Early Holocene Coastlines of the California Bight: The Channel Islands as First Visited by Humans

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Abstract

When first visited by humans 10,000 to 12,000 calendar years before present, the geomorphology of the California Bight was vastly different. In this paper, we apply the latest $^{230}Th/^{234}U$ coral dating corrections to conventional ^{14}C dates and then relate these corrected dates to recent, improved data on sea level changes over time. This allows us to construct geographical profiles of the California Channel Islands and mainland coast to show the maritime environment that greeted the first coastal immigrants. Numerous small islands dotted the span between currently exposed islands, and considerably more island landmass was available for habitation and resource exploitation in both the northern and southern island groups. Lower sea levels made several embayments and especially deep submarine canyons near San Clemente and Santa Catalina Islands more accessible to island hunter-fishers. This revised geographical panorama provides coastal archaeologists with additional data for location and interpretation of Early Holocene sites.

Introduction

The broad implications of $^{230}Th/^{234}U$ coral dating corrections of conventional ^{14}C dates are beginning to be better appreciated by archaeologists (Fiedel 1999), including those concerned with the timing and extent of sea level transgression during the Holocene. We have recently learned that Early Holocene events, including sea level changes, occurred at least 2,000 years earlier than previously thought (Bard et al. 1990; Fairbanks 1990). These new data are graphically presented side-by-side with the earlier radiocarbon data curve in Fairbanks (1990:939, Fig. 2). The magnitude and timing of these sea level changes are now established by Greenland ice-core data and oxygen isotope (^{18}O) studies (Fairbanks 1990; O'Brien et al. 1995). At the peak of the second Greenland ice sheet meltwater pulse, 11,300 calendar years before present (CYBP), meltwater discharge rates exceeded 13,000 cubic kilometers each year (Fairbanks 1990), raising worldwide sea levels 25 m between 12,000 and 10,000 CYBP. Sea level rose another 35 m between 10,000 CYBP and the present (Fairbanks 1990).

To examine the effects of this deglaciation on the California Channel Islands (Fig. 1) and adjacent mainland shoreline, we apply the $^{230}Th/^{234}U$-corrected sea level curve (Fairbanks 1990) to Early Holocene sea levels and reconstruct the 12,000 and 10,000 CYBP coastlines. We also outline the chronology of the separation of ancient Santarosae Island into its present component islands resulting from sea level transgression during the Holocene. Finally, we focus on two specific island sites, Little Harbor on Santa Catalina Island (CA-SCAI-17) and

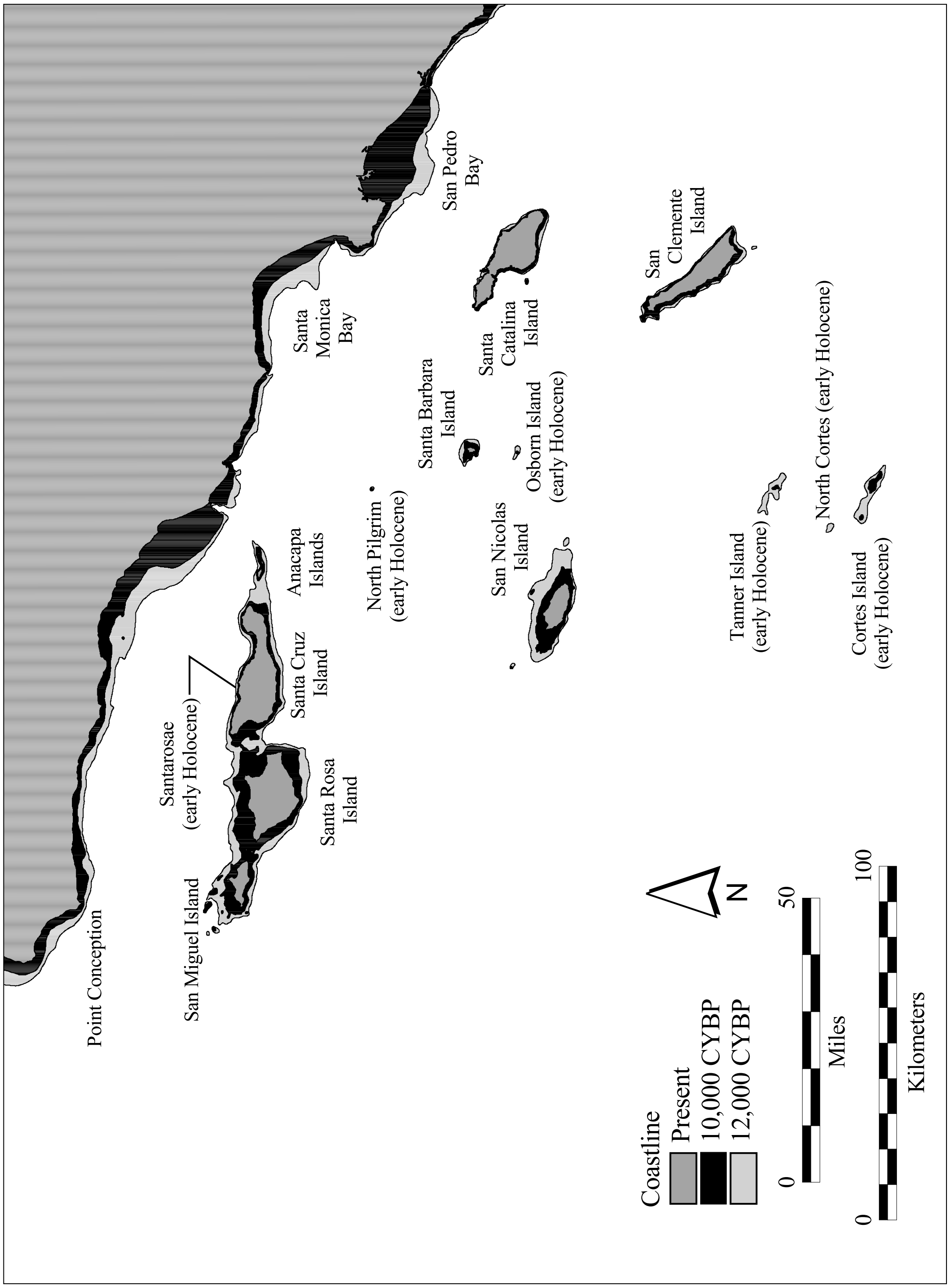

Fig. 1. The California Bight During the Early Holocene.

Eel Point on San Clemente Island (CA-SCLI-43), relative to nearby undersea canyons at about the time of earliest occupation of these sites.

These coastline reconstructions provide archaeologists working Channel Island and mainland coastal sites with a new map of the California Bight as a starting point for investigating and interpreting Early Holocene mainland-to-island and interisland population movement, inter-island navigation opportunities for exploitation of marine resources, site-to-shore distances, and possible loci of the oldest noninundated sites. Prehistoric Channel Island shorelines have been reconstructed before (Johnson 1983; Glassow 1999; Vedder and Howell 1980), but not using the new ^{230}Th/^{234}U-corrected Fairbanks (1990) curve and not for the specific time periods during which the first inhabitants occupied these coastal areas.

This reconstruction is a first approximation based on worldwide sea levels and does not incorporate the effects of specific geological activity on the islands and adjacent mainland coast. In general, geological changes are not of the same order of magnitude in the California Bight as is the dramatic rise of sea level over the last 12,000 years.

Background

Recent crossdating of Barbados coral samples by both conventional (^{14}C) and improved (^{230}Th/^{234}U) chronometric methods (Bard et al. 1990; Fairbanks 1990) provides a corrected time scale for worldwide sea level changes over the past 30,000 calendar years. Although ^{14}C ages for times up to approximately 9,100 B.C. are corrected by dendrochronology, earlier times cannot be corrected in this manner. The equivalence of ^{230}Th dates with dendrochronologically corrected ^{14}C dates for times more recent than 9,100 CYBP allows ^{230}Th dates to be applied as a reliable correction for times before 9,100 CYBP (Bard et al. 1990, Fairbanks 1990). Fairbanks plots these corrected dates and the corresponding uncorrected ^{14}C dates against sea level, yielding the most up-to-date time-versus-sea-level curve now available. The global uniformity of the sea level changes is verified by Bard et al. (1993) in similar measurements on corals from tropical Pacific Ocean environments.

As the 1990 Fairbanks sea level curve shows, at any given time before present the ^{230}Th curve yields higher sea levels than the ^{14}C curve. For example, at 12,000 CYBP the uncorrected ^{14}C curve places sea level about 90 m below the present level whereas the ^{230}Th curve places it only about 60 m below the present level.

An understanding of Early Holocene shorelines in the California Channel Islands has a bearing on a number of archaeological issues, including the following:

1. The land areas of the islands and the related capacity of the islands to provide subsistence for a human community.

2. The water distances between islands and the consequences of those distances for intercommunity travel.
3. The number and location of now-submerged, formerly exposed, islands that affected interisland distances, and the potential role of these former islands as navigational aids.
4. The mainland-to-island water distances and the impact of those distances on contact and trade with the mainland.
5. The proximity of specific island sites to undersea canyons with potentially diverse marine faunal assemblages.
6. The distances to the shoreline from specific island sites at the time of site occupation and the implications of those distances.
7. The potential loci of the oldest sites still above water along a given coast. An interesting and successful set of applications of Early Holocene coastline reconstructions for Peru is outlined by Sandweiss, Keefer, and Richardson (1999). In these applications, the shortest distance from present sites to the Early Holocene shoreline is used as a proxy for estimating which sites are likely to be older than others (the closer to the ancient shoreline, the older the site).

We use 12,000 and 10,000 CYBP as benchmark dates for shoreline reconstruction of all the Channel Islands because they represent, respectively, the Pleistocene/Holocene interface and a generally accepted period for earliest Channel Islands habitation (Erlandson et al. 1997; Erlandson et al. 1996). For the specialized reconstruction of the coastline and submerged canyon at the time of earliest habitation at the Eel Point site on San Clemente Island, we use 9,000 CYBP (Raab and Yatsko 1992; Porcasi et al. 2000). For the Little Harbor site and Catalina Canyon specialized reconstructions, we use 7,500 CYBP as suggested by Raab et al. (1995).

Method

From the 1990 Fairbanks sea level curve we derive the depths below present sea level for the ocean surface at four Early Holocene dates:

CYBP	Surface Depth Below Present Surface (1 fathom=6 feet)
12,000	-61.5 m or -33.6 fathoms
10,000	-34 m or -18.6 fathoms
9,000	-25 m or -13.7 fathoms
7,500	-15 m or -8.2 fathoms

We then trace those depths relative to isobaths (depth contours) on U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA) Nautical Charts No. 18720 (30th Edition, 13 August 1996) and No. 18740 (38th Edition, 28 November 1998) and on the

Eel Point (San Clemente Island) offshore bathymetric map produced by Ridlon (1972). A geographical information system (GIS) is used to facilitate easy calculation of area and distance and to allow representation of land features at varying scales while preserving accuracy. The interpreted isobaths are manually digitized into a topological, single-precision vector coverage in decimal degrees under the Mercator projection specified on the NOAA maps. Polygon coverages representing the Holocene islands and mainland are created from the isobaths. The polygon coverages are then reprojected into the Universal Transverse Mercator projection using the North American Datum of 1927, ensuring accurate area calculations while allowing verification with previously existing data sources. Final maps and tabulated reports are compiled in ArcView GIS™, a registered trademark of Earth Sciences Research Institute.

The chronology of the inundation of Santarosae Island is determined by establishing the maximum present depth of sea water between constituent islands using NOAA Chart No. 18720 and applying the Fairbanks (1990) sea level curve to find the times at which those depths were reached by rising sea water.

Results

The California Bight and the California Channel Islands were much different at the beginning of the Holocene (Fig.1). As is well known, at 12,000 CYBP the present islands of Anacapa, San Miguel, Santa Rosa, and Santa Cruz were joined into one large island called Santarosae, which was within 9 kilometers of the mainland (Figs. 2-5). What is not so well appreciated, however, is that the other islands were also quite different.

San Nicolas Island, now the smallest of the three major southern Channel Islands, was 4.6 times larger than it now is and was, in fact, the largest of the southern group (Fig. 6). Two other fairly large islands, Tanner and Cortes (Figs. 7 and 8), had not yet been inundated and were still a prominent part of the island chain, each rivaling the present San Nicolas Island in size. Santa Barbara Island (Fig. 9) was 10 times larger than its present size, and now-inundated Osborn Island occupied a position 10 kilometers south of Santa Barbara Island (Fig. 10). To the north, tiny North Pilgrim Island (Fig.1) provided a landfall or navigational marker halfway between Santa Barbara Island and the east end of Santarosae Island. Santa Catalina Island (Fig. 11) was 1.3 times larger than at present and was within 24 kilometers of the mainland, one third closer than it is currently (35 kilometers), due primarily to exposure of the mainland coastline. San Clemente Island (Fig.12) was 1.7 times larger than at present and its shore bordered on a deep submarine canyon to the west. In addition, nine smaller islands were scattered throughout the island chain, creating a situation in which no more than 54 kilometers of open water separated one island from its nearest neighbor. The now-inundated Tanner Island was approximately 54 kilometers from both San Nicolas and San Clemente. The total island land area at 12,000 CYBP was approximately 2,138 square kilometers compared to its

Table 1. Present and Past Channel Island Areas (km²)[a]

Island[b]	Present Area (km²)	10,000 CYBP Area (km²)	12,000 CYBP Area (km²)
Cortes	—	11	45
N. Cortes	—	—	4
N. Pilgrim	—	0.2	1
Osborn	—	0.5	4
San Clemente	145	203 (1.4 times larger than present)	243 (1.7 times larger than present)
San Nicolas	58	147 (2.5 times larger than present)	269 (4.6 times larger than present)
Santa Barbara	3	17 (5.7 times larger than present)	30 (10 times larger than present)
Santa Catalina	194	227 (1.2 times larger than present)	255 (1.3 times larger than present)
Santarosae[c]	506	922 (1.8 times larger than present)	1259 (2.5 times larger than present)
Tanner	—	2	28
Total	906	1530 (1.7 times larger than present)	2138 (2.4 times larger than present)

[a]Areas do not include small adjacent islands (now inundated) and ignore variations due to high and low tides. [b]Island names taken from existing names (Johnson 1983) except for N. Cortes, which is coined in this paper. [c]Collectively, Anacapa, San Miguel, Santa Cruz, and Santa Rosa. The current areas of these separated islands are given in Johnson (1983).

present 906 square kilometers. Table 1 lists each island with its 12,000- and 10,000-year-CYBP and present land areas.

By 10,000 CYBP the situation had changed markedly. San Miguel, Santa Rosa, and Santa Cruz Islands just barely formed a single island. Anacapa Island had separated from Santarosae about 11,000 CYBP, and by 10,000 CYBP it was about 6 kilometers from Santarosae and about 12 kilometers from the mainland. Santarosae, now excluding Anacapa, was 18 kilometers from the mainland. Santa Cruz Island separated from Santarosae about 9,800 CYBP. Shortly thereafter, at about 9,600 CYBP, Santa Rosa and San Miguel separated, and Santarosae no longer existed. We offer this chronology with the reservation that the methods used here may not be precise enough to separate events that probably occurred within one or two hundred years of each other.

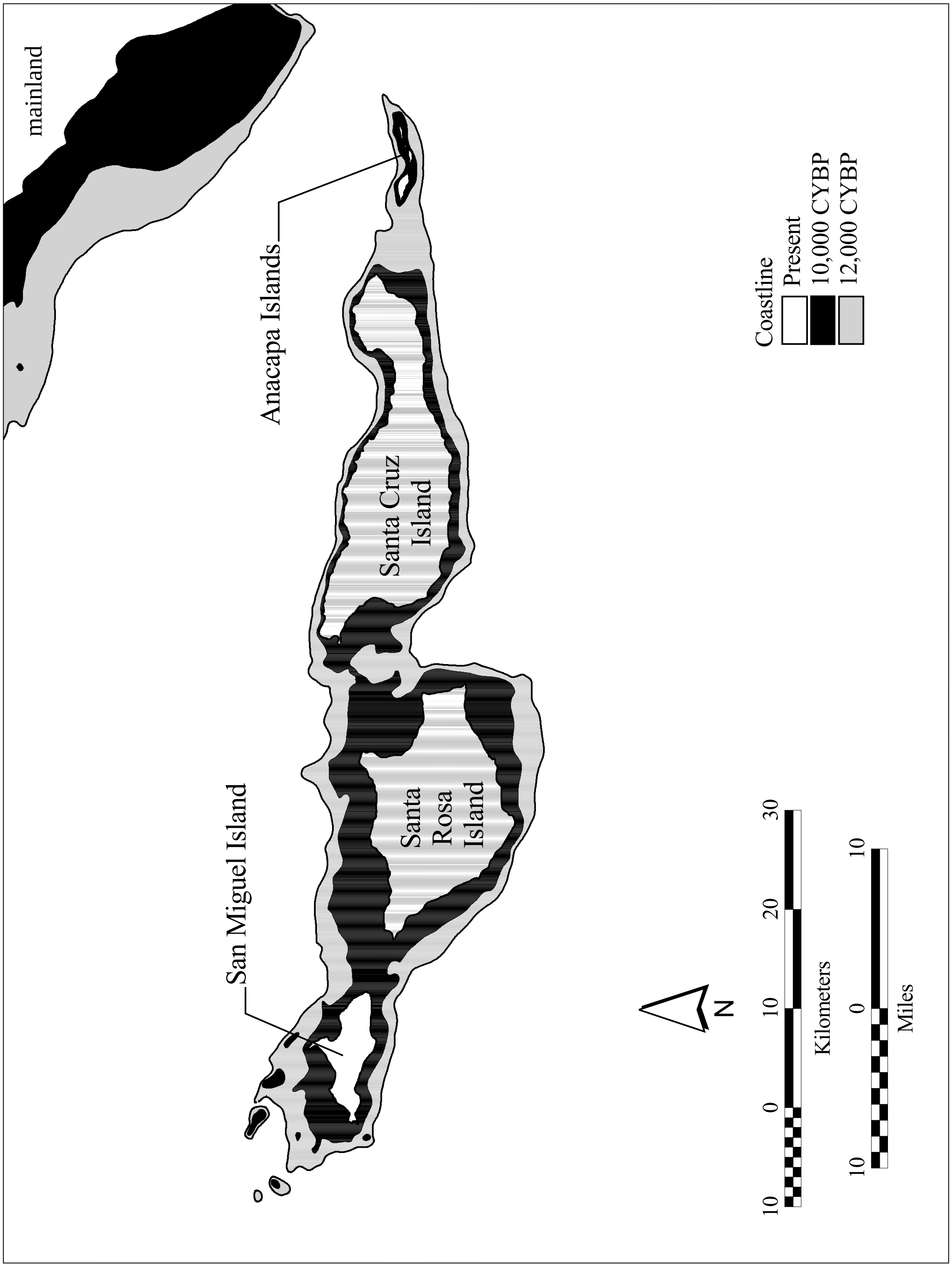

Fig. 2. Early Holocene Santarosae Island.

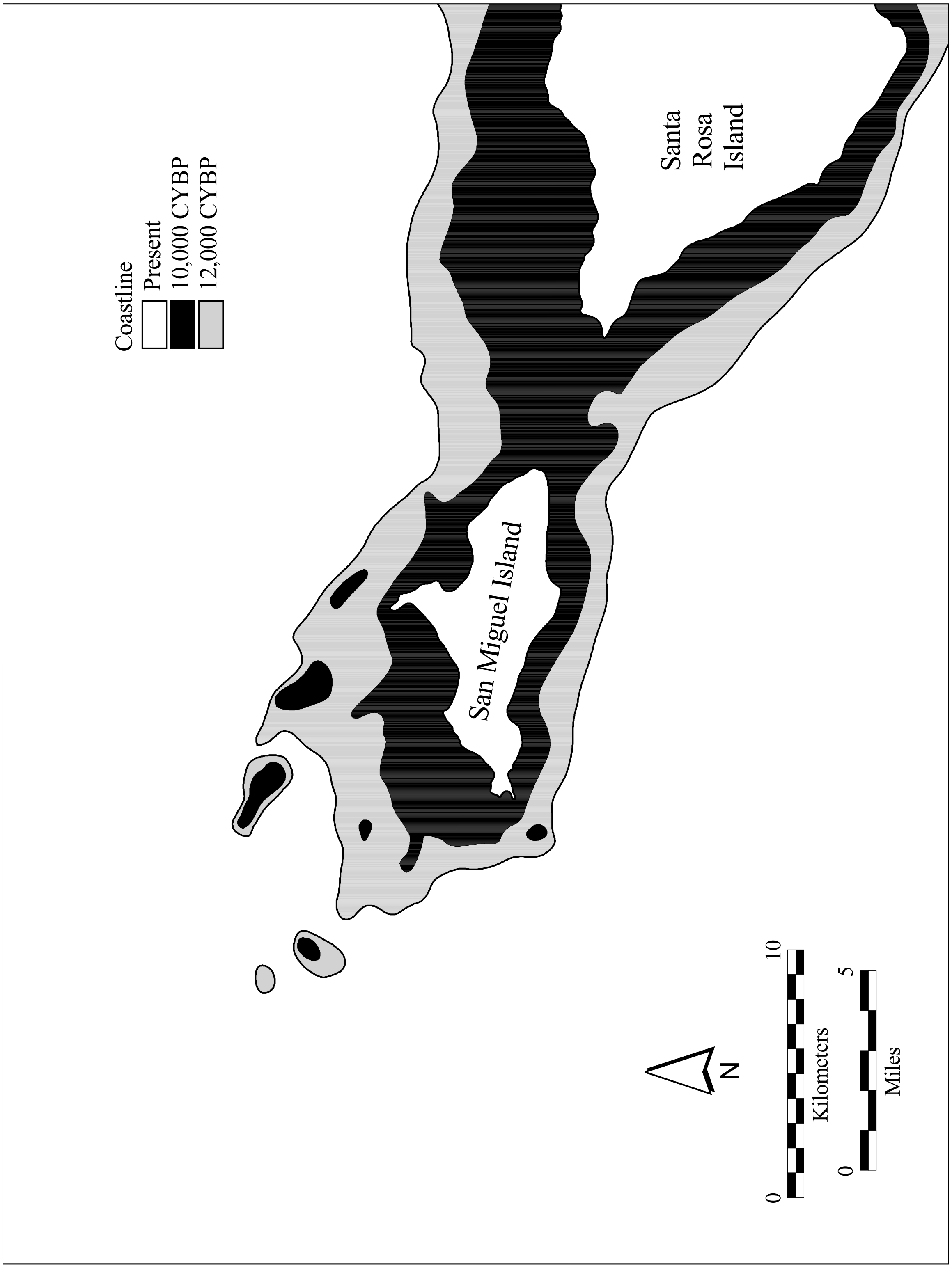

Fig. 3. Early Holocene Santarosae Island.

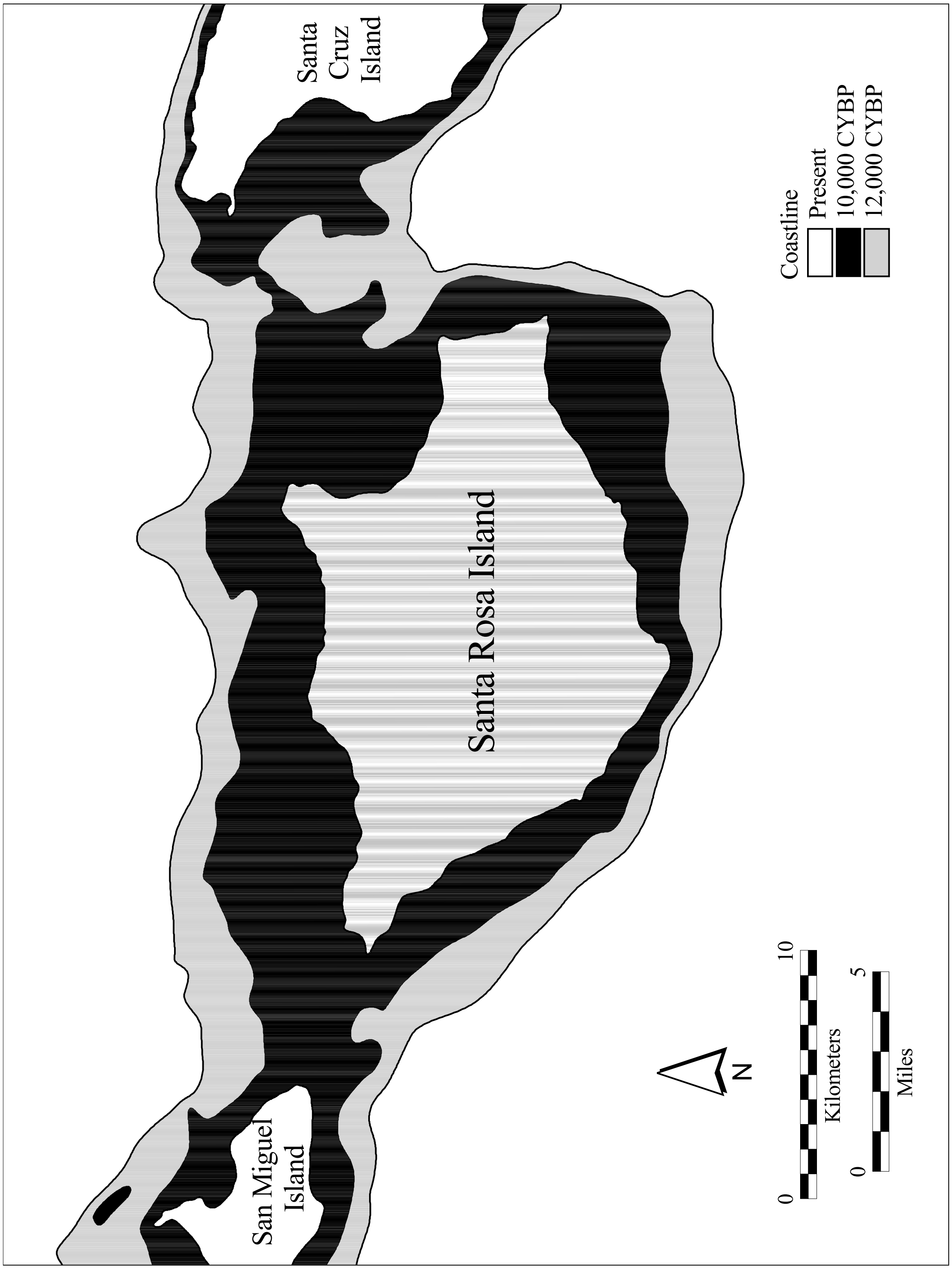

Fig. 4. Early Holocene Santarosae Island.

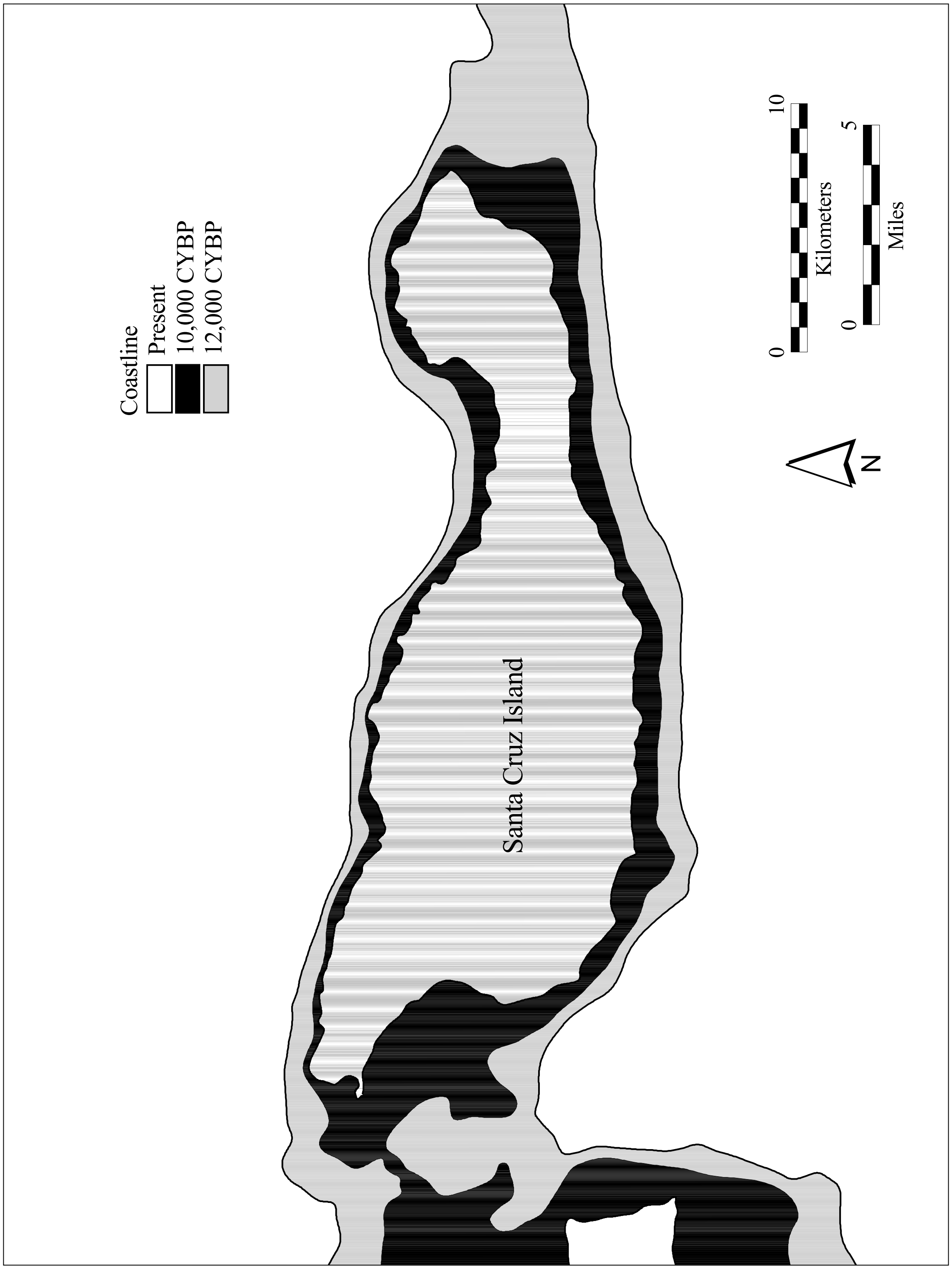

Fig. 5. Early Holocene Santarosae Island.

Fig. 6. Early Holocene San Nicolas Island.

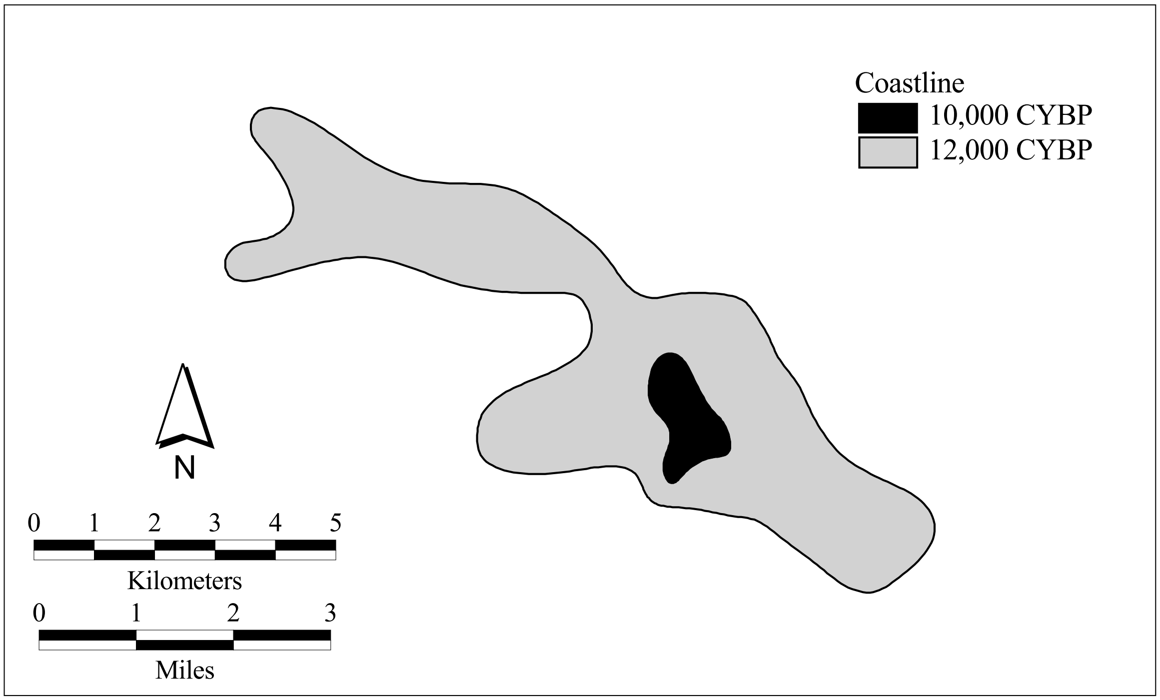

Fig. 7. Early Holocene Tanner Island.

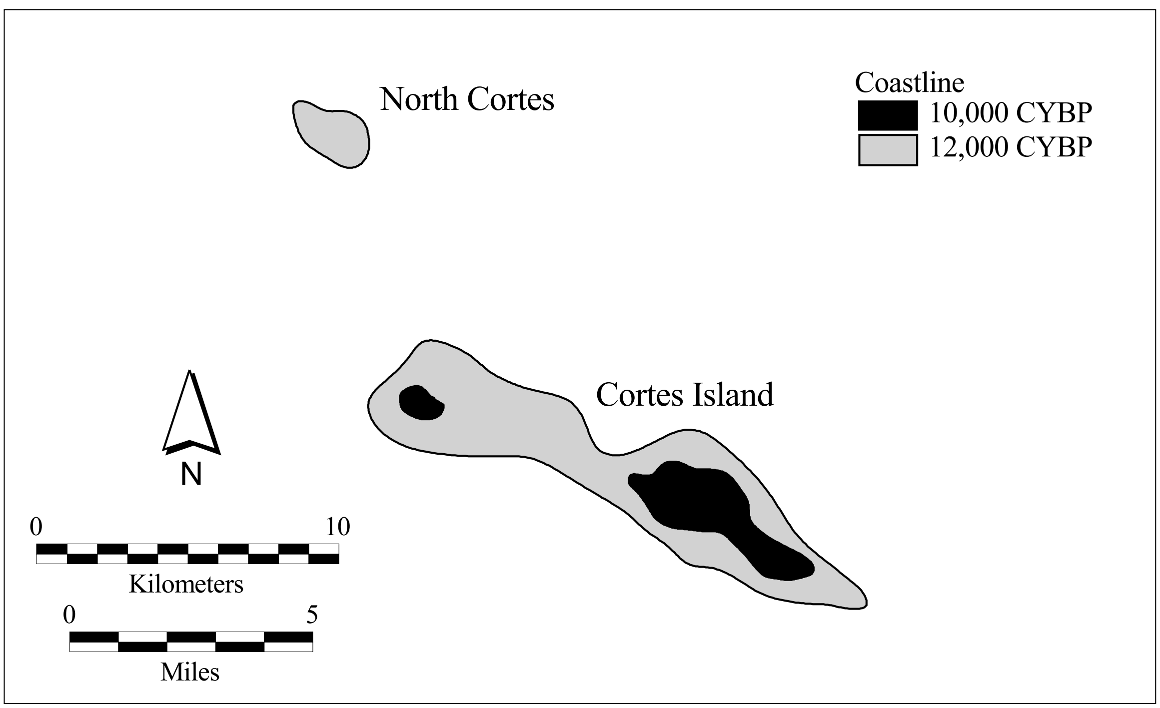

Fig. 8. Early Holocene Cortes Island.

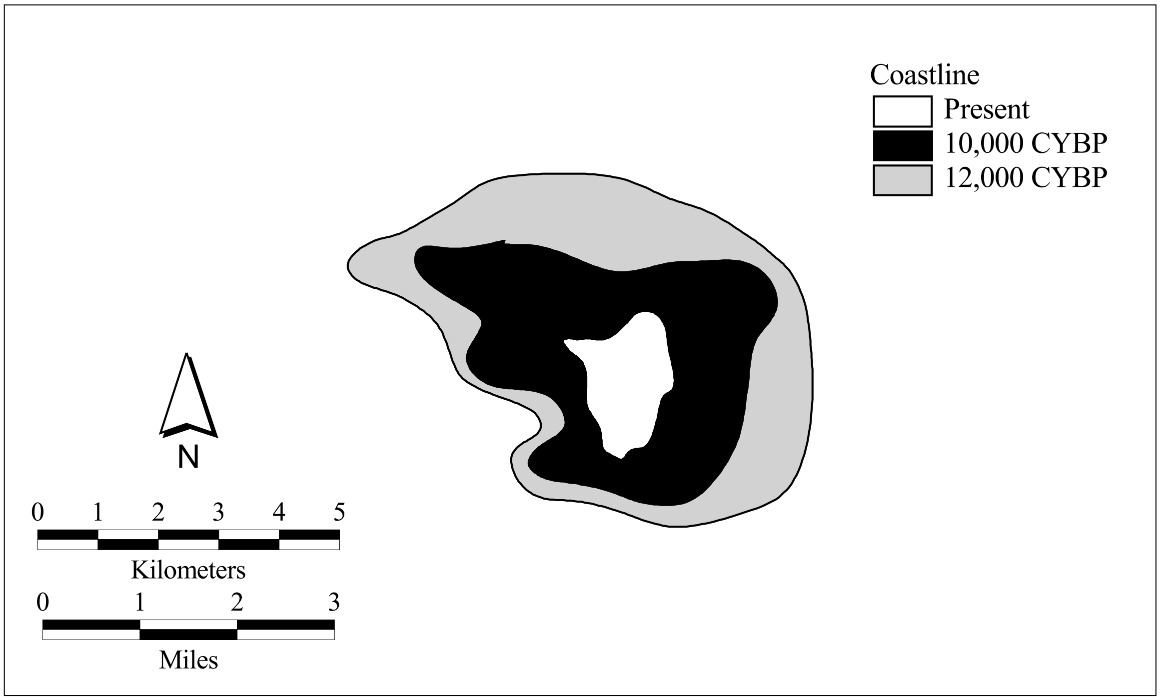

Fig. 9. Early Holocene Santa Barbara Island.

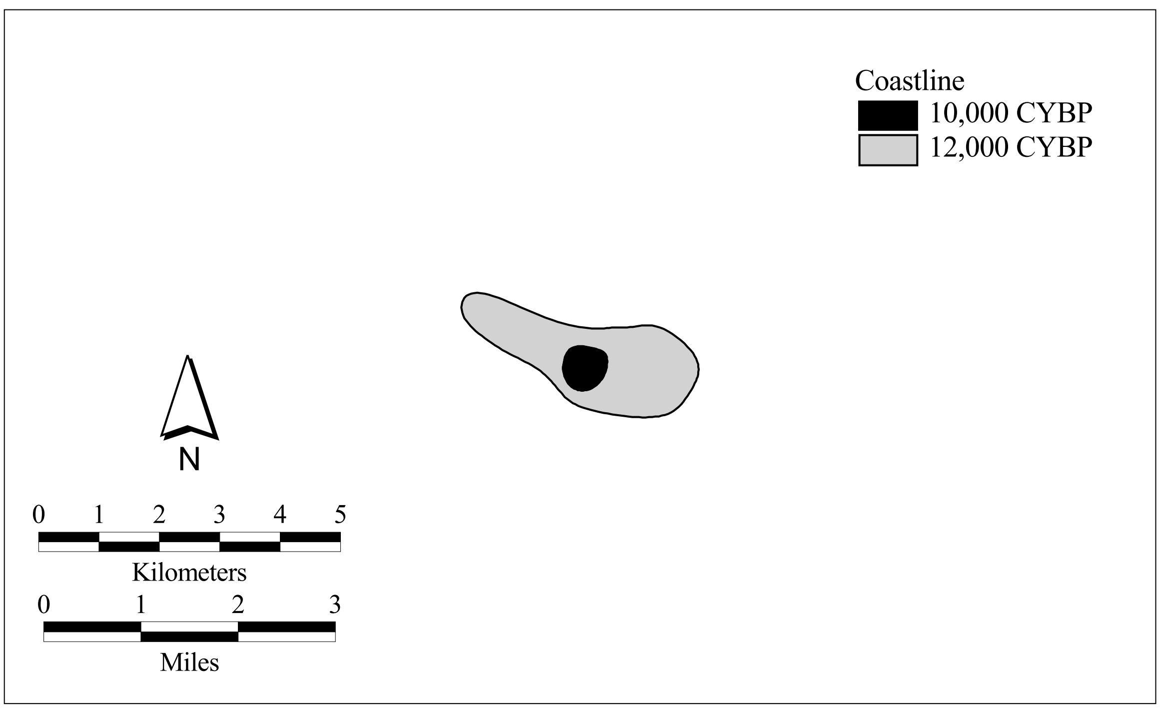

Fig. 10. Early Holocene Osborn Island.

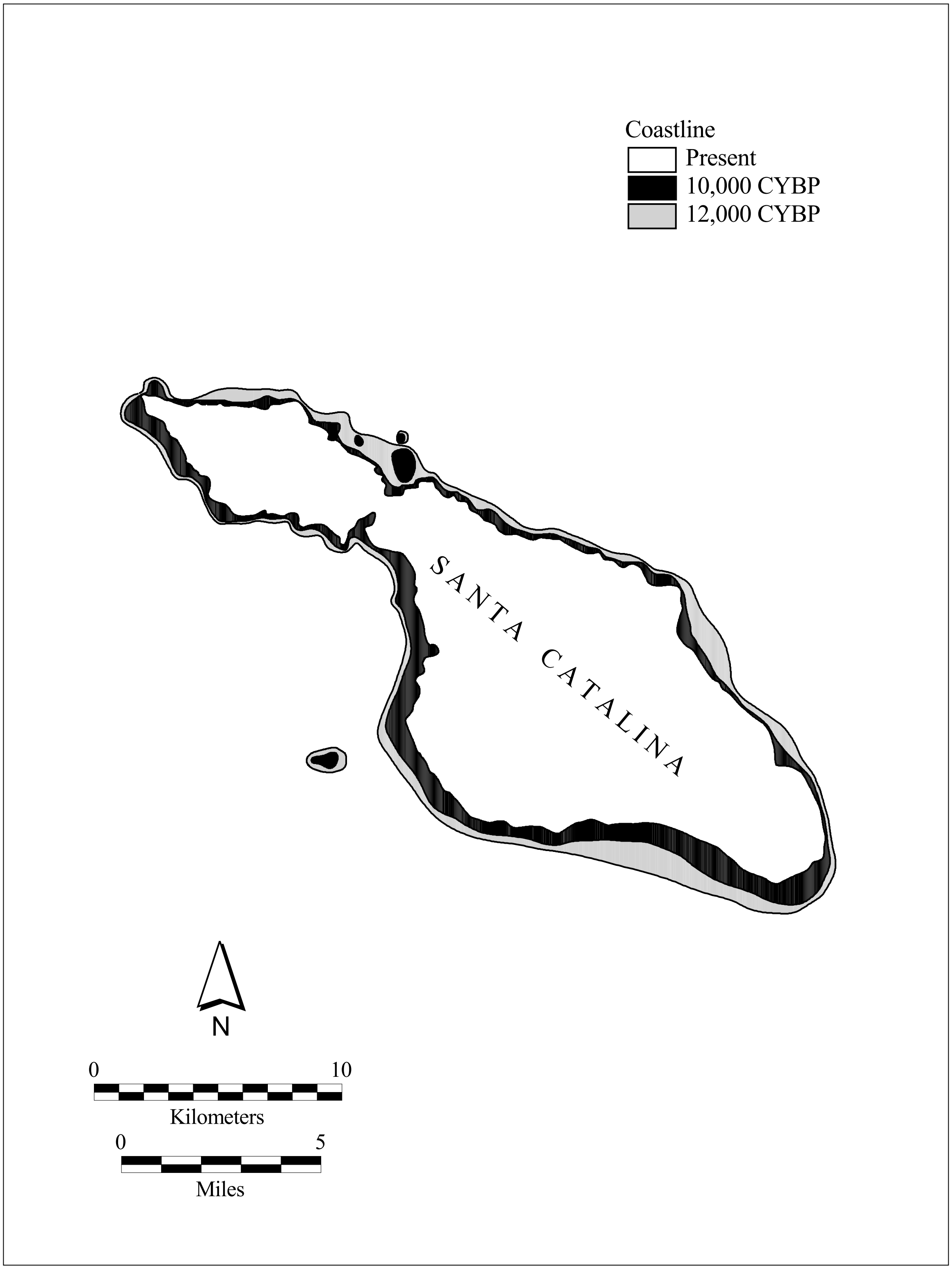

Fig. 11. Early Holocene Santa Catalina Island.

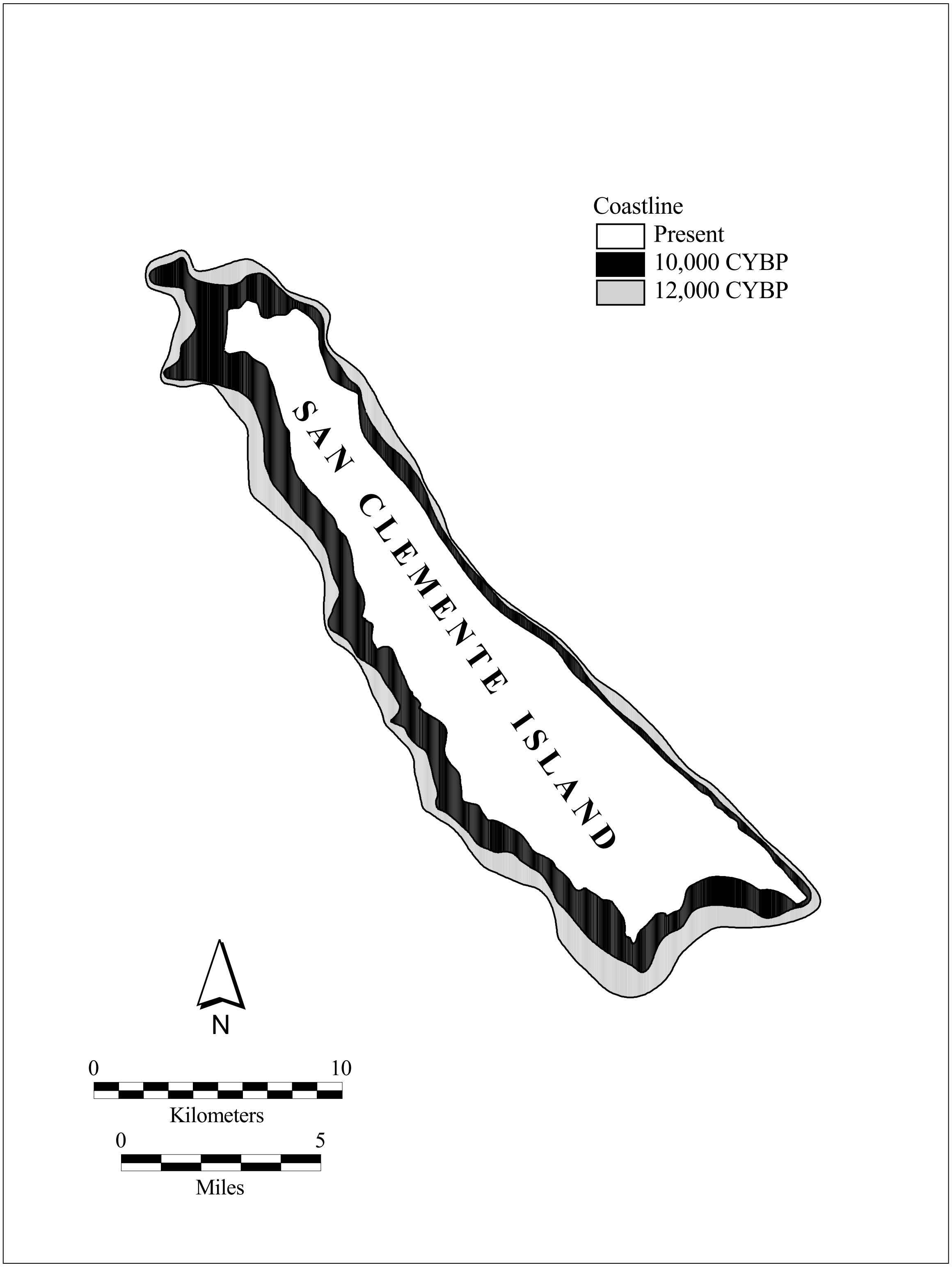

Fig. 12. Early Holocene San Clemente Island.

Although North Pilgrim Island at 10,000 CYBP was no more than a rock jutting from the ocean, it still could be used as a navigational aid. In the southern archipelago, San Nicolas Island had been reduced to only 2.5 times its present area, becoming the smallest of the three major southern Channel Islands (approximately the same size as present-day San Clemente Island). Tanner Island had been greatly reduced to 2 square kilometers, and Cortes Island had separated into two small islands totaling about 11 square kilometers. Santa Barbara Island had been reduced to 5.7 times its current size, and Osborn Island had completely disappeared. Santa Catalina Island was only 1.2 times its present size and was 28 kilometers from the mainland. San Clemente Island was 1.4 times its present size. The nine smaller islands in the chain had been reduced to five, and the maximum water distance between neighboring islands had increased to about 63 kilometers. The total island land area at 10,000 CYBP was about 1,530 square kilometers.

Changes had also occurred along the mainland coast (Fig. 1). In general, several of the large embayments which exist today were far less prominent or even nonexistent. Rivers opening into the ocean and estuaries would have provided markedly different habitation environments than later in the Holocene. In the southern portion of the Bight, San Pedro Bay (directly east of Santa Catalina Island) did not exist at 12,000 CYBP. Instead, a large point (nearly the same size as today's Point Conception) projected to within 25 kilometers of Santa Catalina Island (approximately 8 kilometers further west than the closest mainland approaches at Point Vicente and Point Fermin today). By 10,000 CYBP sea level rise had forced the mainland shoreline about 4.7 kilometers further from the island. Santa Monica Bay experienced similar changes, but to a lesser extent than San Pedro Bay.

Further north, along the Santa Barbara County coast, a broad undersea expanse from Port Hueneme to Santa Barbara was exposed opposite the northern islands. This stretch of exposed land was 50 kilometers long and 15 kilometers wide and was primarily responsible for bringing the Anacapa Islands within 9 kilometers of the mainland. Today, the Anacapa Islands at that point are 20 kilometers from the mainland. By 10,000 CYBP the mainland had receded only 1 kilometer from Santarosae while the island had receded an equal distance. It was between 10,000 CYBP and the present that most of the inundation of this region took place.

At the Eel Point site on San Clemente at 9,000 CYBP (Fig. 13) the shortest distance to the shoreline from the site was 0.55 kilometer. Eel Ridge, above water at that time, projected west from the site for 1.24 kilometers, a relatively short traveling distance from the site. The western terminus of Eel Ridge was only 0.27 kilometer from the head of Eel Ridge Canyon, the only break in the undersea shelf surrounding the island (Ridlon 1972). At 9,000 CYBP the head of this submerged canyon was only 30 meters below the surface whereas presently it is 55 meters under water.

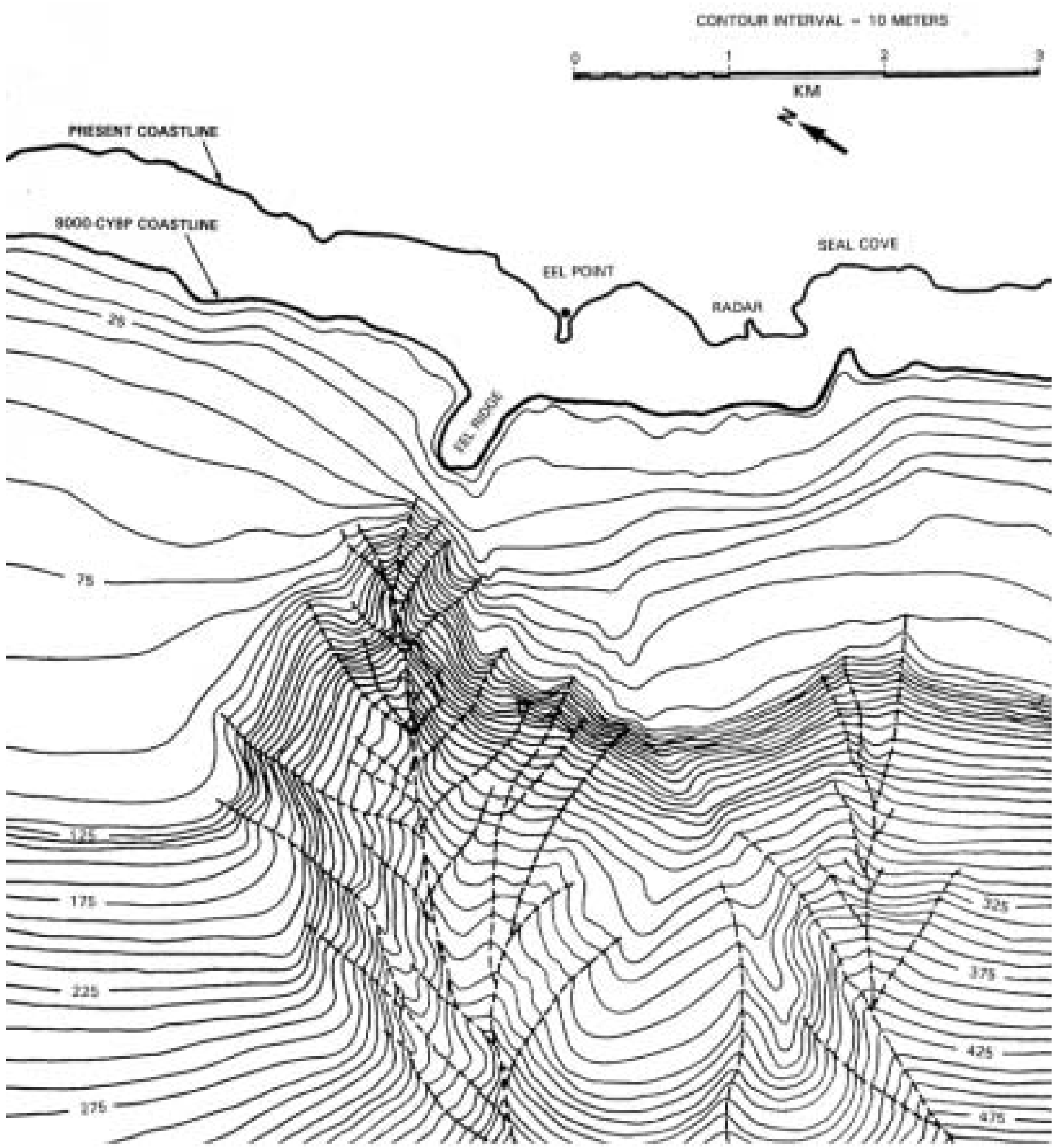

Fig. 13. Eel Point during the Early Holocene.

The proximity of Eel Ridge to this canyon would have made this rocky promontory a likely location for harvesting pelagic fauna which had travelled through the canyon toward shore. It is also worth noting that at 10,000 CYBP Eel Ridge would have stood only 200 meters from the head of Eel Ridge Canyon, and at 12,000 CYBP Eel Ridge would have been at the very brink of the undersea canyon. Habitation sites of the earliest people most likely would have been located on, or near, the now-inundated Eel Ridge.

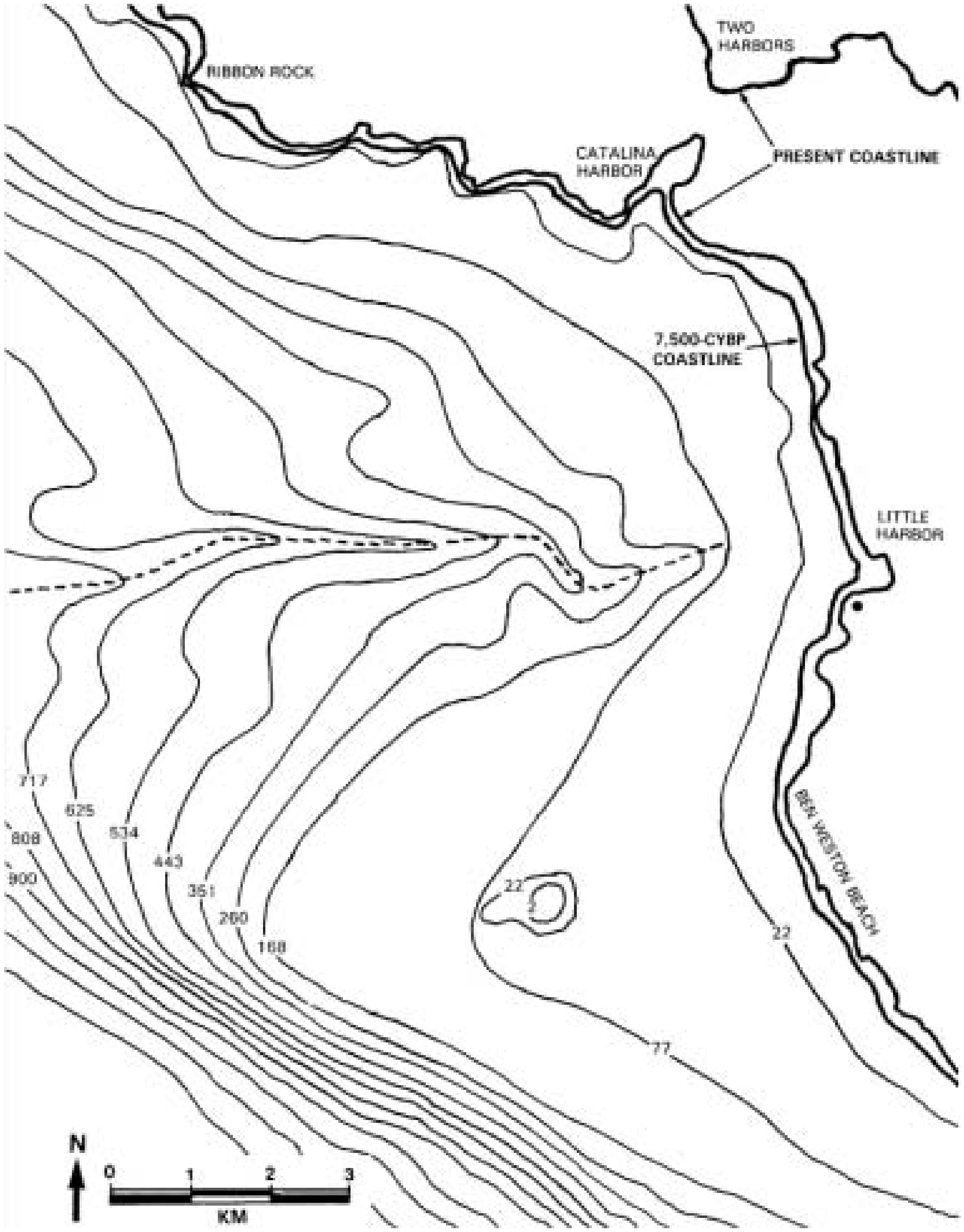

Fig. 14. Little Harbor during the Early Holocene.

Using the same 1990 Fairbanks $^{230}Th/^{234}U$ sea level curve yields a 7,500-CYBP sea level about 15 meters lower than present at the Little Harbor site on Santa Catalina (Fig. 14). This places the present archaeological site further inland (yet high on a cliff), but brings the shoreline below the cliff to within 1.1 kilometers of the brink of the undersea Catalina Canyon. This would have affected the availability of various marine resources to any early occupants of the area.

Coupled with the changed landforms described above was a prolonged sequence of relatively warm sea surface temperature (SST) in the Santa Barbara Channel region during the 12,000-7,000 CYBP period (Kennett 1998). This “sea change” also needs to be considered in interpretations of Early Holocene sites in the Bight. Although SST fluctuated throughout the Early Holocene, this period is marked by sustained periods of warmer SST than during the preceding terminal Pleistocene and the subsequent Middle Holocene (Kennett 1998).

Discussion

Inman (1983) characterizes the California coast as one that retains the general attributes of a collision coast formed by the collision of crustal plates. It has narrow shelves cut by submarine canyons, an offshore residual trench, coastal mountains, and uplifted coastal terraces. The offshore “borderland” “…differs from an ordinary continental shelf in that it encompasses large depressions as deep as 2,100 m below sea level and island peaks as high as 750 m above sea level” (Vedder and Howell 1980:9). The California Bight is, in short, geologically complex.

Inman (1983) identifies the most important factors affecting attempts at shoreline reconstruction as plate tectonics, climate, sea level, and rheological responses of the earth to changes in the distribution of masses of ice and water. The effect of climate is important basically as it translates into ice sheet melting and a corresponding rise in sea level. This effect is subsumed herein as a part of sea level change. Rheological responses to the removal of ice are not considered here because most of those effects occur near the origins of the great meltwater pulses that produce major rises in sea level (in this case, primarily the Greenland ice sheet). Also, any local rheological subsidence caused by the increased water weight of higher sea levels is ignored because it is more than offset by tectonic uplift.

Ancient sea levels are perhaps the easiest factor to deal with because sea levels are a uniform worldwide phenomenon (Bard et al.1993). They also account for the largest change in Holocene shorelines. But geological events, especially uplift and subsidence, also play a part in specific, detailed shoreline configuration. If, for example, an island is uplifted at the same time that the sea level rises, the shoreline change will be less extreme than if the island is not uplifted or even subsides.

Complicating the balancing act between uplift and sea level changes for the Channel Islands is the fact that rates of uplift differ from place to place because the region contains many independently mobile structural blocks (Vedder and Howell 1980). Consequently, specific islands and isolated segments of the continental coastline have different geological histories and rates of motion (Vedder and Howell 1980; Muhs 1980). While it is understood that the primary motion in the Bight is uplift, the rates vary from 0.15 m/1,000 years at Newport Beach (Muhs 1980) to 10 m/1,000 years along a segment of the Ventura coast (Vedder and Howell 1980). There is agreement, however, that average rates of uplift in the region range between 0.2 and 0.4 m/1,000 years (Muhs 1980, 1983; Muhs et al. 1987; Vedder and Howell 1980). For San Nicolas and San Clemente Islands Muhs (1980) uses average uplift rates of 0.21 and 0.20 m/1,000 years, respectively.

Readers are cautioned, however, that the rates of uplift are not well established in detail for the past 12,000 calendar years in this area. The geological uplift studies tend to cover relatively vast periods of time (40,000 to 700,000 years) and are not easily applied to the shorter time spans of Holocene archaeology (Muhs 1980; Vedder and Howell 1980). Thus, it is in the absence of compelling data to the contrary that we assume the 0.2-0.4 m/1,000-year uplift range to be applicable for the Holocene in the California Bight. Consequently, we ignore what would be the relatively minor effects of uplift in the general placement of Holocene shorelines (sea level rise from the early Holocene to the present is over 60 m, about 5 m/1,000 years) (see also Glassow 1999; Johnson 1983). This is not to say that uplift is never a major factor in a specific case, and researchers are urged to determine the geological characteristics of their project areas before applying our results uncritically.

Other findings might also counter the 1990 Fairbanks curve. For example, traces of the so-called 10,000-year/10-fathom terrace are found worldwide. This terrace is attributed to a brief pause in sea level rise about 10,000 years ago during the last deglaciation (Inman 1983). Since the terrace is 10 fathoms (18 m) below the present sea level it implies that 10,000 years ago the sea level was 18 m lower than now, not 34 m lower as shown in the Fairbanks curve. But, as Inman (1983) points out, the sea dropped to this level during interglacial times as well, and the terrace may not be related at all to the last deglaciation.

Another potential problem with the Fairbanks sea level curve arises from reports of the depths from which artifacts are retrieved in some marine archaeological sites. Masters and Fleming (1983) list worldwide field studies in which the recovery depths of artifacts range from 0 to 10 meters below present sea level, but for which the dates range from 2,000 to 9,000 CYBP. For the ages to accurately reflect ancient sea levels, one would have to assume, for example, that in Israel 8,000 years ago the sea level was the same as it is today. Since this is impossible, we assume the site has been tectonically uplifted to its present depth over the past 8,000 years. A reason for the shallow depths of much marine archaeology may simply be that present technology does not permit discovery of marine sites except those that have been uplifted and are within easy reach. Masters and Fleming acknowledge this difficulty, noting that "The blunt fact is that diving teams equipped with simple equipment and small budgets are at present revealing a steady flow of information about submarine prehistoric archaeology…" (Masters and Fleming 1983:608). These problems are summed up by Berger (1983:54), who states (citing Clark, Farrel, and Peltier 1978) that such discrepancies arise from "…differing tectonic activities in various regions of the world…and the selection of samples."

Conclusions

This paper provides an approximate coastline reconstruction of the California Bight and California Channel Islands at 12,000 and 10,000 CYBP. The existing geological data for this region indicate that, in general, geological forces such as uplift and subsidence are not of the same order of magnitude as worldwide sea level rise in determining ancient coastline placement. Our maps offer local archaeologists a general picture of ancient coastline positioning useful in interpretation of their data.

The sea level curve developed by Fairbanks in 1990, based on corrections of ^{14}C dates by the ^{230}Th/^{234}U dating method, is probably the best source for plotting sea level against time. Readers are cautioned, however, to closely examine local geological anomalies in their area of interest before applying our results uncritically.

Acknowledgements

The authors wish to thank ASM Affiliates, Inc., for granting permission for us to prepare the maps presented in this paper using their GIS software and computer hardware. We thank the anonymous reviewers of our manuscript who helped bring it to completion.

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