially high-resolution Holocene record (Kennett and Kennett, 2000; Cannariato et al., 2003). This Holocene (11,500 cal yr BP to present) record represents the upper 17 m of a 200 m core, a late Quaternary sequence spanning the last 160 thousand years (Site 893A/B), drilled in Santa Barbara Basin as part of the ODP (Ingram and Kennett, 1995; Kennett and Ingram, 1995a,b; Behl and Kennett, 1996; Cannariato et al., 1999; Hendy and Kennett, 1999, 2000) (Fig. 15.2). The sequence consists of laminated sediments deposited at an average rate of $\sim$155 cm/1000 yr. Climatic change through the Holocene is inferred from oxygen isotopic ($\delta^{18}O$) analysis of two planktonic foraminiferal taxa: *Globigerina bulloides*, a surface dweller, and *Neogloboquadrina pachyderma*, a species that lives near the base of the thermocline ($\sim$60 m below surface). Our Holocene age model is based on 20 accelerator mass spectrometry (AMS) ^{14}C dates converted to calendar years using a reservoir age of 230 ± 35 years (Ingram and Southon, 1996; Kennett et al., 1997; see Roark et al., 2003 for chronological details). This has provided one of the highest resolution marine Holocene climate sequences in the world: 25 yr intervals from 0 to 3000 cal yr BP and 9000 to 11,000 cal yr BP and 50 yr intervals from 3000–9000 cal yr BP. The high quality of this climate record results from a combination of rapid sedimentation rates, lack of bioturbation, a continuous abundance of foraminifera for geochemical and faunal analyses, and high environmental sensitivity in this region (Kennett and Kennett, 2000).

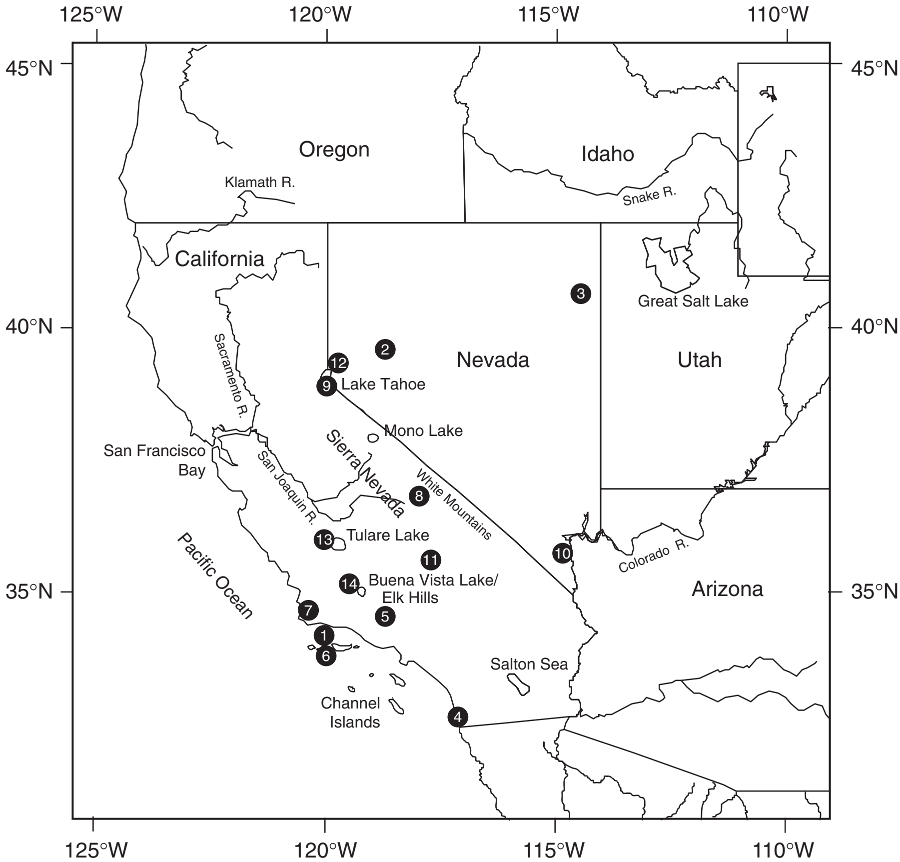

Figure 15.1. Map of western North America showing the locations of the main paleoclimatic records discussed in this contribution. (1) Ocean Drilling Program (ODP), Site 893A/B, Santa Barbara Basin (Kennett and Ingram, 1995b; Huesser and Sirocko, 1997; Kennett and Kennett, 2000); (2) Leonard Rockshelter pollen sequence (Byrne et al., 1979); (3) Ruby Valley pollen record (Thompson, 1992); (4) Archeological pollen sequences (Masters and Gallegos, 1997); (5) Late Holocene tree ring record, coastal Southern California (Larson and Michaelson, 1989); (6) Santa Rosa Island pollen sequence (Cole and Liu, 1994); (7) Union pollen spectra (Morgan et al., 1991); (8) Bristlecone pine tree ring record (LaMarche, 1973, 1974; Hughes and Graumlich, 1996, 2000); (9) Lake Tahoe submerged tree stump record (Lindström, 1990); (10) Southern Great Basin black mat records (Quade et al., 1998); (11) Owens Lake (Benson et al., 2002); (12) Pyramid Lake (Benson et al., 2002); (13) Tulare Lake geomorphology and pollen records (Negrini et al., 2006); (14) Buena Vista Lake and Elk Hills geomorphology (Culleton et al., 2005).

This record reveals millennial-scale oscillations in SST during the Holocene (Fig. 15.2a). Compared with the previous glacial episode (Kennett and Ingram, 1995a), Holocene SSTs were warm (average of ~12.5°C). Three distinct cycles are present in the Middle Holocene with warming between 8200–6300 and 5800–3800 cal yr BP, punctuated by a cool interval from 6300 to 5800 cal yr BP. The coldest SSTs during

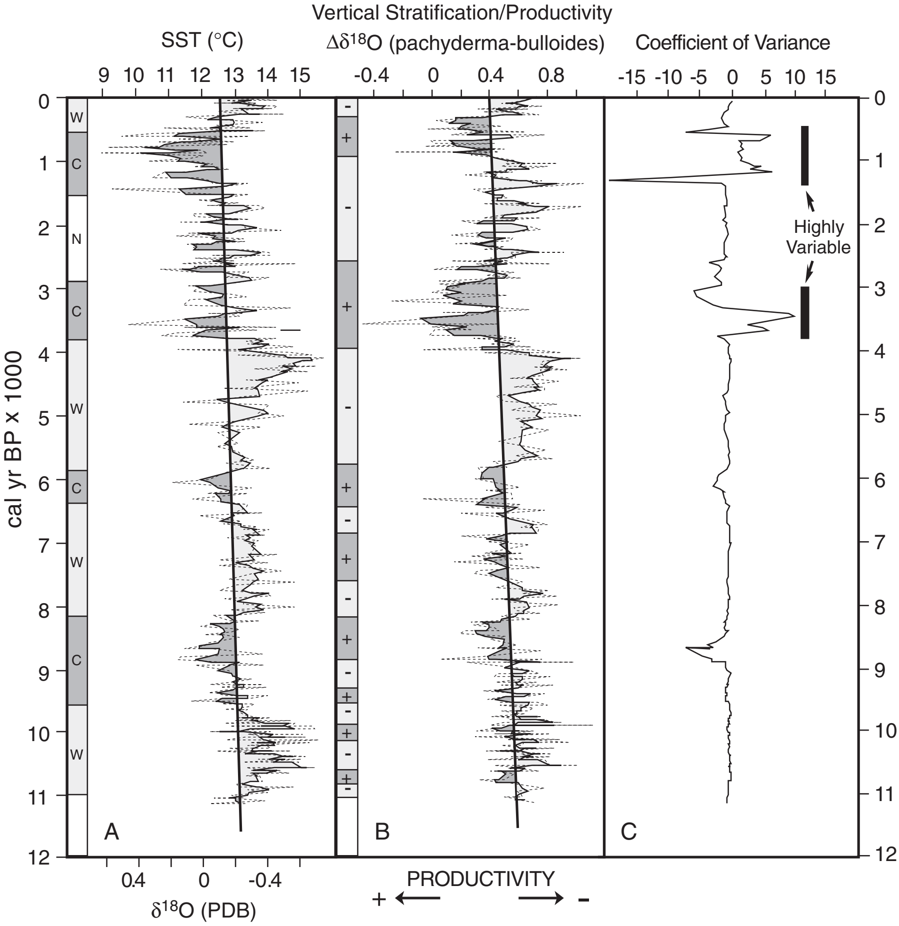

Figure 15.2. Holocene climate record for Santa Barbara Basin. (A) Estimated sea-surface temperature (SST) curve is based on the oxygen isotopic composition of *Globigerina bulloides* (surface-dwelling species of foraminifera) from varved sediments in Santa Barbara Basin. SST estimates are based on Bemis et al. (1998). The SST curve has been normalized for the Early Holocene by removing the oxygen isotopic component resulting from ice volume changes. Bar at left represents warm (w) and cold (c) cycles through the Holocene. (B) Vertical stratification/productivity record inferred from oxygen isotopic differences between *G. bulloides* and *N. pachyderma* (deeper-dwelling planktonic foraminiferal species). Bar at left shows intervals inferred as high (+) or low (–) productivity during the Holocene. (C) Variation in marine climate during the Holocene (δ^{18}O of *G. bulloides*, 50 year resolution). Coefficient of variance (standard deviation/average) was used to compare each oxygen isotopic measurement to the four surrounding it.

the Middle Holocene are centered on 6000 cal yr BP (~12°C). The warmest Middle Holocene interval occurred between 4500 and 4000 cal yr BP (~15°C), in agreement with Friddell et al. (2003). SSTs between 5800 and 5200 cal yr BP were relatively moderate compared to these warm and cold episodes.

Inferred surface ocean productivity fluctuations occurred during the Holocene (Fig. 15.2b), often synchronously with changes in SST. Changes in marine productivity have been inferred using a marine productivity index. This index is based on temperature differences between surface waters (as measured by the oxygen isotopic composition of surface-dwelling *G. bulloides*) and waters at the base of the thermocline (as measured by the oxygen isotopic composition of *N. pachyderma,* which inhabits the thermocline). Sediment trap studies within Santa Barbara Basin indicate that the isotopic difference between *G. bulloides* and *N. pachyderma* reflects the degree of surface ocean stratification, providing measures of upper water column stability, upwelling intensity, and magnitude of surface ocean productivity (Pak and Kennett, 2002). During the Holocene, inferred warming of surface waters was often associated with cooling at the thermocline, and vice versa, suggesting episodic variations in the intensity of upwelling. During cool episodes, little or no vertical temperature gradient existed between surface and thermoclinal species suggesting that upwelling of deeper, nutrient-rich waters was then especially intense during these intervals. Vertical mixing and inferred high productivity were greatest during the Middle Holocene from 7500 to 6800 cal yr BP and 6500 to 5900 cal yr BP. Reduced vertical mixing and lower marine productivity occurred between 6800 and 6500 cal yr BP, and again between 5900 and 3900 cal yr BP.

2.2. Associated terrestrial climate changes

High-resolution $\delta^{18}O$ and total inorganic carbon (TIC) records from Pyramid and Owens Lake basins reveal at least five distinctive climatic episodes in western North America during the Holocene (Benson et al., 2002; Fig. 3; see Fig. 15.1 for locations). Younger Dryas cooling was followed during the earliest Holocene by drying (11,600–10,000 cal yr BP) except for a brief wet period between 10,400 and 10,200 cal yr BP. Relatively wet conditions occurred during the remaining Early Holocene (10,000–8000 cal yr BP). Under these conditions, Lake Tahoe fed Pyramid Lake via the Truckee River and a substantial body of water existed in the Owens Lake Basin (Benson et al., 2002). A drying trend between 8000–6500 cal yr BP is suggested as lake sizes declined in both basins. $\delta^{18}O$ and TIC records from Pyramid Lake suggest periodic wet intervals between 8000 and 6500 cal yr BP with the most pronounced isotopic excursion between 7000 and 6400 cal yr BP interpreted as a major influx of water from Lake Tahoe. Persistently warm and dry conditions occurred throughout the remainder of the Middle Holocene (6400–3800 cal yr BP). At this time Owens Lake dried completely and water flow from Lake Tahoe to Pyramid Lake was substantially reduced. Wetter conditions generally mark the Late Holocene after ~3000 cal yr BP, but several multidecadal major droughts are known to have occurred between 1500 and 600 cal yr BP (Stine, 1994). These new data are generally consistent with the early work of Antevs (1948, 1952, 1955) who argued that the Middle Holocene (~7000–4500 cal yr BP) was warm and dry across much of western North America, the so-called altithermal or climatic optimum.

This was preceded by the anathermal (10,000–7000 cal yr BP) and followed by the medithermal (4500 cal yr BP to present) intervals marked by generally cool and wet climatic conditions. Dry Middle Holocene conditions in the Great Basin are also suggested by decreased sedimentation rates in the Ruby Valley marshlands of western Nevada between 7700 and 5500 cal yr BP (Thompson, 1992), decreases in spring discharge indicated by the absence of black mats in the southern Great Basin between ~7300 and 2500 cal yr BP (Quade et al., 1998), and changes in the distribution of xeric flora (Hansen, 1947; Bright, 1966; Byrne et al., 1979; Mehringer, 1985; Madsen and Rhode, 1990) and associated fauna (Grayson, 2000).

Axelrod (1981) argued that xeric (dry) vegetation expanded into the San Francisco Bay area in the Early and Middle Holocene and Moratto et al. (1978) identified several dry episodes in the Middle Holocene based on pollen records from California (Birman, 1964; Adam, 1967; Curry, 1969; Sercelj and Adam, 1975; Wood, 1975; Casteel et al., 1977) and correlated these with the bristlecone pine precipitation record from the White Mountains (LaMarche, 1973, 1974; Hughes and Graumlich, 1996, 2000) indicating a significant dry episode between 6000 and 4800 cal yr BP. Recent work in the San Joaquin Valley fills out the interior California climate picture. Geomorphic evidence shows Tulare Lake level fluctuations in the Middle Holocene, with two lowstands between ca. 7800–7000 cal yr BP and 5500–3500 cal yr BP, and desiccation indicated by mudcracks at 5500 cal yr BP (Negrini et al., 2006). The stratigraphic data is corroborated by pollen (sedge/cattail) and algae (*Pediastrum*/*Botryococcus*) spectra indicating that the most brackish conditions in Tulare Lake occurred in the Middle Holocene, with especially poor conditions between 5500–4500 cal yr BP. Through the Holocene, inferred lake levels correlate well between Tulare, Pyramid, and Owens Lakes (Benson et al., 2002; see Negrini et al., 2006, Fig. 12).

Further south in the Buena Vista Basin, Culleton et al. (2005) compiled geomorphic and archeological evidence from Buena Vista Lake and the Elk Hills that suggest gradual, low-energy deposition in the lakes and sloughs from 8000–6000 cal yr BP, followed by general desiccation ca. 6000–5000 cal yr BP indicated by buried calcic slough deposits displaying deep cracks and vegetation established on a subaerial surface. These Middle Holocene muds are overlain by 2–3 m of bedded sands and gravels derived from the surrounding uplands, deposited relatively abruptly at high energy judging from the lack of soil development (originally noted by D.W. Fuqua in Buena Vista Lake sediments in 1961; Hubbs et al., 1962, pp. 231–232). This massive erosion event was the culmination of drought-induced devegetation in the uplands, where today the buried Pleistocene soil is stripped of its A horizon, and Late Holocene sediments overlie the scoured Pleistocene B horizon (Culleton et al., 2005). Radiocarbon dates on freshwater mussel shells and archeological assemblages at Buena Vista Lake and Elk Hills place the event toward the end of the Middle Holocene, which would correlate with wetter conditions that caused a Mono Lake highstand (Stine, 1990, 1994) and the reformation of Owens Lake after 3800 cal yr BP (Benson et al., 2002). Overall, the San Joaquin Valley data correlate well with the driest interval in the Middle Holocene as indicated by the

Pyramid Lake $\delta^{18}O$ record (Benson et al., 2002) and are consistent with some of the most compelling evidence for severe Middle Holocene aridity based on submerged tree stumps in Lake Tahoe. Lindström (1990, also see Harding, 1965; Benson et al., 2002) documented ~20 tree stumps submerged up to 4 m below the current lake level. These trees have been radiocarbon dated to between ~6300 and 4800 cal yr BP and represent a low lake-level stand at that time.

Drought conditions appear to have been less severe in coastal California during the Middle Holocene compared with the interior. Relatively dry conditions in the Santa Barbara region are suggested by high percentages of *Chenopodium* and *Ambrosia* pollen in estuarine deposits on Santa Rosa Island between 5200 and 3250 cal yr BP (Cole and Liu, 1994) and dune building became more widespread on San Miguel Island between 7000–3500 cal yr BP (Erlandson et al., 2005). Pollen evidence from sediment records north of Point Conception also suggests dry conditions peaking in the Middle Holocene (7600–4800 cal yr BP) on the Santa Barbara Coast (Morgan et al., 1991). However, frequency changes in pine and oak pollen (Heusser and Sirocko, 1997) in Santa Barbara Basin (ODP Hole 893a) exhibit no distinct trends during the Middle and Late Holocene and thus climatic interpretations are inconclusive. Also, pollen spectra from estuarine and archeological deposits in coastal San Diego County indicate relatively stable environmental conditions during the Holocene (Masters and Gallegos, 1997).

Relationships between marine and terrestrial climatic conditions on the California Coast are complex, but historical data suggest that these two climate systems are currently closely interrelated (Jones and Kennett, 1999). Late Holocene records indicate that intervals marked by cooler SSTs in Santa Barbara Basin were contemporaneous with low precipitation over parts of western North America (Kennett and Kennett, 2000; Graham et al., 2007). A comparison of Santa Barbara Basin core data with the bristlecone pine record from the White Mountains of eastern California suggests correlation between cool SST and drier conditions during the last 4000 cal yr BP (Fig. 15.3). During this interval, cool SSTs and low precipitation dominate between 4000 and 2300 cal yr BP and again between 1500 and 500 cal yr BP. Warm SSTs and higher precipitation are evident between 2300 and 1500 cal yr BP and again following 500 cal yr BP. Cool SSTs between ~1500 and 500 cal yr BP also correlate with lower precipitation evident in a shorter tree ring record from the coastal ranges of Southern California (Larson and Michaelson, 1989; Kennett and Kennett, 2000). Several other lines of evidence also indicate dry conditions during this interval (Graumlich, 1993; Stine, 1994; Raab and Larson, 1997; Jones et al., 1999).

Middle Holocene relationships between inferred precipitation and SST are much less apparent. Prior to 4000 cal yr BP correlations between SST in the Santa Barbara Basin and the bristlecone pine record, so evident in the Late Holocene, are largely absent, possibly reflecting a general shift in climate sensitivity in southern California at the end of the Middle Holocene. During the Middle Holocene dry conditions throughout western North America (Antevs, 1948; Benson et al., 2002) correspond to warm SSTs in Santa Barbara Basin. Similarly warm SSTs through

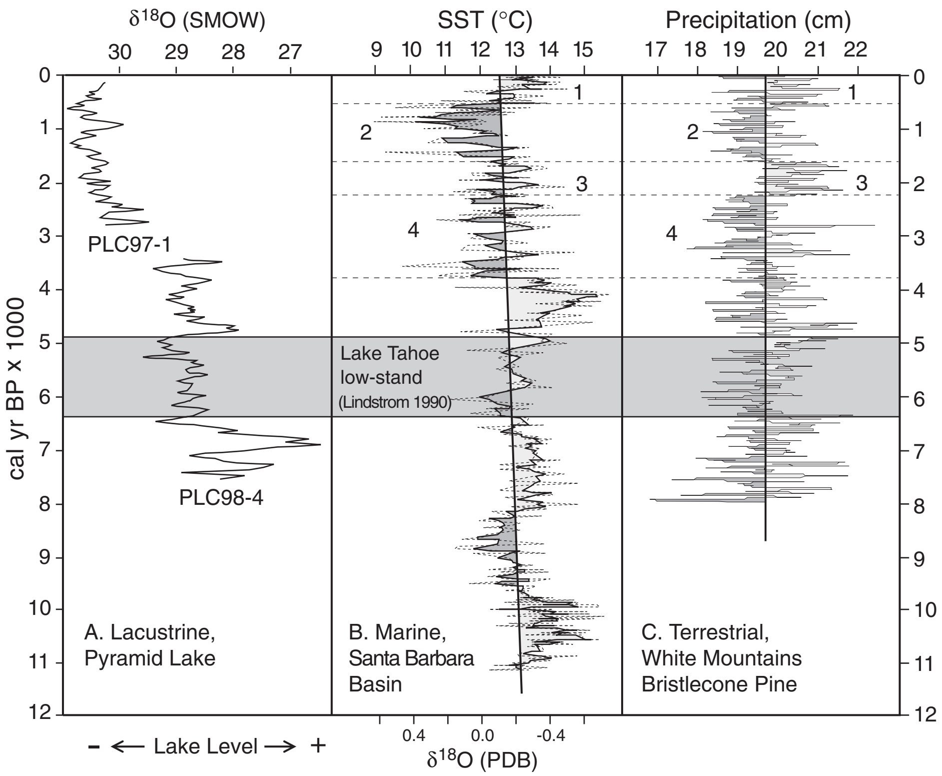

Figure 15.3. Bristlecone pine inferred precipitation (8000 cal yr BP to present) and Pyramid Lake $\delta^{18}O$ record compared with Holocene inferred SST from Santa Barbara Basin. (A) Smoothed (40 yr) $\delta^{18}O$ record for lake carbonates from Pyramid Lake (Cores PLC97-1 and PLC98-4), Western Nevada (Benson et al., 2002). Oscillations in $\delta^{18}O$ are interpreted to largely represent changes in freshwater input into the lakes which correlate to changes in lake size. Late Holocene high $\delta^{18}O$ values (PLC97-1) interpreted by Benson et al. (2002) as representing a phase of cooler, wetter climate; (B) Inferred SST record from Santa Barbara Basin, from Fig. 15.2; (C) Bristlecone pine record of inferred precipitation based on ring width measurements from trees in the White Mountains, California (data from LaMarche, 1973, 1974; Hughes and Graumlich, 2000; see http://www.ncdc.noaa.gov/paleo/drought/drght_graumlich.html). Zones 1 through 4 denote cool/dry (2 and 4) and warm/wet cycles (1 and 4) exhibited by these SST and precipitation records.

the Middle Holocene recorded in another Santa Barbara Basin sequence have been interpreted as evidence for stronger El Niño-Southern Oscillation (ENSO) activity in the Pacific and implied generally wetter conditions in western North America (Friddell et al., 2003). This, however, is inconsistent with indications of widespread Middle Holocene aridity in western North America. Instead, evidence for relatively stable decadal-scale climate variability in Site 893A/B appears to be more consistent with weaker ENSO activity during the Middle Holocene (Sandweiss et al., 1996, 1997, 2001; Overpeck and Webb, 2000; Tudhope et al., 2001; Koutavas et al., 2006).

If so, it follows that generally warmer SSTs at the millennial-scale are not necessarily accompanied by more intense or frequent ENSO activity.

Although inferred relations between SST and precipitation are clearly more complex in western North America, the coolest SST interval (6300–5000 cal yr BP) corresponds with the onset of the driest interval during the Middle Holocene reflected in the bristlecone pine sequence (LaMarche, 1973, 1974), Pyramid Lake $\delta^{18}O$ record (Benson et al., 2002), San Joaquin Valley geomorphology (Culleton et al., 2005; Negrini et al., 2006) and the submerged-stumps from Lake Tahoe (Lindström, 1990; Benson et al., 2002). This suggests that the climate during this interval operated similarly to that of the Late Holocene.

3. Linguistic, genetic, and archeological records

3.1. Linguistic data

Native California's linguistic diversity has long provided the basis for speculation regarding population movements, replacements, and interactions during the last several millennia (Kroeber, 1925). The distribution of major language families (e.g., Hokan, Penutian, and Uto-Aztecan; Fig. 15.4) and their relative linguistic and dialectical differentiation imply a series of population movements in California since the terminal Pleistocene (see Moratto, 1984, pp. 530–574). Hokan languages were thought by Kroeber (1925) to represent the earliest stock, as attested by their relatively disjunct distribution on the north and south coasts (e.g., Pomoan, Salinan, Chumashan), the northern Sierra Nevada (Washo), and the Colorado River and Baja California (Yuman). Speakers of Penutian languages are thought to have entered California's Central Valley from the northeast ca. 4500 cal yr BP, which is signaled archeologically by the Windmiller Pattern in the lower Sacramento Valley (Ragir, 1972). These early Penutians subsequently spread through the Central Valley, the Sierra Nevada foothills, and the central coast, and differentiated into existing language groups of Yokutsan, Miwokan, and Costanoan between ca. 3000–2000 cal yr BP (Moratto, 1984). Later expansions and replacements of Penutians by other Penutian tribes after 1000 cal yr BP are also hypothesized by Moratto (1984, p. 571).

Uto-Aztecan language groups are primarily located on the southern California Coast (Takic), desert interior of the Great Basin (Numic), with an additional pocket in the southern Sierra Nevada (Tubatulabalic, Fig. 15.4). The initial movement from the interior deserts to the Mohave Desert and southern coast is placed at ca. 5000–3000 cal yr BP on the basis of linguistic differentiation between Takic and Numic-Tubatulabalic, where it may be signaled by projectile point traditions common to the Great Basin and Southwest such as Humboldt, Gypsum, and Elko (Moratto, 1984, p. 559; Jennings, 1986; Koerper et al., 1994). Similarities in Yokuts (Penutian) and Uto-Aztecan languages led Nichols (1981) to posit a Uto-Aztecan presence in the southern San Joaquin Valley before the Penutian expansion

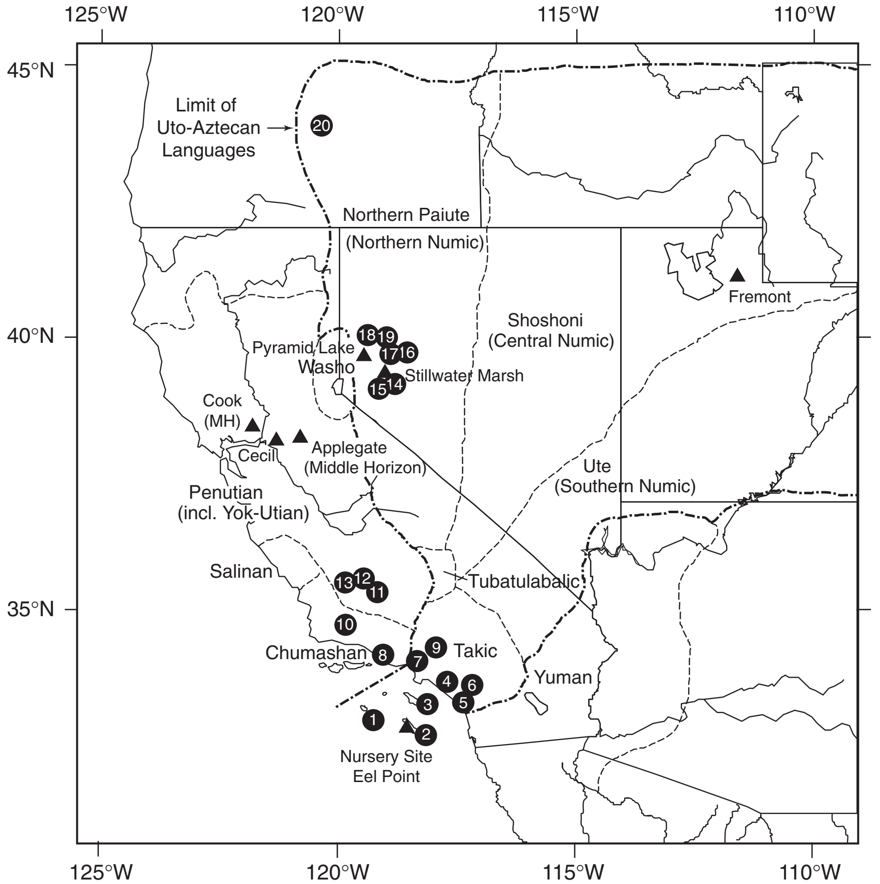

Figure 15.4. Map of western North America showing historic language distributions, prehistoric mtDNA populations (black triangles) and the known distribution of OGR beads that date to between ~5900 and 4700 cal yr BP (numbered). 1 = Celery Site, San Nicolas Island (CA-SNI-351); 2 = Nursery Site, San Clemente Island (CA-SCLI-1215); 3 = Little Harbor, Santa Catalina Island (CA-SCAI-17); 4 = CA-ORA-368; 5 = CA-ORA-667; 6 = CA-ORA-665; 7 = Encino Village (CA-LAN-43); 8 = CA-SBA-119; 9 = Vasquez Rocks (CA-LAN-361); 10 = CA-SBA-3404; 11 = Elk Hills (CA-KER-3079/H; KER-3166/H; KER-5404); 12 = Buttonwillow (CA-KER-2720); 13 = McKittrick (CA-KER-824); 14 = Stillwater Marsh; 15 = Hidden Cave; 16 = Silverwater Marsh; 17 = Lovelock Cave; 18 = Shinners Site F; 19 = Kramer Cave; 20 = DJ Ranch (35LK2758); 21 = Hondo Beach, CA-SBA-530. (Data points from Bennyhoff and Hughes, 1987; King, 1990; Howard and Raab, 1993; Vellanoweth, 1995, 2001; Jenkins and Erlandson, 1996; Raab and Howard, 2002; Culleton et al., 2005).

that ultimately reached Buena Vista Lake as late as 1000 cal yr BP (Moratto, 1984, p. 559). Coeval with a (hypothetical) late Penutian spread south, the dispersal of Numic peoples from southeast California into the Great Basin has been argued to have occurred after ca. 1000 cal yr BP as an intensive, low mobility, seed-processing adaptation was adopted by tribes in Owens Valley (Lamb, 1958; Hopkins, 1965; Goss, 1968; Bettinger and Baumhoff, 1982, 1983).

3.2. mtDNA and Uto-Aztecan peoples

A limited number of ancient and modern mtDNA studies in western North America provide some preliminary insights into hypothetical population movements of Uto-Aztecan populations through the Holocene. Linguistic arguments for close genetic relationships between speakers of Uto-Aztecan languages have been challenged by several studies that indicate that the equation of language to genes or culture is not exact (Kemp, 2006). The hypothesized introduction of maize agriculture into the southwest by migrating Uto-Aztecans from northern Mexico ca. 3000 cal yr BP (Hill, 2002) is contradicted by several lines of evidence that show few similarities between modern Uto-Aztecans of the Southwest and Mesoamerica, though they share some linguistic and cultural traditions (Smith et al., 2000; Malhi et al., 2003; Kemp, 2006). In the northern Great Basin, Kaestle and Smith (2001) found genetic discontinuity between prehistoric (primarily 6000–1000 cal yr BP) populations from the Stillwater Marsh and Pyramid Lake sites and extant Northern Paiute people in western Nevada (Fig. 15.4), consistent with the relatively late expansion of Numic peoples into the northern Great Basin hypothesized by Bettinger and Baumhoff (1982, 1983) on the basis of archeological evidence. Archeological populations in California's Central Valley (Fig. 15.4) dating from ca. 3600 cal yr BP (Early Horizon, Windmiller Phase) at the Cecil Site (CA-SJO-112) and ca. 2100–1800 cal yr BP (Middle Horizon) at the Cook (CA-SOL-270) and Applegate (CA-AMA-56) sites are argued to be most similar to extant southern coastal Takic peoples, rather than the modern Yok-Utian groups (Yokuts, Miwok, and Ohlone) that inhabited the region at European contact (Eshleman, 2002). This accords with Nichols's (1981) linguistically-derived hypothesis that Uto-Aztecan peoples (not necessarily *Takic* Uto-Aztecans) inhabited the Central Valley during part of the Middle Holocene, and that the hypothesized Penutian expansion from the northwest Great Basin at 4500 cal yr BP, thought to be manifested in the Windmiller Culture (e.g., Moratto, 1984, p. 553–555), actually occurred much later. Taken together, these studies suggest that the ethnographic distribution of Uto-Aztecan and other peoples in western North America does not reflect past situations, and that several significant population movements have occurred since the Early Holocene.

From the genetic data, what can we infer about the movement of Uto-Aztecan peoples in western North America? Two prehistoric mtDNA populations are known from the ethnographically Takic San Clemente Island: 7 individuals from Eel Point (CA-SCLI-43 Locus C) and 13 from the Nursery Site (CA-SCLI-1215) (Potter, 2004). The burial components at both sites date primarily to the Late Holocene (Eel Point, ca. 3000 cal yr BP; Nursery Site, 1500 cal yr BP), though Potter (2004, p. 51) suggests that some Eel Point burials may date to the Middle Holocene based on the archeological assemblage and ^{14}C dates as early as 4500 cal yr BP. Haplogroup frequencies for the prehistoric San Clemente Island populations and other prehistoric and extant western populations are compiled from the available literature in Table 15.1 (Note: the Middle Horizon group is the aggregate of the Cook and Applegate populations). Pairwise comparisons of genetic similarity for all groups are calculated in Table 15.2 with Fisher's exact test using the population differentiation option of GENEPOP v.3.4 (Raymond and Rousset, 2002) treating the four haplogroups (i.e., A, B, C, and D) as alleles of a single locus. The Fisher's *P* tests the null hypothesis that the two groups are drawn from the same larger population, rejecting it when *P* values are below a critical level (e.g., $P<0.05$ or <0.10). Note that higher *P* values do not indicate greater genetic similarity between groups.

The analysis replicates that of previous studies, which allows us to see the basis for the interpretations of other researchers. Ancient populations in each region cannot be differentiated from each other (e.g., Stillwater Marsh and Pyramid Lake in western Nevada, $P = 0.79$; Cecil Site and Middle Horizon in the Central Valley, $P = 0.88$), as is the case with the San Clemente Island samples (Eel Point and Nursery Site, $P = 0.26$). This suggests some degree of temporal continuity within each region during the first part of the Late Holocene (Kaestle and Smith, 2001; Eshleman, 2002). The prehistoric western Nevada populations are differentiated from most groups except Yok-Utian, Northern Paiute (compared to Stillwater Marsh), and the Nursery Site at the $P < 0.05$ level, which indicated to Kaestle and Smith (2001) that these groups were pre-Numic, and probably Penutian rather than Uto-Aztecan. As Eshleman (2002) found, the prehistoric Central Valley populations are differentiated from all groups except for Takic at the $P < 0.05$ level. Interestingly, they are also not differentiated from the Eel Point population (vs. Cecil Site, $P = 0.058$; vs. Middle Horizon, $P = 0.13$), but are distinct from the roughly contemporaneous western Nevada groups. Comparing Eel Point and Nursery Site groups to other extant and prehistoric populations is less clear-cut. They are each clearly dissimilar to Chumash, Northern Paiute, Fremont, and Yuman (at the $P < 0.10$ level), but neither can be distinguished from Washo and Takic, and the Nursery Site group is also not distinct from Yok-Utian or the western Nevada prehistoric populations. The relative lack of discernment for the San Clemente Island data is probably owed to the small sample sizes involved. That notwithstanding, the results are consistent with San Clemente's occupation by non-Chumash peoples of Uto-Aztecan stock by the beginning of the Late Holocene, probably having settled the island earlier in the Middle Holocene. The dissimilarity to Chumash argues for relatively little genetic communication between these groups in the Middle Holocene, *contra* Potter (2004). The Middle Holocene settlers would have been part of a broader expansion of Uto-Aztecan peoples into coastal Southern California and the Central Valley.

3.3. **Olivella** *grooved rectangle beads and the Uto-Aztecan interaction sphere*

Clear evidence exists for developing cultural interaction extending from the southern Channel Islands to the Los Angeles and Orange County coastal areas and the

Table 15.1. Haplogroup frequencies in extant and prehistoric population pairs in California and the Great Basin.

		Haplogroup:	A	B	C	D	n	Reference
Extant Groups	Language Stock							
	Hokan	Chumash	11	2	3	8	24	Lorenz and Smith (1996); Lorenz et al. (2002)
		Washo	0	15	10	3	28	Lorenz and Smith (1996); Lorenz et al. (2002)
		Yuman	3	59	38	0	100	Malhi et al. (2002)
	Penutian	Yok-Utian	2	5	2	8	17	Lorenz and Smith (1996); Lorenz et al. (2002)
	Uto-Aztecan	Northern Paiute	0	40	9	45	94	Kaestle and Smith (2001)
		Takic	1	6	9	3	19	Lorenz and Smith (1996); Lorenz et al. (2002)
Prehistoric Groups	Region							
	Great Basin	Fremont	0	25	0	0	25	Kaestle and Smith (2001)
		Stillwater Marsh	1	8	0	12	21	Kaestle and Smith (2001)
		Pyramid Lake	2	6	0	10	18	Kaestle and Smith (2001)
	Central Valley	Cecil Site	0	1	9	6	16	Eshleman (2002)
		Middle Horizon	1	4	14	10	29	Eshleman (2002)
	San Clemente Island	Eel Point	1	2	4	0	7	Potter (2004)
		Nursery Site	2	6	2	3	13	Potter (2004)
						Total	411	

Table 15.2. Fisher's exact test *P* (and standard deviation) for extant and prehistoric population pairs. Fisher's exact *P* is the average and standard deviation of five runs of 1000 iterations for each pair using the population differentiation option of Genepop v.3.4 (Raymond and Rousset, 2002), treating the four haplogroups as alleles of a single locus. Significant values (e.g., $P<0.05$, or $P<0.10$) reject the null hypothes that the two groups are drawn from the same population.

Extant: Hokan			Penutian	Uto-Aztecan		Prehistoric: Great Basin			Central Valley		San Clemente Island		(n)
Chumash	Washo	Yuman	Yok-Utian	Northern Paiute	Takic	Fremont	Stillwater Marsh	Pyramid Lake	Cecil Site	Middle Horizon	Eel Point	Nursery Site	
x	0	0	0.0760 (0.0020)	0	0.0013 (0.0003)	0	0.0007 (0.0002)	0.0105 (0.0007)	0.0011 (0.0001)	0.0005 (0.0001)	0.0113 (0.00083)	0.0411 (0.0041)	Chumash (24)[a]
	x	0.0319 (0.0012)	0.0050 (0.0008)	0	0.3080 (0.0045)	0.0002 (0.0002)	0.0001 (0.0001)	0.0001 (0.0001)	0.0022 (0.0001)	0.0037 (0.0008)	0.1467 (0.0015)	0.0970 (0.0018)	Washo (28)[a]
		x	0	0	0.0026 (0.0004)	0	0	0	0	0	0.0999 (0.0034)	0.0002 (0.0001)	Yuman (100)[b]
			x	0.0340 (0.0020)	0.0696 (0.0034)	0	0.4084 (0.0042)	0.6546 (0.0022)	0.0229 (0.0022)	0.0506 (0.0023)	0.0374 (0.0016)	0.6441 (0.0025)	Yok-Utian (17)[a]
				x	0	0	0.1154 (0.0058)	0.0288 (0.0018)	0.0001 (0.0001)	0	0	0.0105 (0.0009)	N. Paiute (94)[c]
					x	0	0.0006 (0.0001)	0.0018 (0.0002)	0.1328 (0.0057)	0.3339 (0.0036)	0.7634 (0.0025)	0.2702 (0.0042)	Takic (19)[a]
						x	0	0	0	0	0.0002 (0.00002)	0.0002 (0.0001)	Fremont (25)[c]
							x	0.7906 (0.0017)	0.0001 (0.0001)	0.0004 (0.0002)	0.0001 (0.0001)	0.0729 (0.0045)	Stillwater Marsh (21)[c]
								x	0.0003 (0.0002)	0.0009 (0.0001)	0.0010 (0.0002)	0.1868 (0.0047)	Pyramid Lake (18)[c]
									x	0.8837 (0.0015)	0.0581 (0.0016)	0.0110 (0.0008)	Cecil Site (16)[d]
										x	0.1274 (0.0026)	0.0305 (0.0011)	Middle[d] Horizon (29)
											x	0.2624 (0.0046)	Eel Point (7)[e]
												x	Nursery Site (13)[e]

Haplogroup frequency data are from:
[a] Lorenz and Smith (1996) & Lorenz et al. (2002).
[b] Malhi et al. (2002).
[c] Kaestle and Smith (2001).
[d] Eshleman (2002).
[e] Potter (2004).

Great Basin between about 5500 and 4500 cal yr BP (Vellanoweth, 2001). The best indicator of increased interaction between these spatially disparate areas is the distribution of *Olivella* grooved rectangle (OGR) beads produced on the southern Channel Islands or adjacent mainland coast. King (1990) pointed out that the known spatial distribution of OGR beads generally overlaps with the historic distribution of Uto-Aztecan peoples in western North America, as defined by Kroeber (1925). Howard and Raab (1993) and Raab (1997) were among the first to point out the presence of this rare bead form on the southern Channel Islands. Vellanoweth (1995) reported the presence of OGR beads on San Nicolas Island (CA-SNI-161), along with *Olivella* bead manufacturing debris. Outside of Southern California, Jenkins and Erlandson (1996) documented OGR beads in the northern Great Basin (south-central Oregon). Beads of this kind have also been found at other sites in the western Great Basin (Bennyhoff and Hughes, 1987; Vellanoweth, 1995, 2001; Raab and Howard, 2002). This distribution is wedge-shaped with its terminus on the southern California Coast (south of Malibu) and offshore islands (see Fig. 15.4; Koerper, 1979; Raab, 1997; Raab and Howard, 2002).

More recent work has expanded the known range of OGR beads beyond the ethnographic distribution of Uto-Aztecan languages (Fig. 15.4). A few have been documented in historic Chumash territory (Rincon Point, CA-SBA-119, Bennyhoff and Hughes, 1987; Honda Beach, CA-SBA-530, Lebow et al., 2002; Xonxon'ata, CA-SBA-3404, Hildebrandt, 2004, p. 64). Seven examples are known from the west side of Kern County in the southern San Joaquin Valley, which was inhabited by Yokuts tribes of the Penutian language stock when the Spanish arrived. Culleton et al. (2005) noted that these beads were found on older landforms flanking the former wetlands of Buena Vista Slough, the outlet for Buena Vista and Kern lake that flows north to Tulare Lake and ultimately into the San Joaquin Delta. These OGR bead sites are mainly open-air surface deposits on the Elk Hills, some with clear Late Holocene components, but their antiquity is corroborated by a direct AMS date on one OGR (of three recovered) from CA-KER-5404 of 5300–5000 cal yr BP (2 sigma; Beta-118254), and association with freshwater mussel shell at KER-3166/H dated to 5300–4800 cal yr BP and 5500–4900 (2 sigma; Beta-108267 and Beta-116693). These two sites and other OGR bead sites in the Elk Hills vicinity are also on Pleistocene – to Early Holocene – age landforms (KER-824, Bramlette et al., 1982; and, KER-3079/H Locus C, Culleton et al., 2005) or are partly buried by presumed terminal Middle Holocene sediment (KER-2720, Sutton, 1996; collection viewed by BJC at CSU Bakersfield). This suggests that OGR beads were circulating in larger numbers in the Middle Holocene southern San Joaquin Valley than in the other ethnographic non-Uto-Aztecan areas, such as Chumash territory. Vellanoweth (2001) noted the presence of three OGR beads near the Elk Hills at the time he wrote, and suggested that they represented part of a trade network that ran through the valley from Tejon Pass, and along trails up the west and east sides of the Sierra Nevada into the Uto-Aztecan Great Basin. An alternative explanation is that the Middle Holocene inhabitants of the Buena Vista Basin were speakers of Uto-Aztecan languages, and the anomaly of the OGRs in ethnographic Penutian lands reflects an earlier distribution of Uto-Aztecan peoples (cf. Nichols, 1981; Moratto, 1984).

4. Discussion

Marine climate data from the Santa Barbara Basin indicates that SSTs oscillated during the Middle Holocene between warm and cold states. In general, SSTs were relatively warm during the Middle Holocene, supporting interpretations of Friddell et al. (2003), except for one distinct cold interval between about 6300 and 5800 cal yr BP. More moderate SSTs are evident in this record from 5800 to 5000 cal yr BP. Inferred high marine productivity between 6300 and 5800 cal yr BP corresponds with the coldest SSTs during the Middle Holocene. Climatically influenced changes in terrestrial environments along the coast during the Middle Holocene appear to have been less drastic than in the interior, particularly in central and northern California (Jones and Waugh, 1997). Dry climatic conditions persisted throughout much of the Middle Holocene in eastern California and the Great Basin (Benson et al., 2002) with the driest interval occurring between 6300 and 5000 cal yr BP (LaMarche, 1973, 1974; Lindström, 1990).

The distribution of OGR beads from the southern Channel Islands across southern California and into the western and northern Great Basin suggests increased interaction among these peoples between about 5900 and 4700 cal yr BP. This exchange may have reduced the risk of resource shortfalls associated with dry environmental conditions during the Middle Holocene (see Larson et al., 1994; Kennett and Kennett, 2000 for Late Holocene examples of this phenomenon). The distribution of these beads seems to reflect the establishment of a new trade conduit, perhaps related to the inferred migrations of people from southern California desert environs to the southern Channel Islands (Grenda and Altschul, 1995; Potter, 2004; also see Warren, 1968 and Mikkelsen et al., 2000 for more generalized ideas of Middle Holocene movement from the interior to the coast). Persistently dry conditions in western North America between 6300 and 5000 cal yr BP would have expanded desert environments of southern California, displacing some groups to more humid and productive coastal and interior wetland regions.

We suggest that some Uto-Aztecan groups were displaced as conditions in the southern California desert became dryer and less productive. Some groups may have moved into the southwestern Great Basin where conditions were dry but less severe than those in the southern California desert areas. The western Great Basin (specifically the Carson and Humboldt sinks in western Nevada) appear on genetic grounds to have been occupied by Penutian peoples (Kaestle and Smith, 2001), whose presence may have forced migrating Uto-Aztecans to the southern coast and into the Central Valley from the south. Dry conditions were ameliorated on the coast by maritime influences and the environment provided a range of additional resources not available in the desert interior. The wetlands and lakes of the San Joaquin Valley were clearly affected by Middle Holocene aridity, yet still would have provided more favorable conditions than the interior desert of the southeast. Archeological populations from the Sacramento/San Joaquin Delta and Sierra Nevada foothills that bear closest genetic affinity with modern Takic groups (Eshleman, 2002), and the distribution of OGR beads in the southern San Joaquin Valley, offer evidence of pre-Penutian Uto-Aztecan populations during the Middle Holocene. Such migrations by early Uto-Aztecan groups may have promoted the flow of trade goods, such as OGR beads, over vast areas of western North America.

This interpretation implies a modification of the Uto-Aztecan interaction sphere as developed by Howard and Raab (1993), Jenkins and Erlandson (1996), Vellanoweth (1995, 2001) and Raab and Howard (2002). Marshaling the genetic, linguistic, and archeological data from the Central Valley, the presence of OGR beads outside of the historic distribution of Uto-Aztecan languages is readily explained by an early Uto-Aztecan presence in that region (Nichols, 1981; Moratto, 1984, p. 559). If a Penutian expansion into central California did not occur ca. 4500–4000 cal yr BP, as suggested by most linguistic reconstructions, this places the Penutians in western Nevada at the time OGR beads were circulating there (Fig. 15.4). This accords well with the mtDNA from Pyramid Lake and Stillwater Marsh, which shows ancient populations most similar to California Penutian groups, and unlike the later Numic peoples who occupied the Great Basin historically (Kaestle and Smith, 2001). So, the conspicuous cluster of OGR beads in Middle Holocene western Nevada may not comprise part of an ethnolinguistically-defined cultural interaction sphere among Uto-Aztecans, but perhaps reflect trade interaction between groups at the northwestern frontier of Uto-Aztecan territory. Raab and Howard (2002, p. 595) describe just this possibility:

> "It is also unrealistic on logical grounds to expect a linguistic boundary to be "impermeable" to the movement of various kinds of materials, including beads. For these reasons, we would expect to find OGR beads on both sides of any linguistic frontier. The model presented here does not predict an absence of OGR beads outside of the Uto-Aztecan area; rather it predicts significantly higher frequencies within this area".

Thus, the movements of people from the interior to the coast left a legacy of intergroup networks that allowed the communication of coastal trade items deep into Uto-Aztecan lands and beyond, perhaps into early Penutian territory in the Great Basin. Both increased exchange and migration may have been behavioral responses to unstable, dry conditions in western North America. Increased interaction and migrations of Uto-Aztecan speaking people to California's Central Valley, southern coast, and offshore islands had a profound effect on the evolutionary trajectory of coastal peoples in these regions and are fundamental in explaining the differences observed at historic contact between peoples of Southern California.

5. Conclusions

Articulating multiple lines of archeological, paleoclimatic, linguistic, and genetic evidence from western North America demonstrates the linkages between environmental change and human adaptive response during the arid Middle Holocene.

We argue that declining terrestrial resource abundance in the desert interior between 6300–4800 cal yr BP stimulated the movement of Uto-Aztecan populations toward more productive aquatic habitats on the southern California Coast and the Central Valley. The options for migration and settlement were likely limited by the presence of early Penutian groups aggregated around the marshes and lakes of western Nevada (e.g., Pyramid Lake and Stillwater Marsh), and the predecessors of the Chumash on the Santa Barbara mainland and northern Channel Islands, groups whose local aquatic environments were sufficiently productive to buffer the effects of terrestrial resource decline. In addition, and concomitant with population dispersal, extensive trade networks among Uto-Aztecan and other groups are signaled by the distribution of *Olivella* grooved rectangle beads dated to 5500–4500 cal yr BP from the southern coast, the southern San Joaquin Valley, and the western Great Basin. Inter-regional exchange of goods helped mitigate localized resource shortfalls, and may have developed within systems of kin relations and intermarriage between Uto-Aztecan groups, as were other exchange systems between California and the Great Basin (see Jackson and Ericson, 1994). Taken as a whole, the Uto-Aztecan response to Middle Holocene climate change comprised several inter-related elements: dispersal toward more stable and productive habitats, risk-minimization through resource exchange, both of which relied upon maintaining cooperative social networks that acted over great distances in western North America.

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