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Late Holocene Paleoclimatic Stress and Prehistoric Human Occupation on San Clemente Island

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Late Holocene Paleoclimatic Stress and Prehistoric Human Occupation on San Clemente Island

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Anthropology

by

Andrew Yatsko III

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The dissertation of Andrew Yatsko III is approved.

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2000

DEDICATION

This dissertation is dedicated to the memory of

Roy A. Salls

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT OF THE DISSERTATION

Late Holocene Paleoclimatic Stress

and Prehistoric Human Occupation

on San Clemente Island

by

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Adverse paleoenvironmental conditions during the late Holocene appear to have notably influenced prehistoric cultural evolution in the Southern California Bight region. Radiocarbon dates from an island-wide, probabilistic sampling survey of archaeological

sites on San Clemente Island displayed a substantial reduction in their frequencies that correlates with a period of persistent drought during the late Medieval Climatic Anomaly between about AD 1050 and 1250. Persistent droughts would have had significant impacts on subsistence resources in a marginal environment like San Clemente Island's, especially through reduced accessibility to water. Prehistoric populations would have responded to such adverse paleoenvironmental conditions by either contracting residence around a reduced number of available water sources or by abandoning the island. The possibility that the reduced frequency of radiocarbon dates is an indicator of a prehistoric cultural response to these extreme environmental conditions was then tested using an expanded site survey sample to obtain a supplemental suite of radiocarbon dates for comparison.

The new survey sample investigated temporal and spatial site relationships in areas of varying prehistoric water availability on the island during the Medieval Climatic Anomaly. Analyses of these data show changes in prehistoric settlement patterning for the island that clearly indicate dramatic changes in paleodemography across the entire Medieval Climatic Anomaly (A.D. 650 to 1250). These changes include a dramatic decline in the number of sites dated during the Medieval Climatic Anomaly. There was a depopulation of the island's upland terrains, and some sites were occupied on lower elevation terrains associated with potentially more reliable water sources. It is not confirmed that this assumed decline in population ever reached the point of island abandonment.

Strong parallels are demonstrated between this San Clemente Island chronology and other archaeological sequences from areas of western North America where regional abandonments and major population movements also correlate with the Medieval Climatic Anomaly. While these cultural responses vary among regions, all are best explained as responses to environmental deterioration and related demographic stress rather than processes of progressive social evolution or economic intensification.

Chapter 1

Introduction

In recent years, much archaeological research in the California Channel Islands and on the southern California coastal mainland has addressed questions regarding the influence of paleoenvironmental forces on regional prehistoric populations during the late Holocene. Archaeologists working in the region postulate that at least two paleoenvironmental influences -- changes in sea-surface temperature and persistent drought conditions -- separately or together exerted significant influences on prehistoric cultural evolution in maritime southern California. This dissertation addresses the probable role that adverse paleoclimatic conditions played in influencing the size and distribution of prehistoric human populations on San Clemente Island.

Researchers in the northern Channel Islands suggest that fluctuations in sea-surface temperature (SST) during the Holocene influenced productivity in marine ecosystems and consequently the size and distribution of dependent, marine-adapted populations (Arnold 1992; Arnold and Tissot 1993; Colten 1992; Glassow 1996; Glassow et al. 1988; Walker and Snethkamp 1984). Periods during which winter SST temperatures exceeded 20° C over many years are thought to have been hostile to the existence of kelp forests, causing food shortages for coastal populations. Colten (1992) and Arnold (1992, 1995) have argued that elevated SST at about A.D. 1150-1300 was particularly devastating to maritime subsistence. This is proposed as one of several factors responsible for disruption of northern island maritime economies, abandonment of sites, deterioration of health conditions, and increased violence. It is also thought to have acted as one of several causal factors in the subsequent emergence of a chiefdom-level social organization on Santa Cruz Island (Arnold 1992:75-76).

Researchers on San Clemente Island and Santa Catalina Island in the southern Channel Islands present an alternative perspective (Bradford 1994; Porcasi 1992; Raab et al. 1995a; Salls 1988, 1990, 1992). Citing a broad range of paleoclimatic data (e.g., Davis 1992; Enzel et al. 1989; Graumlich 1993; Larson and Michaelsen 1989; Mehringer 1986; Stine 1994), Raab and Larson (1997) argue that among the paleoenvironmental forces discussed by Arnold (1992), cycles of severe drought may have played a larger role than sea temperature. They further suggest that the southern Channel Islands' comparatively small, isolated precipitation catchments would have been extremely sensitive to these adverse paleoclimatic trends.

Fundamentally, the goal of both these lines of research has been to understand how the interaction of particular paleoenvironmental stresses and archaeologically detectable cultural responses, including subsistence intensification, adoption of new technologies and settlement patterns, development of regional exchange networks and long-term alterations to human health, affected cultural change. However, the precise nature and cultural impact of these forces, individually or in combination, remains a matter of debate (see Arnold et al. 1997; Raab and Larson 1997).

This debate cannot be resolved here. At the present time, comparative arguments regarding relative influences of prehistorically fluctuating SSTs are problematic for San

Clemente Island and for the southern Channel Islands in general. This grows out of substantial geographic differences between the northern and southern Channel Islands that may not be immediately apparent considering the relative proximity of these island sub-groups. A number of important issues pertain here.

First, the primary data used to characterize prehistoric SST values derive from localized conditions peculiar to the Santa Barbara Channel, which separates the northern Channel Islands from the Santa Barbara mainland, and particularly the Santa Barbara Basin that underlies the channel (Arnold et al. 1997:305). The tightly clustered northern Channel Islands lie in close proximity to a cold-water upwelling zone between Santa Barbara and Point Conception (Engle 1994). They are affected by a complex mixing of cold and warm countercurrents, dominated by the cool California Current that flows from the northern Pacific along the California coast. The Santa Barbara Basin is the source of varved sediment samples that have been analyzed by oceanographers and biologists to reconstruct a number of major shifts in marine conditions in the basin during the past (e.g., Kennett and Ingram 1995a, 1995b; Pisias 1978, 1979; Soutar and Isaacs 1969). Importantly, these researchers carefully note that their results should not be used to represent SST conditions beyond the basin.

Second, Arnold et al. (1997:305) point out that the more dispersed southern Channel Islands are far removed from oceanic conditions influencing the Santa Barbara Basin and lie within warmer waters closer to subtropical zones. Because of this, prehistoric human populations there were less likely to experience abrupt or severe subsistence impacts during warm-water events. They further argue that the biological effects of warm water events would be expected to be substantially different, given the many large and small scale physiographic and ecological distinctions between and within these two island groups (see Engle 1994). By contrast, paleoclimatic data from reconstructed prehistoric precipitation rates cited by Raab and Larson (1997) represent a relatively consistent regional and extra-regional perspective with clear application over the entire Southern California Bight.

Third, there are no relevant marine paleotemperature data from the southern Channel Islands. No quantitative prehistoric SST analyses comparable to those conducted for the Santa Barbara Basin (e.g., Kennett and Ingram 1995a, 1995b; Pisias 1978, 1979) exist for the region of the Southern California Bight in and around the southern islands. Critiques by Raab et al. (1995a) and Raab and Larson (1997) suggest that evidence from the southern islands fail to show depressed subsistence conditions coincident with the warm SSTs cited for the Transitional period in the Santa Barbara Channel region. However, these inferences are developed in the absence of an objective understanding of actual prehistoric SST conditions around the southern islands. Instead, this alternative perspective derives in large part from interpretation of mid-Holocene (ca. 5,200 B.P.) warm water fauna in the Little Harbor Site on Santa Catalina. These faunal data are coincidental with elevated SSTs identified during that period for the Santa Barbara Channel (Pisias 1978), but not with SST data actually contemporary with the Transitional period discussed by Arnold (Raab et al. 1995a).

For all these reasons, I do not address the possible influences of past elevated SSTs on San Clemente Island's paleodemography in the scope of this research. I have chosen instead to focus only on the probable role of atmospheric paleoclimatic stress, particularly severe and persistent drought. New chronological data from San Clemente Island define a significant decline in the frequency of dated sites between 1300 and 600 B.P., with dates apparently absent for the periods between 900 and 700 B.P. and between 1200 and 1000 B.P. (Yatsko and Raab 1997). These temporal patterns are revealed in the frequency of radiocarbon (^{14}C) dates and correlate with periods of paleoenvironmental stress related to cycles of persistent drought (Larson and Michaelson 1989).

The interval during which these depressed frequencies occur (A.D. 650 to 1250) is one of widespread and prolonged decreased precipitation and frequent drought known to climatologists as the Medieval Warm Period, the Secondary Climatic Optimum, the Little Optimum (Ingram et al. 1981; Sulman 1992), or the Medieval Climatic Anomaly (Stine 1994). Chronologies for these differently expressed periods of atmospheric paleoclimatic stress are regionally variable (Jones et al. 1999). Stine (1994:549) describes the Medieval Climatic Anomaly on the basis of evidence from the western Great Basin of "epic" droughts between ca. A.D. 892-1112 and 1209-1350, with an intervening very wet period. Larson and Michaelsen (1989:22-23) document comparable periods of very low rainfall and drought for coastal southern California between approximately A.D. 650 and 1250 with sustained droughts between A.D. 750 and 770, A.D. 980 and 1030, and A.D. 1100 and 1250. Like Stine's sequence, Larson and Michaelsen's is also punctuated by a period of high rainfall between A.D. 800 and 980. In both cases, the latter periods of drought coincide with the Middle-Late Transition described by Arnold (1992). In the current research I employ the term Medieval Climatic Anomaly, as applied by Larson and Michaelson (1989) to the period A.D. 650 to 1250.

This time of heightened aridity coincides with patterns of demographic stress and economic crises across much of western North America (Jones et al. 1999) and is increasingly recognized for its droughts and warming temperatures in other parts of the world (Hughes and Diaz 1994; Lamb 1977, 1982). Populations across western North America confronted significant declines in resource productivity caused by repeated and prolonged droughts. These are apparent as extensive, sometimes extreme, patterns of change in the archaeological record, including reduced or relocated populations, hiatuses of occupation, and abandonment of sites and regions (Jones et al. 1999).

These patterns would be consistent with those predicted by biogeographical models for the distribution of human populations on islands, particularly small or marginal ones (Keegan and Diamond 1987). The theory of island biogeography deals with critical variables in the physical, or "geometrical," properties of islands that specifically influence the probability and success of their colonization by species (MacArthur and Wilson 1967). Generally, these have to do with distance from the mainland or other islands, geometric configuration of an island or island group, and the areas of individual islands. The focus of human island biogeography is how these properties influence the colonization of islands by humans (Keegan and Diamond 1987). Island area is among the more critical variables in the study of human island biogeography, especially as this influences the presence or abundance of critical subsistence resources. Humans are more likely to occupy and remain on a large island than a small one because larger islands have inherently greater variety and quantity of resources necessary for survival. Small islands can support smaller populations in a steady state but with higher levels of susceptibility to catastrophic events (e.g., extended droughts), an impoverished resource base, or population growth.

For continental fringe islands like the California Channel Islands, different characteristics of their sizes, geologies, and microclimates produce biogeographical variables that are expected to have influenced temporal and spatial patterns of prehistoric human occupation. Glassow (1993) sees biogeographical factors expressed in the marked differences in the diversity and abundance of subsistence plant species on Santa Cruz Island, Santa Rosa Island, and San Miguel Island, which influenced prehistoric human population densities. Nevertheless, Glassow (1993) also believes that island biogeographical theory has comparatively little to offer archaeologists working on islands that are readily accessible from a mainland area, like the northern Channel Islands.

However, because San Clemente Island represents an extreme case of the high-risk prehistoric littoral environment postulated by Larson (1987) for the Southern

California Bight, I believe it presents a context where certain models for human biogeography apply. The "epic droughts" (Stine 1994) punctuating the Medieval Climatic Anomaly would have had direct effects on San Clemente Island's marginal terrestrial ecosystems by impacting available water sources and also reducing primary production of terrestrial resources. Given these biological realities, prolonged drought would certainly have reduced the availability of water to the degree that the island's human population experienced significant subsistence stress. During these periods of stress, the island's prehistoric occupants would have responded within a set of "risk minimization" subsistence strategies that range from retreating to more productive or less stressed areas of the island's environment to abandoning the island.

Theoretical underpinnings for models concerning paleoenvironmental influences on human populations are derived from population ecology. In the present research, I seek to understand how the interaction between particular paleoenvironmental stresses and cultural adaptations affected cultural change. On San Clemente Island, I expect these paleoenvironmental forces to have stimulated archaeologically detectable cultural responses. These could include intensification of subsistence strategies, adoption of new technologies, and/or changed settlement patterns. Some of the best indicators of culture change are found in archaeological settlement patterning. How ancient cultures deployed themselves on the landscape in functionally differentiated modes of settlement may be highly informative (Binford 1980; Kelly 1995). As hunter-gatherer cultures organize themselves to exploit vital resources, patterns of settlement are likely to reflect related patterns of social organization, economics, and technology.

Based on environmental variables peculiar to San Clemente Island, I propose two alternative hypotheses for the prehistoric island population's response to periods of severe drought during the Medieval Climatic Anomaly. First, the pattern of settlement on the island during the Medieval Climatic Anomaly may have involved a reduced number of residential localities increasingly concentrated around a small number of water sources. Alternatively, prehistoric populations on San Clemente Island may have migrated off island during the Medieval Climatic Anomaly in response to worsening drought conditions.

To address these hypotheses, I built on the results of a 1991-92 island-wide probabilistic site survey (the Probabilistic Survey) by means of a supplemental, island-wide sampling survey. The two surveys are designed to complement one another and to avoid or minimize concerns of bias in the selection and use of radiocarbon dates as a measure of population change (Glassow 1998). They present alternative approaches to sampling among the topographic, ecological, and hydrological variables found on San Clemente Island. Used together, these can portray the prehistoric island population's responses to climatic stresses experienced during the Medieval Climatic Anomaly. These two surveys' cumulative chronological record provides empirical evidence for a punctuated decline in San Clemente Island's prehistoric population during the Medieval Climatic Anomaly. A settlement shift to areas with more predictable fresh water sources occurred when certain upland areas of the island were abandoned.

This view of late Holocene paleodemography for an island at the margin of the Southern California Bight has wider implications for the study of prehistoric human population dynamics in other Channel Islands settings and across the region as a whole. San Clemente Island's well-preserved archaeological record potentially offers a finer resolution of the influence of paleoenvironmental stress on prehistoric regional cultures than may be currently available in some other Channel Islands. This is certainly the case when compared to the more disturbed coastal mainland context. Characteristics of San Clemente Island's environment and its archaeological sequences are presented in the following three chapters.

Chapter 2

Research Context

Glassow (1980), Meighan (1989), and others have written that the California Channel Islands provide archaeology with some of the world's best laboratories for investigating the development of human adaptive systems. As islands, they provide discrete geographic units on which a diversity of resources available to human populations may be accurately measured. Individually, the Channel Islands vary significantly in a number of environmental characteristics that affect human adaptations, permitting the testing of empirical hypotheses where verification requires such variability. No less important, the islands' ecosystems are simpler than those of the mainland and potentially easier to understand. As the basis for such investigations, the Channel Islands contain numerous, relatively intact archaeological sites representing the exploitation of marine resources over a period dating back at least 9,000 to 10,000 years.

The Channel Islands' isolation has promoted an especially high degree of preservation in the archaeological record. This is in stark contrast with the mainland coast, where development and vandalism have destroyed a large portion of the sites representing maritime cultural development. Preservation on some of the Channel Islands is also enhanced by the absence of burrowing animals, providing greater stratigraphic integrity than is normally found in mainland sites. While urban sprawl has rapidly overwhelmed the nearby southern California coast, land use in the Channel Islands is increasingly being directed away from development.

There are eight California Channel Islands, divided into northern and southern groups. Clustered immediately off the Santa Barbara and Ventura mainland, the northern Channel Islands include San Miguel Island, Santa Rosa Island, Santa Cruz Island, and Anacapa Island. South of these and southwest of the Los Angeles mainland, the more dispersed southern Channel Islands are Santa Catalina Island, Santa Barbara Island, San Nicolas Island, and San Clemente Island. Santa Catalina Island and the western portion of Santa Cruz Island are privately owned. All the others are federal lands. San Miguel, Santa Rosa, Anacapa, and Santa Barbara islands and the eastern end of Santa Cruz Island make up Channel Islands National Park. The U. S. Navy owns the remaining two, San Nicolas and San Clemente Islands.

Geography and Geology

The southernmost California Channel Island, San Clemente Island, is located 72 km from the Palos Verdes Peninsula, the nearest point on the southern California mainland, and 32 km from the nearest Channel Island, Santa Catalina Island (Figure 2.1). The island is 34 km in length along a northwest-southeast trending axis, varying in width from 2.5 km to 6.5 km and encompassing 148 km^2.

San Clemente Island has a diverse topography as the result of tectonic and climatic dynamics during and preceding the Quaternary Period. The geology into which the island's topography is carved is composed mainly of Miocene andesite (15.5 Ma), with lesser amounts of dacite, rhyolite, and marine sedimentary rock (Merrifield et al. 1971; Olmsted 1958) (Figure 2.2). Quaternary sediments, including dune sands, eolianite, alluvial fans, and marine terrace deposits, overlie this Miocene bedrock over much of the island (Crittenden and Muhs 1986:293).

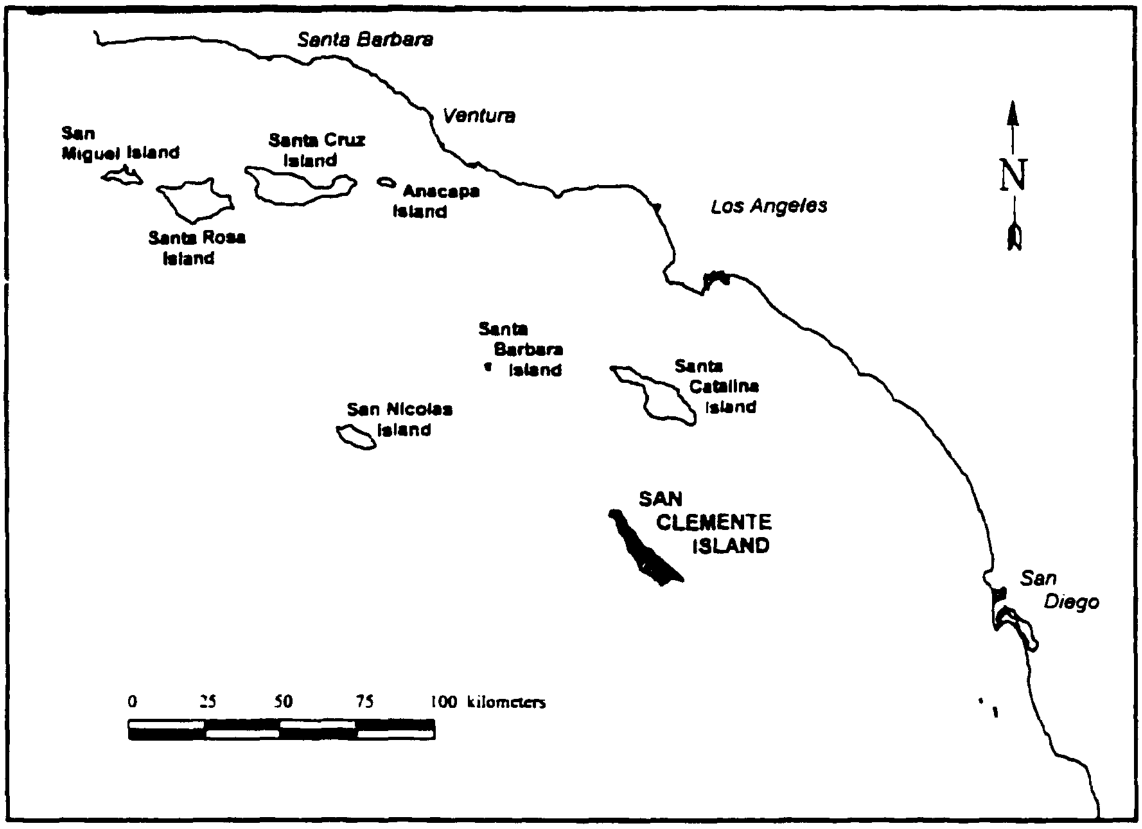

Figure 2.1. California Channel Islands and the Southern California Bight

Geologically, San Clemente Island is an uplifted structural block along the submerged San Clemente Fault (Lawson 1893; Muhs 1980:8; Smith 1898). Exposure of the island block above sea level occurred in the early Pleistocene (Ridlon 1969). Uplift since that time appears to have continued at a rate of between 20 cm and 40 cm per thousand years (Muhs 1980). The island's maximum elevation (Mt. Thirst) is presently 599 m above sea level.

San Clemente Island's tectonic activity has been fundamental to the evolution of its landscape. Sea cliffs and shore platforms along the island's west coast were eroded and marine deposits laid down during eustatic sea level fluctuations across the Pleistocene (Muhs 1980; Whitney 1865). These features have since been elevated by tectonism. During emergent intervals, marine sediments on offshore shelves were transported by prevailing onshore winds onto adjacent uplands as dune deposits. These dune fields have modified and masked some wave-cut terrains.

Bathymetric studies show no evidence that fluctuating sea level through the late Pleistocene ever created a dry land link between any Channel Island and the mainland (Vedder and Howell 1980). The northern Channel Islands are grouped significantly closer to the mainland than any individual island in the southern group except Santa Catalina Island. However, even at the time of significant sea-level lowering during the last glacial maximum (17,000 - 18,000 B.P.), San Clemente Island was not significantly closer to any other land mass than it is now (Vedder and Howell 1980). These differences in configuration and proximity among the Channel Islands have created significant contrasts in their ecologies. Larger inshore islands such as Santa Cruz and Santa Catalina have biological systems more similar to the mainland than outlying islands like San Nicolas or San Clemente. San Clemente Island has a native ecology more like that of Guadelupe Island, another continental fringe island off Baja California.

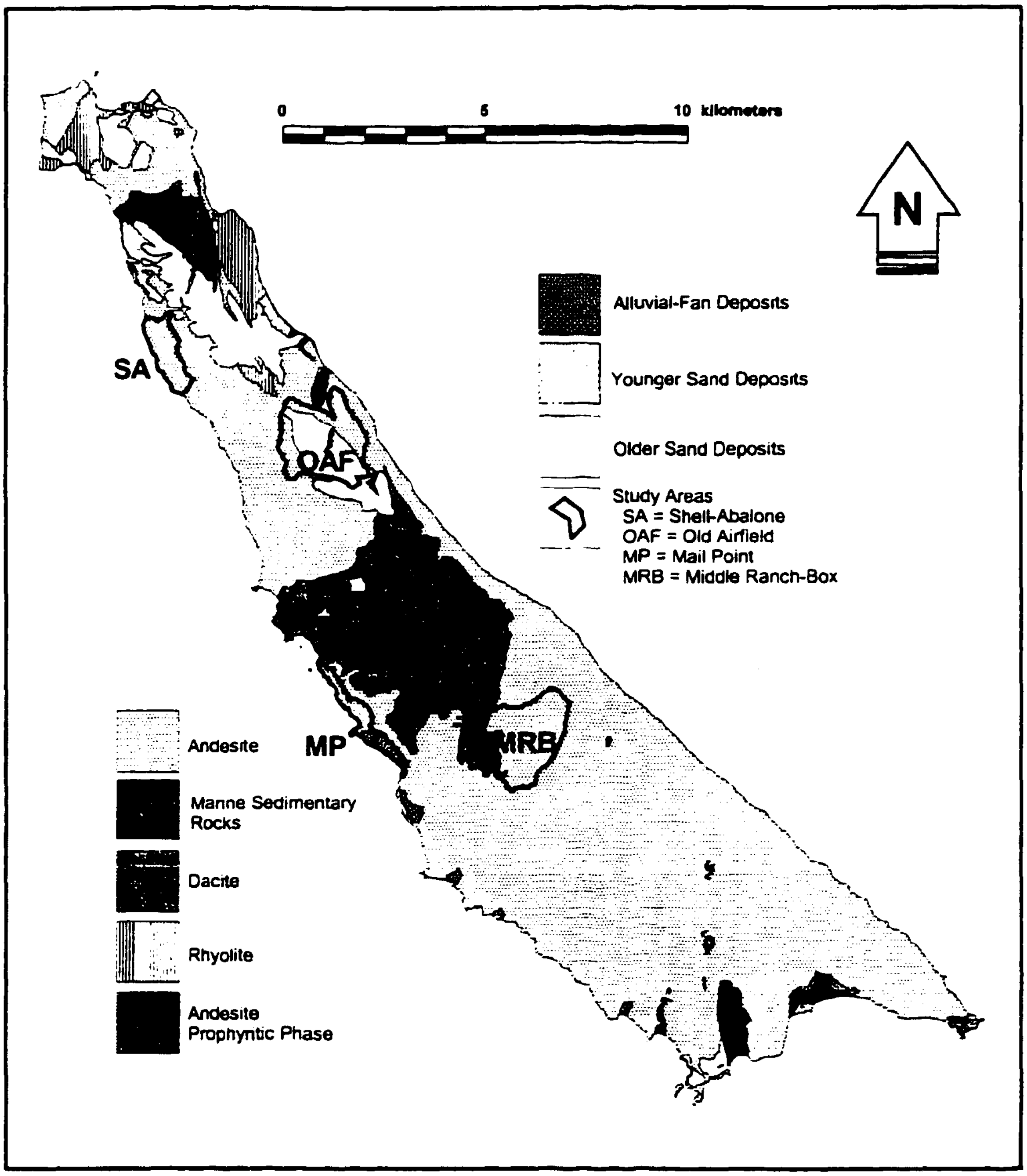

Figure 2.2. San Clemente Island geology and dissertation study areas

Island Terrains

For purposes of stratifying the distribution of archaeological site loci, I have divided San Clemente Island's topography into six "terrains:" Coastal Terrace, Upland Marine Terraces, Plateau, Eastern Escarpment, Major Canyons, and Sand Dunes (Yatsko 1989, 1992) (Figure 2.3). This topographic stratification draws from Muhs' (1980) segregation of the island's emergent marine terrace elements for a soils study and mirrors Reinman's (1985; Reinman and Lauter 1984) differentiation of topographically-defined sampling strata on San Nicolas Island in his analysis of archaeological survey data.

The first three differentiated terrains - *Coastal Terrace*, *Upland Marine Terraces*, and *Plateau* - are composed largely of emergent marine terraces. Structurally, these terraces consist of three geomorphic elements - wave-cut platforms, sea cliffs, and post-emergent colluvial wedges covering the rears of the platforms at the bases of sea cliffs. I segregate these principal terraced terrains on the basis their relative age (where higher is older) and degree of erosion or deposition. This differentiation also considers their proximity to the littoral ecotone, as this is seen to influence access to coastal subsistence resources. These three terrains are discussed vertically and chronologically, from the younger Coastal Terrace, up through the Upland Marine Terraces, to the older, more evolved Plateau terrain.

Coastal Terrace

The Coastal Terrace consists of the first two marine terraces above sea level, the one currently being abraded (the 1st) and the lowest and youngest emergent terrace

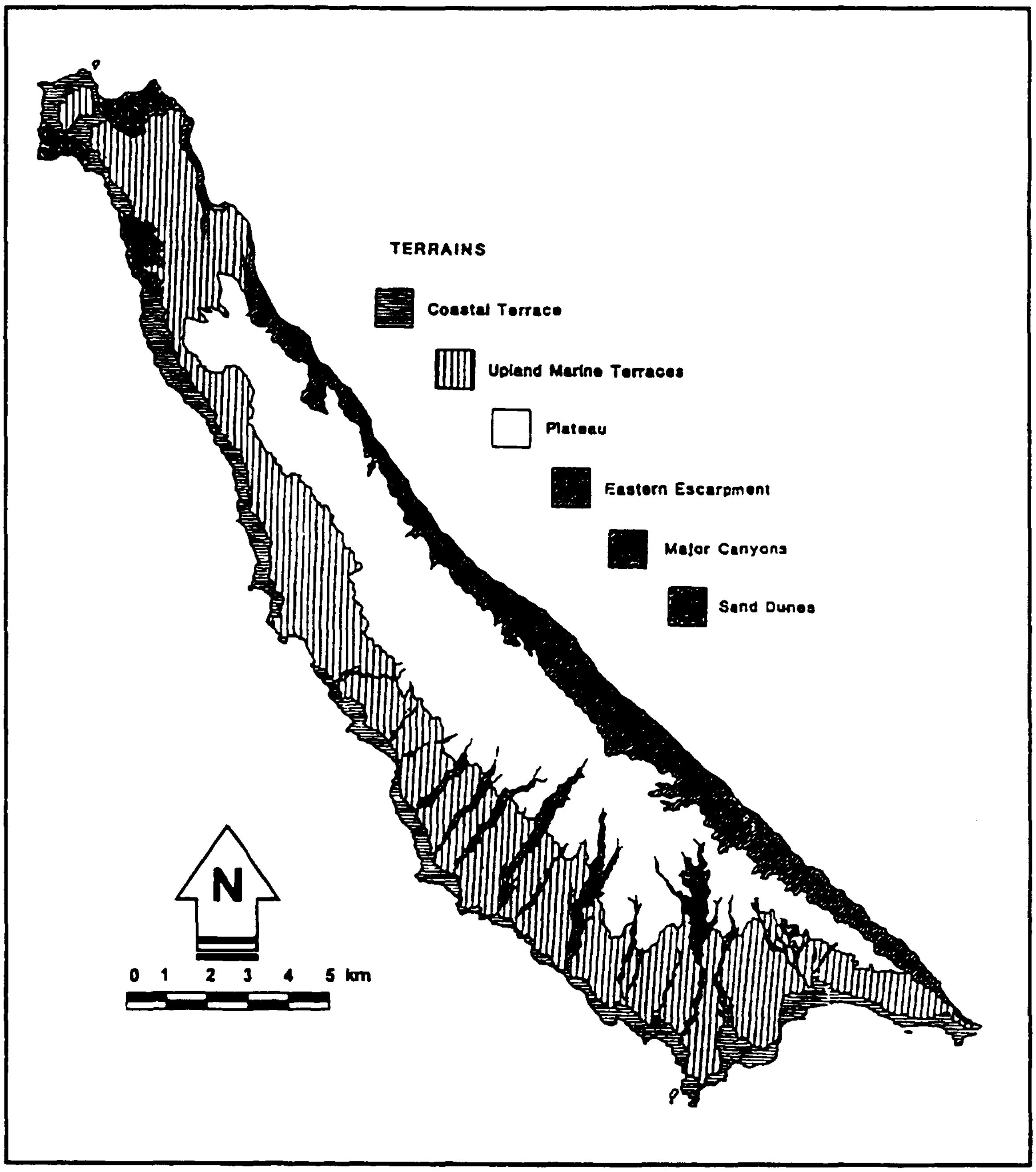

Figure 2.3 San Clemente Island terrains

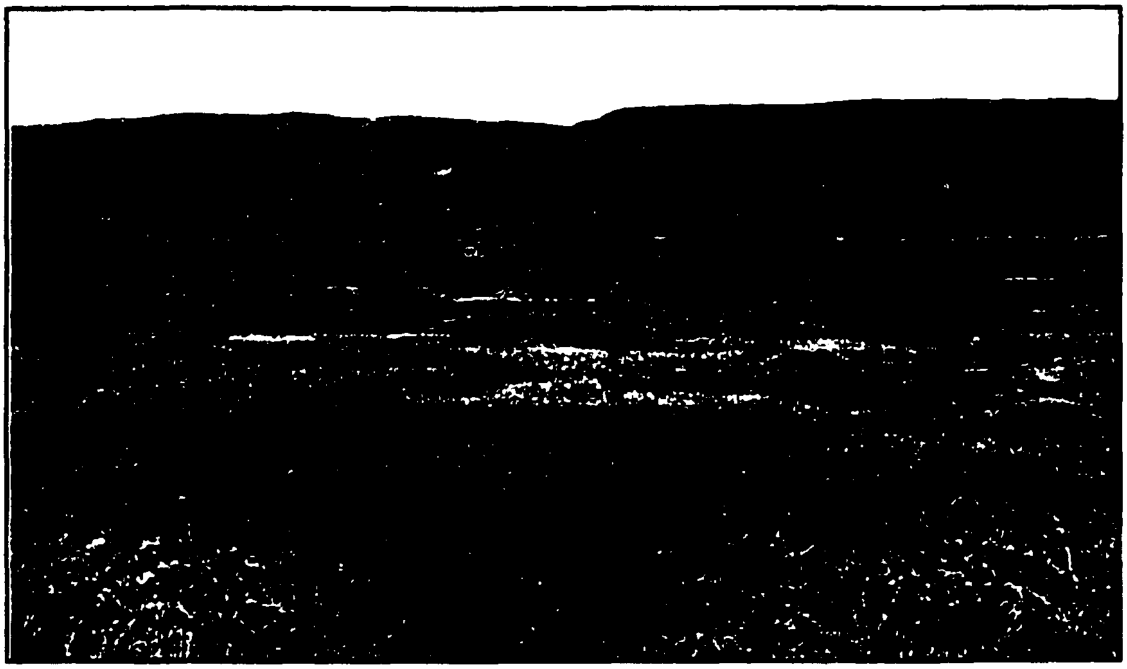

Figure 2.4 Coastal Terrace in the SA Study Area

(the 2nd). Cut during the last interglacial about 125 ka (Muhs 1980), the second terrace is a gently sloping (<10%), narrow coastal plain (Figure 2.4). Rising in elevation from sea level to about 30 m at the base of the Upland Marine Terraces terrain, the Coastal Terrace terrain is featureless except for scattered bedrock seastacks. It averages 300 m to 400 m in width, but some stretches narrow to only 50 or 75 m. Thin soils cover most of the terrace except where colluvial wedges have built up at the base of cliffs and certain of the Major Canyons have deposited substantial alluvial fans. The Coastal Terrace is continuous along the northern, western, and southern coastlines, except where interrupted by the Sand Dunes in the northwest or where sea cliffs rise directly from the shoreline into the Upland Marine Terraces. Overall, this terrain covers approximately 13 km^2, or about 8.5% of the island's land area.

Figure 2.5 Upland Marine Terraces along the central western slope of San Clemente Island, viewed south from edge of the Plateau toward Eel Point

Upland Marine Terraces

The Upland Marine Terraces incorporate a well-expressed vertical sequence of emergent marine terraces that ascend the island from the rear of the Coastal Terrace platform to the top of the fossil sea cliff defining the margin of the Plateau terrain (Figure 2.5). These terraces date from around 215 ka to 1.5 Ma, or older (Muhs 1980). In elevation, this terrain extends above the 30 m contour to 450 m elevation at mid-island. Soil conditions are similar to those on the Coastal Terrace. Found mostly along the western or southern exposures of the island, the Upland Marine Terraces are laterally continuous in their northwest extent. South of mid-island, however, this lateral continuity is increasingly dissected by the Major Canyons. This is the largest San

Clemente Island terrain, with a total area of just over 56 km^2, or 37% of the island's surface.

Figure 2.6 Looking north-northwest across the northern Plateau.

Plateau

The Plateau is open, rolling, peripherally-dissected upland terrain (Figure 2.6) composed of emergent marine terrace features that have been altered or masked to such a degree by erosional and depositional processes that they are often difficult to discern. Erosion has significantly degraded the Plateau's sea cliffs, while over much of its northern extent stabilized dune deposits also have buried both sea cliffs and platform surfaces. This composite terrain is continuous along the central spine of the island, with only occasional interruptions by steeply sloped topography. It rises from about 120 m in the north to 599 m mid-island and grades gradually downslope to 275 m at the southern margin above Pyramid Cove. The Plateau's margins are defined by the upper limits of the Upland Marine Terrace terrain and the comparable upper edge of the Eastern Escarpment. This lateral boundary is increasingly irregular toward the south due to dissection by the Major Canyons. The Plateau is the second largest island terrain area, covering 51.7 km^2, or 34% of the island.

The remaining three terrains – *Eastern Escarpment*, *Major Canyons*, and *Sand Dunes* – are byproducts of other erosional, depositional and tectonic processes that are still shaping San Clemente Island's landscape.

Eastern Escarpment

The precipitous, dissected Eastern Escarpment is the fault scarp of the San Clemente Fault. With slopes often in excess of 45°, this terrain is continuous along the entire eastern side of the island. Oriented north-northeast, the Eastern Escarpment is a cooler and moister island terrain. It covers elevations from sea level up to 150 m in the north, 550 m at Mt. Thirst, and 230 m in the south near Pyramid Head. The Eastern Escarpment comprises a little more than 19.7 km^2, or 11.7% of the island surface.

Major Canyons

Fifteen narrow, precipitous drainages along San Clemente Island's southwestern slope collectively make up the Major Canyon terrain. The product of erosion accompanying rapid tectonic uplift and an episodic hydrology, these canyons severely dissect the other terrains they traverse, especially the southern Upland Marine Terraces.

While constituting only 5.1% of the island's area (about 7.8 km^2), these canyons create some of the island's more dramatic and isolated topography. The canyon walls drop off sharply from the bordering terrace platforms, in some cases descending nearly vertically to relative depths of up to 150m. These shelter prevailing winds and produce relatively cool and moist conditions on the canyon floors, supporting a Canyon Shrubland/Woodland flora. Plunge pools and other natural bedrock catchments also hold significant amounts of runoff water through even the driest periods of the year.

Sand Dunes

Composed of active or recently-active calcareous (fragmented marine shell) sands, the Sand Dunes overlie portions of the Coastal Terrace and Upland Marine Terraces. The Sand Dunes are a brilliantly white, rounded terrain, with their active portions bare of vegetation, except where vegetation has begun to stabilize dune surfaces. Present sea level has cut off their sand source, and this change is rapidly removing their seaward face while their windward slopes progressively deflate. There were originally four sand dune areas at the northern and southern extremes of San Clemente Island. These consisted of three separate but proximate dune fields in the north covering an area over 3.5 km^2 and a fourth, smaller field located on China Cove in the south. Two of the northern fields were destroyed by construction of the island airfield in the late1950s. The surviving northern dune field encompasses approximately one km^2 of lands along the island's west coast opposite Wilson Cove.

The majority of San Clemente Island's terrain remains much as it did when the first humans occupied the island nearly 10,000 years ago. Then as now, uses of the landscape would have been differentially constrained by these terrain characteristics. Fossil sea cliffs and colluvial wedges in the Upland Marine Terraces significantly restrict areas of level ground suitable for occupation on the associated terrace platforms. Conversely, these same cliffs and the walls of the Major Canyons contain abundant rock shelters, many of which were occupied. Similarly, because of terrace dissection by the Major Canyons in the south of the island, access differences between the northern and southern Upland Marine Terraces appear to have influenced both the density and distribution of sites.

Climate

At first glance, San Clemente Island does not appear to be a particularly severe environment for hunter-gatherer-fishers. However, aboriginal populations would have faced a range of paleoenvironmental challenges, especially those created by the island's relative aridity.

The climate of southern California is classified as Mediterranean, with warm dry summers and cool wet winters. Climatic diversity is least in coastal areas, whereas conditions change rapidly toward the interior. The cooling effects of evaporation and heat transfer between water and air moderate temperature extremes in the coastal zone. In the case of San Clemente Island's climate, the influence of the Pacific Ocean is reflected in modest temperature ranges and the lack of frost.

Elevation and distance from the sea determine variability in microclimates across

San Clemente Island. These microclimatic factors exist within larger-scale, regional circulation systems such as prevailing winds and subtropical pressure systems. Southern California's climate is influenced by a semi-permanent subtropical high-pressure cell centered over the north Pacific (Kimura 1974). The region's weather system is dominated by this cell, especially during the spring and summer months. Under its influence, a well-mixed boundary layer, up to 500-600 meters deep, is formed when warm and moist Pacific air drifts over comparatively cold water in the Southern California Bight, creating a persistent bank of fog. This marine layer results in high humidity and a large number of cloudy days on San Clemente Island. Above this layer, conditions are relatively warm, dry, and cloudless. This layer of cool, moist marine air usually migrates onshore in the evening, evaporating in the afternoon peak sun hours.

In the winter months, the ridge weakens (Kimura 1974). Winter frontal storms, generated in the north Pacific, move into California from the west. As these storms move into southern California from the southwest, tropical, moisture-filled air is entrained in the low-pressure system, resulting in generally abundant precipitation throughout the coastal region. However, San Clemente Island departs from these coastal precipitation trends, typically receiving only a fraction of mainland rainfall totals.

In recent decades, however, climatologists have come to understand better the El Niño/Southern Oscillation (ENSO)–La Niña cycle as a perturbing influence on this Mediterranean climatic pattern (Amaral 1995). An El Niño event is an ocean-atmosphere response to a heating of the ocean surface in the southwest Pacific that induces the net eastward migration of warm surface waters. A typical El Niño event lasts for 14-22 months and decays when there is no longer enough warm water to sustain the cycle. El Niño events tend to dry out Australia and south Asia, bring heavy rains to the west coast of South and Central America, and typically (but not always) supply California with well above average winter precipitation. La Niña is the cold counterpart of El Niño in the ENSO cycle in which sea surface temperatures in the eastern Pacific drop below normal. These occur following some (but not all) El Niño years. La Niñas are characterized by warm winters in the Southeastern United States, colder than normal winters from the Great Lakes to the Pacific Northwest, and below average precipitation in California.

The effects on San Clemente Island ecosystems by this ENSO cycle were observed during El Niño/La Niña events of 1982-84 and 1997-99. In both 1982-83 and 1997-98, the warmer El Niño waters had a considerable effect in reducing the abundance of kelp along the island's western coast. Conversely, cooler SSTs during the La Niñas in 1983-84 and 1998-99 resulted in heavy kelp growth. Similar contrasts in the condition of the island's terrestrial botanical communities were also apparent.

Until very recently, San Clemente Island's climate characteristics have been derived from averaged island weather records collected at the airfield on the extreme north end of the island between 1962 and 1977. These data suggest the island received on average slightly more than 150 mm of precipitation per year, with a range from 80 mm to 290 mm, less precipitation than some mainland regions classified as deserts. By contrast, the Los Angeles Basin and inshore Santa Catalina Island receive about 380 mm per year. The formal collection of island weather data was discontinued in the late 1980s.

To fill this information gap, a new system of three, self-reporting meteorological stations was installed across the center of the island in 1993. These meteorological stations traverse the range of island terrains and associated environmental zones, including the Coastal Terrace, the Plateau, and the Eastern Escarpment. This microclimatic monitoring system has significantly improved baseline weather data for the island. Some of the new data challenge previous assumptions. The new stations have reported annual rainfall totals doubling those from the airfield. Instructive here are the annual precipitation numbers for the 1997 and 1998 water years presented in Table 2.1. Based on mainland comparisons, the 1996-97 water year can be characterized as falling within a "normal" range for precipitation. By contrast, the 1997-1998 water year coincided with that year's major El Niño event and is representative of maximum expected annual precipitation levels.

Water Year	Coastal Terrace	Plateau			Eastern Escarpment
	Eel Point	*Nursery*	*Hoeppel*	*OP1*	*Nanny*
1996-97	114 mm	202 mm	200 mm	143 mm	125 mm
1997-98	286 mm	422 mm	491 mm	409 mm	163 mm

Table 2.1: San Clemente Island precipitation data (CSU Northridge Climatology Program 1998)

By way of comparison, Table 2.2 presents precipitation totals for the same water years from comparable topographic contexts on neighboring Santa Catalina Island. These demonstrate similar rainfall gradients across that island's topography and indicate relatively moister conditions on Santa Catalina, which compare favorably with those for the adjacent Los Angeles mainland.

Water Year	**Santa Catalina Island**				**Los Angeles Mainland**
	Western Coast	**Inland Ridges**		**Leeward**	
	Two Harbors	***Airport***	***Middle Ranch***	***Avalon***	
1996-97	312 mm	400 mm	395 mm	304 mm	314 mm
1997-98	475 mm	722 mm	657 mm	524 mm	788 mm

Table 2.2: Santa Catalina Island and Los Angeles mainland precipitation data (Catalina Island Conservancy 1998)

These new San Clemente Island data describe precipitation gradients that suggest that the extreme aridity characterized for the island is more a function of the lower elevation of the airfield's recording station than a reflection of island-wide conditions. The island's Plateau and leeward Eastern Escarpment receive more rainfall than the Coastal Terrace. Clearly, the island's topographic crest has more potential for catching rainfall than suggested by the earlier airfield precipitation data. However, these precipitation totals are still significantly less than those recorded from similar topographic contexts on nearby Santa Catalina Island and continue to define arid conditions.

Terrestrial Ecology

The geographic isolation of islands is conducive to the appearance of unique life forms. The flora and fauna of San Clemente Island exemplify this characteristic of island biogeography. The island's flora includes fourteen endemic species or subspecies, the most among the California Channel Islands. An additional twenty-nine plants occur only at San Clemente Island and one or more of the other Channel Islands and Mexico's Guadalupe Island.

Eight major plant communities have been described for San Clemente Island. These include Grassland, Maritime Succulent Scrub (with four segregated phases), Maritime Sage Scrub, Canyon Shrub/Woodland, Coastal Salt Marsh, Coastal Strand, Sand Dune, and Sea Bluff Succulent (Kellogg and Kellogg 1994). Most of the island is covered by Grassland and the various Maritime Succulent Scrub phases (e.g., *Lycium* phase, *Opuntia* phase, *Cholla* phase).

On the emergent marine terraces, plant communities are composed principally of different combinations of xeric Maritime Succulent Scrub vegetation phases, which include cacti, box-thorn (*Lycium californicum*), and other drought-resistant species. Cacti, such as the prickly pear (*Opuntia littoralis*), provide edible "pads" and fruits. Sage species, particularly *Salvia columbariae*, were also a valuable source of seeds for prehistoric peoples.

The Plateau terrain presents a marked contrast to the coastal terraces, dominated by the island's Grassland plant community. Before the devastation of the island by introduced European grazing animals, the Plateau probably supported stands of shrub species. These are now in the process of recolonization following feral animal removal. In the past, species such as malva rosa (*Lavatera assurgentiflora*) and Mormon tea (*Ephedra* sp.) were probably more widespread, affording considerable cover and sources of fuel. The Plateau may have been an important location for collecting vegetal resources, such as acorns, seeds, fibers, and corms, including San Clemente Island brodiaea (*Brodiaea kinkiensis*).

Across the island, native perennial grasses have been replaced by exotics since European occupation. Although they once had a wider distribution, trees are now confined to moist environments of the canyons and the Eastern Escarpment because of historic overgrazing. Among these, oaks (*Quercus tometella*) survive as isolated stands, and native shrubs and grasses are only beginning to rebound. These conditions make it difficult to estimate the prehistoric productivity of terrestrial plant resources for prehistoric hunter-gatherer populations.

There is no archaeological or paleontological record of native land mammals of economic significance on San Clemente Island. Mammalian species like the Island fox (*Urocyon littoralis*), the white footed deer mouse, and the domestic dog are the only ones likely to have produced terrestrial meat sources. All are known or likely to have been introduced prehistorically by humans. The largest terrestrial species not expected to have been a product of human introduction is the Island night lizard, for which there is no evidence of use as a subsistence resource.

Marine Ecology

San Clemente Island occupies a portion of the Southern California Bight bounded on the north by the Santa Catalina Basin and on the west by the San Nicolas Basin. To the southeast of the island is the San Clemente Basin, and the Tanner Bank and Cortes Bank seamounts are located 60 km and 80 km, respectively, to the southwest. San Clemente Island is principally exposed to the warm waters of the north-flowing Southern California Countercurrent, although water temperatures are generally slightly lower on the western side of the island, particularly during summer months, owing to localized upwelling and the influence of the offshore California Current. The near-shore waters support a diverse assemblage of fishes and invertebrates as well as several species of marine mammals.

The rocky intertidal zone of the "outer," windward shoreline that fringes the Coastal Terrace possesses extremely rich biological communities, with affinities to warmer-water systems to the south and occasional representation of colder-water forms (Murray and Littler 1978). The biota of the leeward intertidal zone at the base of the Eastern Escarpment has its greatest affinities with the southerly warm-water systems. Further, because the Eastern Escarpment's steep contours continue sub-tidally to a depth of more than 900 m, the immediate offshore waters along the island's eastern shoreline are ecologically pelagic.

The Coastal Terrace affords the primary access to the western shoreline, where the bulk of the faunal component of the prehistoric islanders' marine diet appears to have been obtained. This intertidal zone provided shellfish, including abalone (*Haliotis* spp.), mussels (*Mytilus* spp.), and gastropods (*Tegula* sp.). The shore and near-shore habitats, including the rocky intertidal, shallow rocky reef, deep rocky reef, kelp bed, and soft bottom, were also highly significant as sources of fish, a principal component of the prehistoric diet (Salls 1988). Mainstay species of the prehistoric fish diet, such as the California sheephead (*Semicossyphus pulcher*), were easily taken from shore or near the shore.

Sea mammals were also available along the kelp bed zone. Since the island contained no terrestrial mammals larger than the Island fox, pinnipeds would have been important sources of meat, fat, skins, and other resources. The Coastal Terrace supported pinniped rookeries and "haulouts" where these animals could be easily captured (Bleitz-Sanburg 1987). Currently resident pinniped populations include California sea lion (*Zalophus californianus*), northern elephant seal (*Mirounga angustirostris*), and harbor seal (*Phoca vitulina*). The island supports significantly smaller pinniped populations than seen on San Nicolas or San Miguel Islands. The prevailing north-northwesterly winds and currents also carried driftwood (for fuel and construction) and dead or dying whales (for food and raw materials such as bones for constructing houses) to the shore along the Coastal Terrace (Bleitz-Sanburg 1987). Sea birds and sea otter were also available within this zone.

Prehistoric and Ethnographic Cultural Affinities

Historic, ethnohistoric, and ethnographic sources establish the Los Angeles Basin region of southern California and the southern Channel Islands as historically and protohistorically occupied by the Gabrielino (Kroeber 1976; Bean and Smith 1978). Archaeological data suggest that occupation of this region by linguistically related groups extends into the middle Holocene (Howard and Raab 1993). Evidence in the ethnohistoric record also implies the existence of protohistoric inter-island and island-mainland economic and social interactions prior to a late Mission Period aboriginal depopulation of the southern Channel Islands (Walker et al. 1993).

Archaeological evidence.

Archaeological evidence suggests a prehistoric interaction sphere segregated the southern Channel Islands and adjacent mainland from the northern Channel Islands and adjacent Santa Barbara mainland as early as the middle Holocene. The spatial and temporal distributions of Olivella "grooved rectangle" (OGR) beads show the occurrence of this bead type is most frequent on Santa Catalina, San Clemente, and San Nicolas islands, portions of the adjacent mainland coast, and the western Great Basin (Howard and Raab 1993; Jenkins and Erlandson 1997). OGR beads from the Nursery Site (CA-SCLI-1215) on San Clemente Island are dated at 4,820 RYBP (Raab and Yatsko 1998). The OGR bead type is also dated to 5,200 RYBP from the Little Harbor Site on Santa Catalina (Raab et al. 1994), between 4,590 and 5,025 RYBP on the Orange County mainland (Gibson 1992; Mason et al. 1992), and between 4880 and 5465 CYBP on San Nicolas Island (Vellanoweth 1995).

The occurrence of OGR beads is typically in areas historically occupied by people speaking languages of the Takic subfamily of Uto-Aztecan (King 1990). This suggests a correlation between the hypothesized migration of Uto-Aztecan peoples into southern California and a social interaction sphere connected with the appearance of OGR beads around 5,000 BP (Howard and Raab 1993). While actual dating of the arrival of Takic speakers on San Clemente Island is not established, these data suggest it was contemporary with these middle Holocene OGR bead dates.

Physical anthropological evidence

Osteometric evidence of human skeletal remains from San Clemente Island shows that two genetically distinct groups sequentially occupied the island during prehistory (Titus 1987; Titus and Walker 1986). Cranial morphology and non-metric cranial traits differ from early and late prehistoric cemeteries on the island. These data are consistent with the hypothesis that people of the "California" physical type -- high faces and broad heads -- lived on San Clemente Island during the early prehistoric period and that later people of the "Western Mono" physical type -- narrow heads and broad noses -- intruded into the area. The "California" physical type is associated with the Chumashan linguistic family that prehistorically occupied the northern Channel Islands and the adjacent Santa Barbara mainland. The "Western Mono" physical type is found in the Monache area of the Sierra Nevada and in the territory of the Gabrielino.

Ethnohistoric evidence.

The Indian population on San Clemente Island first had contact with Europeans in the late sixteenth century but no sustained interaction until after Spanish colonization in

1769. Genealogical relationships reconstructed from early mission and church marriage and baptismal records, and from J. P. Harrington's ethnographic notes on the Gabrielino, show that intermarriage occurred between people from San Clemente Island and Santa Catalina Island in the Historic period (Johnson 1988). Evidence also exists for intermarriage between southern Channel Islands people and Gabrielino and Chumash villages on the mainland. Johnson (1988) suggests that the San Clemente Islanders were late in abandoning the island and that it was probably not depopulated until ca. 1815.

Summary

San Clemente Island lies at the environmental and cultural margin of the Southern California Bight region. While its surrounding waters provide an abundance of marine resources, its circumscribed terrestrial environment presents geographic and ecological conditions that include more restricted sets of subsistence resources than are found on many of the other Channel Islands. San Clemente Island has a comparatively more arid climate than elsewhere in the Southern California Bight region and exemplifies a high-risk prehistoric littoral environment for human occupation (Larson 1987). There is also evidence that the island's prehistoric occupants had cultural ties with regional cultures on the southern Channel Islands and the adjacent mainland as early as to the middle Holocene. This kind of circumscribed terrestrial environment affected by region-wide climatic processes and patterns of prehistoric regional cultural integration is ideal for investigating the ways that fluctuating paleoenvironmental conditions influenced human settlement patterns during the late Holocene. The course of San Clemente Island archaeological investigations over the last half-century has provided the intellectual and methodological precedents for the current research. These are discussed in the following two chapters.

Chapter 3

Archaeological Research Precedents

The California Channel Islands

Since the late 19th century, San Clemente Island and the other California Channel Islands have experienced periods of increasing archaeological activity. Early archaeological investigators in the Channel Islands had research goals concerned with obtaining artifacts and human remains for museum collections, almost exclusively from aboriginal cemeteries (Abbott 1879; Alliot 1915, 1917; Carr 1880; Putnam 1878; Reichlen and Heizer 1963; Schumacher 1877, 1878a, 1878b; Yarrow 1879). By the 1920s, both untrained amateurs and fully professional archaeologists were active among the islands. While much of this work was in the tradition of earlier relic collectors, there was also increasing attention to provenance (e.g., Bryan 1930; Rogers 1929). Some professionals, including R.L. Olson (1930), also attempted to define temporal and spatial variations in these islands' archaeological records in order to reconstruct their cultural histories. However, only sporadic research was undertaken until after the Second World War, when P. Orr (1968) began work at Santa Rosa Island. His work served as a link between the temporally-oriented workers of the 1920s and the problem oriented research begun there in the early 1950s (Glassow 1980).

In 1953, the UCLA Archaeological Survey began a continuing program of research in the Channel Islands. Early Survey activities included extensive reconnaissance and some excavations on Anacapa, San Nicolas, Santa Catalina, Santa

Barbara, and San Clemente Islands (e.g., McKusick and Warren 1959; Meighan 1959; Reinman and Townsend 1960). These efforts merged with those of the Southwest Museum, then working largely in the northern islands (Rozaire 1959). Into the 1960s, major objectives of Channel Islands research were to inventory archaeological resources of each island and trace the evolution of maritime ecological adaptations (Glassow 1980). To better document the characteristics of maritime adaptations, investigators abandoned the focus on cemetery excavations and initiated techniques of midden analysis developed during investigations of San Francisco Bay shell mounds (e.g., Cook 1946; see Meighan 1959), laying the early foundation for much current cultural ecological research. From the early 1970s, the islands' principal federal land-owning agencies, the National Park Service and the U.S. Navy, have been more active in the study and management of archaeological resources on seven of the eight Channel Islands.

Both federal management and academic research continue to involve survey and the development of local and regional chronologies. In the last twenty years, each of the Channel Islands has received some degree of intensive archaeological survey but with variable coverages. The four smaller islands, San Miguel, Anacapa, San Nicolas, and Santa Barbara, have all been subject to comprehensive, systematic surveys (Kennett 1998). Surveys from the mid-1960s, late-1970s, and early 1980s by Rozarie (1965), Greenwood (1978), and Glassow (1982) documented a total of 603 sites on San Miguel Island. Greenwood (1978) also recorded 27 sites during a complete survey of Anacapa Island in the 1970s. In 1983-84, Reinman and Lauter (1984) surveyed the entirety of San

Nicolas Island, recording over 355 sites. In 1978, Greenwood (1978) consolidated and extended earlier work by Rozaire (1965) to document archaeological sites on Santa Barbara Island.

The three largest islands, Santa Cruz, Santa Rosa, and Santa Catalina, have experienced more varied and less complete survey coverages than the three smallest islands discussed above. Despite it being the most accessible of the Channel Islands, Santa Catalina Island has the least complete inventory of its archaeological resources and has had no comprehensive site survey (Wlodarski 1982). Recent survey and excavation research there has been sporadic, principally involving field school projects (e.g., Raab et al. 1995a; Reinman and Eberhart 1980; Rosenthal et al. 1988).

In 1973-74, Glassow (1977) surveyed a stratified random sample of drainages on Santa Cruz Island, recording nearly 380 sites. Since that time, many coastal and interior areas of the island have been systematically surveyed and over 635 sites have been recorded (Arnold 1987, 1992; Glassow 1977; Kennett 1998). Among these, Peterson (1994) surveyed and dated sites in the Coches Prietos drainage basin on the south side of the island, and most recently, Kennett, Morris and Rick surveyed the Scorpion drainage basin on eastern Santa Cruz (Kennett 1998).

Orr (1968) claimed to have surveyed all of Santa Rosa Island between the late 1940s and 1960s, but recent work by the National Park Service, Kennett (1998), and others indicates that his surveys were not undertaken systematically. Systematic surveys since the purchase of Santa Rosa Island by the National Park Service in 1991 now include the island's entire coastline and the Jolla Vieja, Cañada Verde, and Arlington Canyon drainages (Kennett 1998). A total of 680 sites are now on record for Santa Rosa Island.

Archaeological Research on San Clemente Island

Like the other seven California Channel Islands, San Clemente Island experienced only intermittent archaeological activity in the late nineteenth and early twentieth centuries. This early work was largely the uncontrolled, poorly provenienced relic collecting common in that era. The first documented visits to San Clemente Island were by Paul Schumacher (1878a, 1878b) in 1875 and 1877 (Putnam 1878). Even at this early date, Schumacher (1878a:201) indicates that others had preceded him:

> As on San Nicolas Island, the greater portion of our collection was obtained on the surface of the shell mounds; and here too we found to our sorrow that the larger utensils, the well worked, and often rare articles were broken by vandals and scattered about.

After Schumacher came relic collectors for the Lowie Museum (Trask 1897), avocationalists from Santa Catalina Island (Glidden n.d.; Holder 1896, 1910), private southern California collectors (e.g., Murbarger 1947, 1949), sheep ranchers (Murphy n.d.; Smull and Cox 1989), and, after the Navy acquired the island in 1934, military collectors (Flynn 1942). None of these amateur efforts left any substantive account of the character or distribution of the sites collected (see Zanhiser 1981).

In 1939, Woodward (1939, 1941, 1942) of the Los Angeles County Museum of Natural History conducted the first systematic archaeological investigations on San

Clemente Island. This fieldwork included site survey in the Pyramid Cove-China Point area at the southern end of the island and excavation of the Mission period Big Dog Cave site near Horse Beach Cove.

Investigators in the 1950s and 1960s included S. Rogers from San Diego State College (Noah 1987), Sayler (1959) for the San Diego Museum of Man, Bryan (1962, 1963) and Rozaire (1962) for the Southwest Museum, Redfelt (1964) from the Archaeological Survey Association, and McKusick and Warren (1959) for the UCLA Archaeological Survey.

McKusick and Warren's (1959) site-survey and excavation project was the first San Clemente Island archaeological study to address contemporary scientific research goals and the first to attempt a representative survey of the island's sites. On the basis of 120 sites recorded, they estimated that the island had approximately 350 sites, or about two sites per km^2. This was the earliest documented estimate for the density of cultural resources at the island. They were the first to excavate at the Eel Point Site (CA-SCLI-43) on the island's central west coast, producing the first published documentation of this important archaeological site (McKusick and Warren 1959). McKusick and Warren (1959:136-138) also attempted the first cultural chronology for the island, suggesting three sequential cultural complexes: Milling Stone Complex, Mortar and Pestle Complex, and Big Dog Complex. While this sequence has not survived the scrutiny of subsequent investigators, it was the initial effort on San Clemente Island to move beyond purely descriptive studies to a higher level of historical synthesis.

In 1975, M. Axford (1975) and San Diego Mesa College started a six-year archaeological field survey, excavation, and analysis on the island. Initially based on McKusick and Warren's (1959) estimate of 350 sites island-wide, the Axford survey quickly encountered an unanticipated volume of archaeological sites requiring an almost complete commitment to survey. As the project ended in 1980, Axford (1976, 1977, 1978, 1984, 1987) had documented approximately 1900 cultural loci (recorded as 1634 sites) across the northern 60% of the island, implying an island total of about 3200 sites, or 21.6 per square km.

Axford's work revealed something of the actual size and complexity of San Clemente Island's archaeological resource base. San Clemente Island was shown to contain archaeological sites numbering in the thousands and occupying every major topographic province. In a subsequent critique of Axford's results, it became clear to me that a comprehensive site inventory for the island must be carefully planned, systematically implemented and, of necessity, phased over a period of many years (Yatsko 1989).

Axford's work also began a San Clemente Island radiocarbon chronology. Twenty radiocarbon dates were produced from sites spanning the eighteenth century to about 8,000 RYBP (Breschini et al. 1996:50-51). The antiquity of these dates again brought the island's research potential to the attention of Meighan at UCLA. In particular, he was impressed by a 8,180 ± 110 RYBP date collected from the Eel Point site and decided to begin new UCLA research on the island (Axford 1984; Meighan

1984). Between 1983 and 1987, Meighan (1983, 1984, 1986, 1989) and the UCLA Institute of Archaeology conducted four archaeological field school excavations on San Clemente Island (see also Armstrong 1985; Meighan and Horner 1993). The UCLA work ranged widely over the island, including Coastal Terrace sites like the Eel Point Site (CA-SCLI-43), Big Dog Cave (CA-SCLI-119), and North End Shelter (CA-SCLI-1178), and Plateau sites like the Nursery Site (CA-SCLI-1215), Ledge Site (CA-SCLI-126), and Old Airfield Site (CA-SCLI-1487). This research produced a number of academic theses and dissertations (Foley 1987; Noah 1987; Rechtman 1985; Salls 1988; Scalise 1994; Titus 1987).

The Ledge, Old Airfield, and Columbus sites all contain early Historic period cultural components (Meighan 1986; Noah 1987; Rechtman 1985), while the North End Shelter produced radiocarbon dates of 6,300 ± 90, 4,950 ± 90, and 5130 ± 55 RYBP (Foley 1987). UCLA's efforts at the Eel Point Site in 1983, 1984, and 1986 produced significant new data on the maritime economy of the island's prehistoric peoples and revealed cultural components spanning from the Early Holocene to European contact (Salls 1988, 1990a, 1990b). At the time, this understanding effectively doubled previous estimates of the antiquity of human occupation of San Clemente.

After UCLA discontinued fieldwork in 1987, M. Raab and the CSU Northridge Center for Public Archaeology conducted five archaeological field schools and other excavation and site survey projects between 1988 and 1996 (Eisentraut 1990; Hale 1995; Raab 1993, 1996; Raab and Yatsko 1990; Raab et al. 1994, 1995a, 1995b, 1997; Salls and Hale 1991). Most important to discussions here are the 1994 and 1996 Northridge excavations at the Eel Point Site. These developed a more detailed radiocarbon chronology for Eel Point, and analyses of midden deposits from Eel Point yielded detailed insights into trans-Holocene maritime techno-economic change (Porcasi 1995; Porcasi et al. 1998; Raab et al. 1995b, 1998) and changes in settlement-subsistence patterns (Erlandson et al. 1998; Fiore 1998).

Nearly all substantive work under the UCLA field schools, and much of that by CSU Northridge, investigated the larger, more complex class of site on San Clemente Island (the Eel Point Site, Nursery Site, etc.). However, at my direction, the CSU Northridge field schools also conducted the first substantive testing of the myriad small sites that more generally characterize the island's archaeology. In 1988, 1989, and 1990, CSU Northridge tested a dozen, small (less than 15 m diameter), single-component middens on the Coastal Terrace, Upland Marine Terraces, and the Plateau. These sites were excavated to examine faunal exploitation, particularly of shellfish, and produced dates of occupation from both the middle and late Holocene. Analysis of percentages and size characteristics of these sites' shellfish contents suggests a pattern of late prehistoric overexploitation of the intertidal zone (Raab 1993; Raab and Yatsko 1992: 182-186).

Concurrent with UCLA and Northridge research, I directed other archaeological site survey and testing programs across the island in support of Navy cultural resource management (e.g., Berryman and Berryman 1988; Chiswell 1991; Quintero 1988; TMI

1992; Yatsko 1989). Many of these projects were resurveys of areas previously covered by McKusick and Warren (1959), Axford (1984), and others (Zahniser 1981) to assess the adequacy of site location and record data. In most areas, between 40% and 90% of observable sites had not been found by the earlier surveys, with most previously recorded sites inadequately documented or poorly provenienced.

In response to these findings, I began to design a stratified, random cluster, probabilistic survey to gain a more representative inventory of island sites. This sampling survey was first attempted under contract in 1987-88, but that project developed contractual conflicts and was suspended, unfinished, in late 1988 (Smith 1988). However, insights gained during that initial attempt suggested that the original 10% sample was too small. The sample size was increased to 15%, and a more detailed research design was prepared (Yatsko 1991). CSU Northridge conducted this expanded Probabilistic Site Survey under contract in the fall and winter of 1991-1992, documenting 1,143 sites within 73 twenty-five-hectare sample units and recovering ^{14}C samples from 27 selected sites that yielded a total of 68 radiocarbon dates (Yatsko and Raab 1997).

Most recently, my cultural resources management research has shifted focus to the systematic testing of selected sites for the identification of significance characteristics that would require their preservation under Section 106 review (e.g., Doolittle 1997; Hildebrandt and Jones 1996; York 1997). Along with the foregoing research by UCLA and Northridge, these investigations of the island's numerous sites have led to expanded understandings of the site function, content, and relative chronology that underlie the applied aspects of this dissertation research.

Archaeological Sites on San Clemente Island

The research discussed above has cumulatively led to the broader understanding that the island's characteristic archaeology lies in the numerous small, discrete occupation middens encountered island-wide (Meighan 1984; Yatsko 1989). These sites constitute one of the densest concentrations of cultural loci in western North America. While early pilfering and vandalism had some effect on the island's archaeological integrity, the magnitude of this disturbance in no way approaches that documented for the mainland or neighboring Santa Catalina Island. Despite 60 years of Navy use, disturbances due to military activities have been less severe than is commonly assumed, with only about 15-20% of the island's land area affected to any degree. Archaeological loci on areas that remain undisturbed are relatively pristine.

Some areas of the island's emergent marine terrace terrains (the Coastal Terrace and Upland Marine Terraces) have between 100 and 300 of these small sites per km^2 (Raab and Yatsko 1990; Raab 1993; Yatsko 1989, 1996c). Overall, San Clemente Island may contain more than 7,600 archaeological sites, many composed of multiple small loci (Yatsko and Raab 1997). These small sites contain the bulk of the island's volume of archaeological deposits and most of the information important to understanding island settlement and adaptive systems through time.

To facilitate consistent site documentation, sampling, and analysis in this very large site population, in 1986 I developed standardized nomenclatures for defining and characterizing the archaeological "site" on San Clemente Island (Yatsko 1986, 1989, 1996b).

Definition of a "Site"

. On San Clemente Island, an archaeological "site" is a discrete and potentially interpretable locus of cultural materials. "Discrete" means spatially bounded by at least relative changes in material densities; "interpretable" refers to the presence of material densities of a quality and quantity sufficient to support inferences about behavior; and "materials" means artifacts, ecofacts, and features (Yatsko 1986).

Archaeological loci on San Clemente Island are very discrete, with well-defined surface material and midden boundaries. My site nomenclature roughly differentiates them by size as small, medium, and large. Small (<15 m diameter) shelly midden sites predominate, with wide variability in their density of marine shell. Such sites occur as sometimes slightly mounded midden deposits on level to moderately sloped terrains (Figure 3.1) or in rock shelters. Midden loci are usually overlapped and surrounded by scatters of flaked lithics, other artifacts (e.g., groundstone artifacts, hammerstones), and unmodified or fire-altered rock. Moderate (15-30m diameter) and large (30-100m diameter) sites generally consist of multiple, overlapping small midden loci, representing temporally distinct prehistoric occupations.

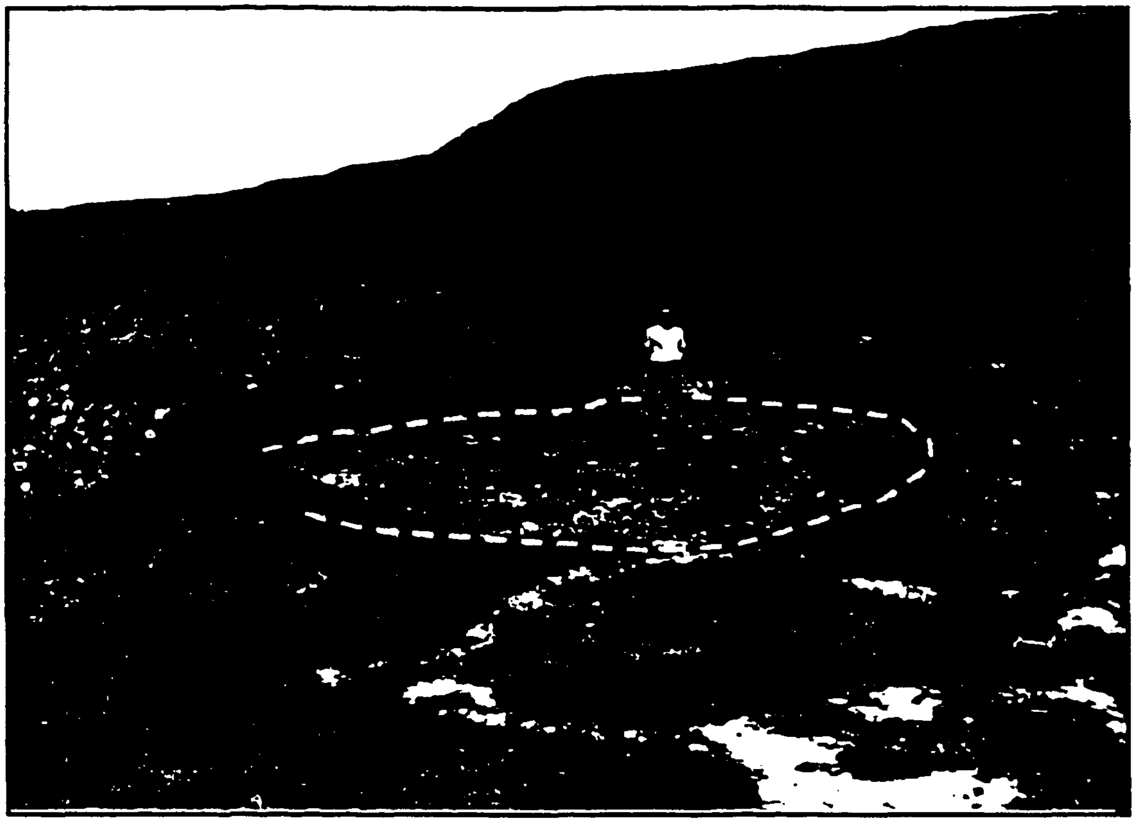

Figure 3.1 Archaeological site SA-61, located on the Coastal Terrace in the SA Study Area. The dashed line delineates the boundary of this site's deflating, 12-meter-diameter shell midden.

Descriptive Site Typology

I also developed a standardized site typology that classifies island sites based on constituent characteristics of their surface middens (Yatsko 1989, 1996b). Over time, the dark, carbon-rich midden deposits that typify the most visible sites on the island lose their "carbonaceous" matrix through deflation, leaching, and oxidation. Eventually, this process results in the loss of nearly all color in the soil matrix, progressively embedding the more persistent midden constituents (e.g., marine shell, flaked stone, and groundstone artifacts) into the parent soil. This progressive loss of carbonaceous material is seen as an indicator of relative site age. However, these descriptive types can only be applied as comparative indicators of relative site age to sites within a discrete area of a particular terrain rather than for the island as a whole. This is because gradients in precipitation and wind exposure across the island's topography mean that processes of deflation, leaching, and oxidation may vary significantly between one general terrain locality and another. Nonetheless, this approach provides a tripartite site typology for differentiating "carbonaceous" (young), "deflated" (middle-aged), and "embedded" (senile) middens within typical site survey units (Yatsko 1989, 1996b).

The surface expression of a "carbonaceous" midden has a very organic fine-to-sandy-textured matrix of high carbon content, dark gray to black in color (often resembling powdered charcoal). Such middens possess variable shell densities, ranging from very abundant to apparently absent. A "deflated" midden has little or no organic matrix visible on the surface; its texture and color grades with that of surrounding soil. The surface of this type of deposit has a deflated, often dense, pavement of fragmentary marine shell. However, the undeflated subsurface deposit retains a moderately organic matrix and is still medium gray to black in color. An "embedded" shell midden is most often a partially buried shell lens, embedded in the parent soil and lacking any observable organic soil matrix. Site soil texture and color are the same as the surrounding soil. These typological categories describe modal site characteristics within a continuous gradient of surface midden conditions among island sites. In practice, I have modified these to include intermediate stages (e.g., "deflating" -- transitional between carbonaceous and deflated -- and "deflated-to-embedded" -- grading between deflated and embedded midden conditions).

Summary

Before the late 1950s, archaeological research on San Clemente Island and the other southern Channel Islands generally lagged that conducted on the northern Channel Islands. Since that time, however, academic and cultural resources management research advances on San Clemente Island have moved the island's archaeology beyond a single-site or single-island perspective to a more regional frame of reference. Early, largely descriptive studies have given way to sustained evaluations of hypotheses and explanatory models of cultural behavior. The San Clemente Island data can be used to investigate hypotheses regarding how paleoenvironmental stress affected prehistoric southern Channel Islands populations and whether it stimulated resource intensification, new technologies, increased specialization, or settlement shifts. The following chapter discusses how recent trends in San Clemente Island research have framed the orientation of the current research.

Chapter 4

Research Orientation

This project evolved out of Navy cultural resources management (CRM) research I started in the late 1980s to address the need for improved characterization of the numbers and kinds of prehistoric archaeological sites on San Clemente Island. It began with the practical goal of acquiring a sample of the types and chronology of the island's prehistoric cultural loci. However, my initial review of chronological data emerging from the 1991-92 Probabilistic Survey revealed a provocative correlation between frequencies of site dates and temporal curves for sea surface temperatures (SST) (Pisias 1978, 1979) and precipitation (Larson 1987; Larson and Michaelson 1989) in coastal and insular southern California. I chose to assess San Clemente Island's place within a broader regional investigation of the influences of changing paleoenvironmental conditions on the evolution of prehistoric cultures. Because the balance struck between regulatory and scientific goals is at the core of archaeological research on San Clemente Island, here I discuss applied and scientific research orientations as complementary objectives.

Regulatory Objectives

Archaeological research on San Clemente Island is fundamentally driven by compliance with the National Historic Preservation Act of 1966, with the goal to identify and preserve significant archaeological resources. In this regulatory process, an archaeological site's significance is determined by its eligibility for listing on the

National Register of Historic Places (National Register). Site significance is based on how the information it contains can contribute to an understanding of history or prehistory and consequently how these data may address specific or general scientific research questions. However, significance for individual archaeological sites cannot be determined in isolation. Rather, it must be considered within broader local or regional contexts, requiring comparability among data across a region. Resulting placement of a site or class of sites within a generalized reconstruction of an overall archaeological pattern allows for a more informed assessment of significance.

Glassow (1985) suggests that those data most relevant to the study of settlement systems will be found in the distributions and abundance of a full range of site types and their environmental affinities. He points out that there has been a tendency in California archaeology to neglect sites on the smaller end of the size range or to assess them as having less appreciable significance. Some archaeologists assume that small, surface, or disturbed sites are of limited value to the study of prehistory. As a result, these types of cultural resources frequently have been ignored in the development of local and regional research designs or archaeological syntheses (Talmage et al. 1977:1). As noted in the preceding chapter, the small-sites character of San Clemente Island's archaeological loci makes their investigation particularly appropriate to studies of settlement patterns there. Sampling a full range of archaeological loci is necessary to assess prehistoric demographic patterns, subsistence activities, and general adaptive strategies (Talmage et al. 1977:1).

Scientific Objectives

The Island Research Design

Scientific research objectives for San Clemente Island are not different from the larger goals of archaeology. Since 1988, these have been defined within a frequently updated island research design (Raab and Yatsko 1990, 1998). In its current iteration, the island research design identifies three general objectives: (1) the development of cultural chronologies; (2) the reconstruction of past lifeways; and (3) the understanding of processes of cultural change (Fagan 1994:43; Thomas 1991:50-56).

Building an Island Chronology

Chronology building is of obvious importance to archaeology. Prior to the advent of radiocarbon dating, researchers in coastal California generally assigned prehistoric artifacts or events to a time period through the analysis of cultural strata within archaeological sites (Fagan 1994:52-73; Trigger 1989:304-305). In contrast to the northern Channel Islands, San Clemente Island's sites produce few chronologically diagnostic object types. Radiocarbon dating of associated organic materials affords nearly the only reliable means of assigning ages to artifacts, features, stratigraphic levels, and intervals of cultural change for San Clemente Island. Advances in radiocarbon dating of sites and site components have improved temporal resolution of San Clemente Island's prehistoric chronology, facilitating the investigation of a range of research topics (Raab and Yatsko 1998).

Radiocarbon Dating

Channel Islands researchers have been among the leaders in the use of radiometric dating for archaeological research along the California coast. Meighan's (1959) work at the Little Harbor site on Santa Catalina Island produced one of the earliest radiocarbon dates in southern California (Breschini 1996). In the northern Channel Islands, Orr (1968) first published radiocarbon dates from Santa Rosa Island in the 1960s. Research conducted during this period on San Clemente Island was still being done without the use of radiocarbon dating (Bryan 1963; McKusick and Warren 1959; Redfelt 1964). As observed earlier, it was not until Axford's (1984) survey in the late 1970s that the first radiocarbon dates were obtained. Dates ranged from historic times to the early Holocene. The earliest and most intriguing dates were 6,300 RYBP from North End Shelter and 7,800 - 7,900 RYBP from the Eel Point Site (Breschini et al. 1996:51; Raab and Salls 1995:27).

The number of San Clemente Island radiocarbon dates increased rapidly after the mid-1980s. From just twenty dates in 1983, the list expanded to nearly 100 by 1992 (Breschini et al. 1996; Raab and Salls 1995:27). Currently, the number of radiocarbon dates from San Clemente Island stands at over 265. However, this rapid increase in San Clemente Island radiocarbon dates does not mean that all dates are equally reliable. Reliability of many radiocarbon dates collected before the late 1980s is influenced by a host of factors, including uncertainties about processing techniques (field and lab), lack of dendrocalibration, the marine reservoir effect (ΔR), fractionation effects, and others (Taylor 1987). In recent years, some archaeologists (Glassow 1998; Rick 1987) have addressed these problems systematically through careful selection of materials for dating, requesting appropriate laboratory processing techniques, and applying up-to-date marine reservoir and dendrocalibration corrections published by Stuiver and Reimer (1993).

In the early 1990s, two archaeological projects on San Clemente Island were yielding suites of dates that afforded a reliable basis for reconstructing the island's long-term cultural developments: the continuing Navy-CSU Northridge excavations at the Eel Point Site and the 1991-92 Probabilistic Site Survey. The 108 dates these projects have produced were obtained employing well-defined and closely comparable collection, laboratory processing, and correction protocols (Raab et al. 1994).

Radiocarbon Chronology for the Eel Point Site

The fifteen-year research effort at the Eel Point site has been pivotal in the development of the radiocarbon chronology for San Clemente Island and coastal southern California. The considerable body of radiocarbon dates assembled for the southern California region points to initial occupation of the Channel Islands and mainland coast during the early Holocene, with widespread coastal settlement by the middle Holocene (Breschini et al. 1996). Recent syntheses of California maritime prehistory identify perhaps ten coastal or pericoastal sites dated to between 9,500 and 10,500 RYBP, with five of these reported from the California Channel Islands (Erlandson and Colten 1991). Numerous sites are now known to date between 8,000 and 9,500 RYBP (Jones 1991, 1992). Roughly 75 of those reported from central and southern California coastal contexts have ages between 7,000 and 8,000 RYBP, including the Eel Point Site

(Erlandson and Colten 1991:2; Jones 1992).

Building a reliable, established chronology at Eel Point has been problematic. Meighan's 1983-86 investigation at the Eel Point Site yielded a dated sequence across much of the Holocene. Salls (1988:361, 372) cites twenty-four radiocarbon dates ranging between about 1,090 and 10,000 RYBP, all but four of which were processed in the UCLA radiocarbon lab. Three dates, ranging between 9655 ± 325 and 9870 ± 770 RYBP, resulted in widespread citation of Eel Point as one of the earliest sites on the North American Pacific coast (Erlandson 1994; Erlandson and Colten 1991; Jones 1991; Salls 1990b, 1992). Despite this, aspects of the site's radiocarbon chronology puzzled some regional researchers, including Erlandson (1994:214):

> After calibration, the marine shell dates suggest that the early occupation of SCLI-43B occurred primarily between 7900 and 8500 cal BP. . . . In contrast, calibration of the early charcoal dates results in calendar ages falling between about 9900 and 10,800 cal BP. Thus, the midpoints of the charcoal dates pre-date those of the oldest marine shell date by between 1400 and 2300 calendar years. . . the discrepancy between the oldest shell and charcoal dates is curious.

Questions of this kind encouraged the Navy-CSU Northridge excavations at Eel Point in 1994 and 1996 (Fiore 1998; Porcasi 1995; Porcasi et al.1998; Raab et al. 1995b). During the1994 fieldwork at Eel Point, two 1984-86 excavation units were re-opened and their sidewall profiles examined and tested. The 1986 unit tested was the one from which Salls' (1988:361) three oldest dates had been obtained. New, paired shell and charcoal samples were collected from the 250-260 cm basal stratum, the source of the oldest dates. These two samples were commercially processed by Beta Analytic, producing dates in close agreement, with ages of 5,510 ± 50 RYBP and 5500 ± 160

RYBP, respectively. The large difference (ca. 4,150 radiocarbon years) in the age of these dates from those Salls obtained for the same cultural stratum is problematic. Factors accounting for the discrepancy might include asphaltum contamination of the original samples or the presence of "old wood" (Erlandson 1994). More likely, however, problems stem from procedural errors or poor quality controls at the now-closed UCLA radiocarbon lab (G. Russell, personal communication 1997). Whatever the source of the errors, results from the Navy-CSU Northridge fieldwork now make it difficult to accept Salls' (1988) claims of a 10,000 RYBP initial occupation of Eel Point. Further, trends in these more recent dates (see Appendix 1) have required exclusion of the twenty Eel Point dates from the old UCLA lab from the site chronology and from island-wide chronologies (Raab and Yatsko 1998). Even with exclusion of these problematic dates, the remaining suite of dates still shows clearly that Eel Point was occupied early in the Holocene, by about 8,000 RYBP or approximately 9,000 calendar years before present (CYBP).

Before publication of UCLA's problematic radiocarbon dates (Salls 1990b), the earliest Eel Point date was 8,180 ± 110 RYBP, obtained from shell collected by Mesa College (Axford 1984; Salls 1988:359). The 1994 Navy-CSU Northridge project also entailed opening one of UCLA's 1984 Locus B test units and obtaining paired radiocarbon samples of shell and charcoal from the 150-160 cm basal stratum. Resulting dates were 7,910 ± 70 RYBP and 8,110 ± 300 RYBP, respectively. These dates were subsequently corroborated through repeated dating of this and other site areas' basal strata (Erlandson et al. 1998; Raab et al. 1994, 1995b).

The Eel Point Site's cumulative dates (Appendix 1) offer one of the most detailed, single-site, trans-Holocene cultural chronologies available anywhere on the California coast (Raab and Yatsko 1998). However, the capability of this sequence alone to reliably characterize an overall San Clemente Island cultural chronology is complicated by a number of factors. First, the sequence represents a record of prehistoric occupation and subsistence for only one site and its associated subsistence catchment. Second, the selection of samples has admittedly been somewhat arbitrary, generally skewed to particular kinds of proveniences likely to produce the earliest occupation dates (e.g., basal house floors).

There also remains some question about how representative current sampling of the site deposit might be. Based on the excavation testing conducted in 1994 and 1996, and on solid core probing I conducted across the site in 1994, the site's overall volume is now seen to be composed of myriad small (i.e., <15 m in diameter) occupation deposits configured as overlapping and inter-bedded stratigraphic components. These internal components are analogous to the characteristic "small site" loci across the island. Understanding this, there is a significant potential for sampling error in the arbitrary, clustered probing of less than 1% of the site from which the current suite of dates was obtained. This proportion is unlikely to fully represent the overall *site* chronology and is even more unlikely to be representative of the overall *island-wide* chronology.

Radiocarbon Chronology for the Island-wide Probabilistic Survey

California researchers have suggested that radiocarbon-date frequencies, like those from the 1991-92 Probabilistic Survey data, can be a reasonable proxy measure of general paleodemographic patterns or at least a basis for hypothesizing about such patterns (Breschini et al. 1996; Glassow et al. 1988; Glassow 1998). All other things being equal, one might logically expect that as a prehistoric human population expanded or contracted in size it created a correspondingly larger or smaller number of discrete archeological sites or cultural strata. Assuming a regional sampling of radiocarbon dates reasonably reflects all of this variation, it should be possible to perceive general population trends in the form of shifting date frequencies. Of course, a difficulty with this approach is that seldom are all other things equal, and the capacity of a sample of dates to reflect accurately something as complex as a regional archaeological record is subject to question. Numerous possible sources of error include biased selection of sites for dating, small samples of dates for many time periods, variable deposition of datable materials across time, and settlement dynamics that result in greater or lesser numbers of sites regardless of the actual magnitude of a prehistoric population (Glassow 1988).

All of these difficulties acknowledged, it is important to note the frequencies of these San Clemente Island radiocarbon data. The Probabilistic Survey's sampling strategy eliminated a good deal of bias in the selection of the sites dated. The Probabilistic Survey probabilistically sampled approximately 15 percent of the island's surface (Yatsko and Raab 1997). The excavated sample from this site population represented essentially all site types and topographic settings identified for the island and yielded a total of 68 radiocarbon dates from charcoal and shell samples (see Appendix 1). These dates could be assigned to a total of 57 separate cultural components or strata. For purposes of representing frequencies of these dates through time, the problem of "double counting" dates was avoided by counting each discrete provenience with paired dates of the same statistical age as a single date.

Even dates not from probabilistic sampling, like Axford's, reflect a wide range of site types in many different island settings. Figure 4.1 plots 57 dates from the Probabilistic Survey against 93 dates from the remaining total, or "island-wide," sample (Raab and Yatsko 1998). The island-wide sample is drawn from a variety of sources, including Breschini et al. (1996), Raab et al. (1994, 1997), Erlandson et al. (1998), Gallegos (1994), and radiocarbon laboratory reports on file at the CSU Northridge Center for Public Archaeology and the Navy's Natural Resources Office. The sample presented in Figure 4.1 represents less than one-half of the total radiocarbon dates currently available. I excluded Probabilistic Survey dates from the same cultural components or strata in order to avoid "double counting," and I excluded dates from earlier studies with uncertainties regarding their context. The sample in Figure 4.1 also excludes the 20 problematic UCLA Eel Point Site dates discussed earlier. For this comparison, all dates in Figure 4.1 would ideally have been corrected and calibrated to current standards. Unfortunately, many of the earlier dates lack sufficient documentation to make such adjustments. As such, Figure 4.1 plots only mean uncalibrated radiocarbon dates for both suites in one-century increments.

The configurations of the frequency distributions shown for the Probabilistic Survey and island-wide samples in Figure 4.1 are strikingly similar in the time range from about 5,000 RYBP to the present. That the Probabilistic Survey sample does not include dates earlier than 5,000 RYBP cannot be viewed as a defect because dates in the island-wide sample earlier than 5,000 RYBP come almost entirely from the long cultural sequence documented at the Eel Point Site. These early dates are an artifact of Eel Point's deep, undisturbed stratigraphy, which is currently a singular phenomenon on San Clemente Island.

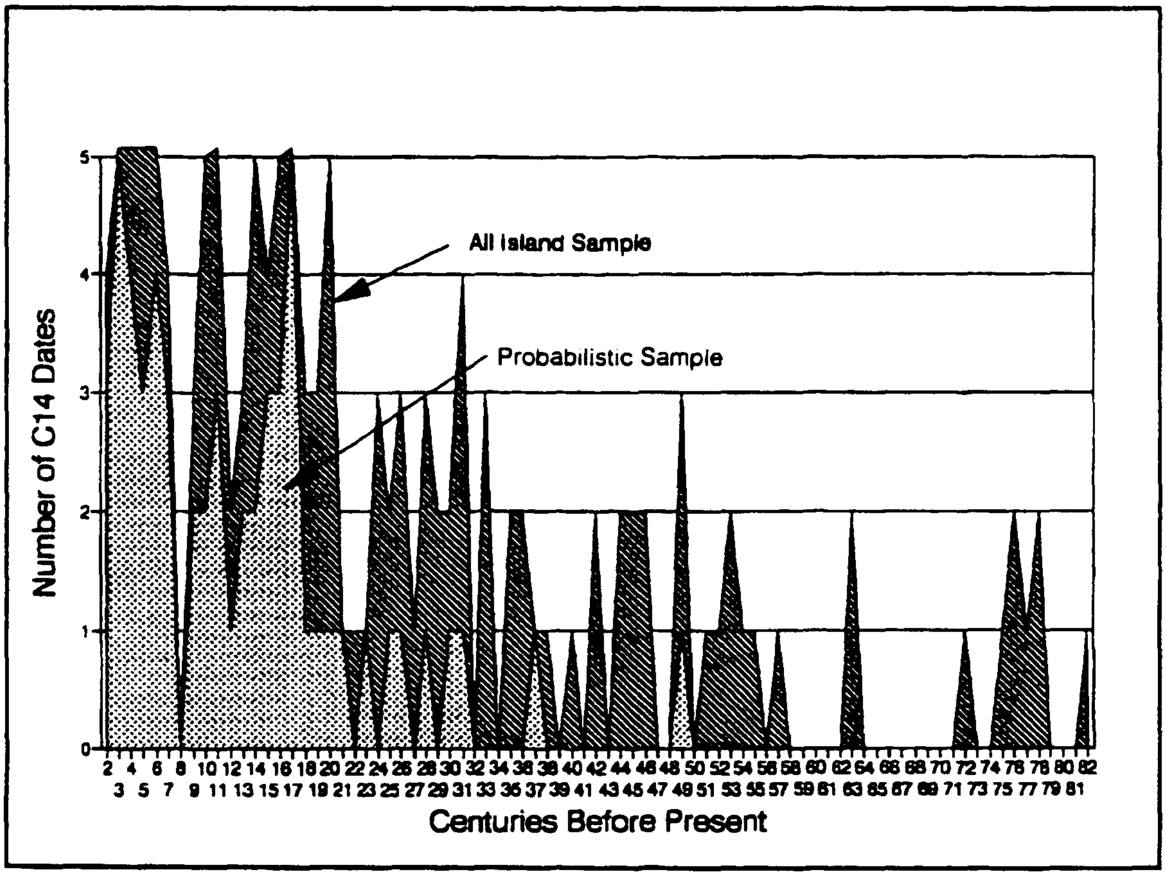

Figure 4.1. Frequency distributions of San Clemente Island radiocarbon dates (Raab and Yatsko 1998)

More important to the current discussion are the consistently high frequencies of dates in the Probabilistic Survey and all-island samples after about 2,000 RYBP, both being punctuated by a dramatic and synchronous drop to zero at 800 RYBP. Unlike gaps prior to about 3,500 RYBP, which likely reflect sampling error associated with work at Eel Point, the decline at around 800 RYBP is significant because it occurs in the midst of a trend otherwise characterized by multiple dates. This hiatus was originally noticed in 1992 when the then un-calibrated Probabilistic Survey dates were first plotted. It was noted that this interruption in the trend corresponded to the occurrence of late Holocene paleoenvironmental stresses in coastal southern California associated with marine paleotemperature and paleoclimatic conditions during the Middle-to-Late Period Transition between about A.D. 1100 and 1300 (ca. 650 - 850 RYBP). Researchers have drawn attention to this period as particularly stressful to coastal populations (Arnold 1992; Arnold et al. 1997; Jones et al. 1999; Raab et al. 1995a; Raab and Larson 1997). Among the hypotheses arising from this research is one that Channel Islands populations would have been particularly at risk from prolonged droughts, forcing the partial or complete abandonment of some islands during this interval.

Late Holocene Cultural and Environmental Stress

An important research challenge facing contemporary California archaeology is to understand the nature and development of prehistoric cultural adaptations, particularly in the area of cultural-environmental interactions. Some southern California researchers have called for a fundamental rethinking of the cultural and environmental dynamics behind culture change (Jones and Kennett 1996; Larson and Michaelson 1989). Archaeological research is increasingly demonstrating that the late Holocene was a period during which coastal Californian populations experienced a complex series of stresses capable of altering cultural organization.

Some scholars view California's past as a gradual, trans-Holocene cultural elaboration, with increasingly secure and productive lifeways attributable to technological innovations, the addition of new foods to the diet (such as acorns and marine resources), and complex social hierarchies (Basgall 1987; Bettinger 1991; Broughton 1994a, 1994b). Native peoples are presented by some as instinctive conservationists capable of maintaining stability, productivity, and biodiversity in whole ecosystems (Bean and Lawton 1996; Blackburn and Anderson 1994; Haley and Wilcoxon 1997; McCawley 1996). Such reconstructions rarely consider the possibility that locally heavy exploitation or environmentally induced stresses were important influences on culture change (Byrd et al. 1998; Jones et al. 1999; Raab and Jones 1997; Raab and Larson 1997).

Modeling Paleoenvironmental Influences on Cultural Evolution

Theoretical bases for models concerned with paleoenvironmental influences are found in population ecology. Understanding population dynamics is a fundamental research objective of all ecological research, including studies of prehistoric hunter-gatherer populations (Jochim 1979; Jones et al. 1999; Kelly 1995; Smith and

Winterhalder 1992). In recent years, Channel Islands researchers have addressed the question of what role paleoenvironmental forces played in the size and distribution of prehistoric island (and coastal mainland) populations. Increasingly, archaeologists working in the region are convinced that at least two paleoenvironmental influences -- sea temperature and late Holocene climatic perturbation -- exerted a significant influence on prehistoric cultural evolution in southern California. As noted earlier, the precise nature and cultural impact of these forces, individually or in concert, remains a matter of lively debate (e.g., Arnold 1997, Arnold et al. 1997 *contra* Raab and Bradford 1997, Raab and Larson 1997; also see Jones et al. 1999). Fundamentally, the goal of this line of research is to understand how the interaction of particular paleoenvironmental stresses and cultural adaptations affected cultural change.

Terrestrial Paleoclimatic Stress

Recent decades have seen a reexamination of prehistoric cultural change in coastal southern California within a newly developed, relatively high-resolution terrestial paleoclimatic record. Important is a 7,000-year pollen record from a radiocarbon-calibrated core taken from the San Joaquin Marsh at the head of Newport Bay, Orange County (Davis 1992). This record reveals major shifts in effective moisture, particularly during the late Holocene. Since San Joaquin Marsh fluctuates between fresh water and saltwater conditions, decreased stream flow and lower discharge of springs feeding the marsh permitted saltwater incursions beginning about 1,800 years B.P. Relatively low pollen deposition and sedimentation rates and the presence of marine-estuarine organisms and the pollen of salt marsh plants mark these incursions (Davis 1992). Conversely, comparatively rapid sedimentation rates, abundant palynomorphs, and high percentages of *compositae* pollen marked periods of high stream flow (Davis 1992).

Tree-ring data are also recognized as important indicators of precipitation rates and other paleoclimatic phenomena (Fritts 1976), but these have only recently become available from coastal southern California. Larson and Michaelsen (1989) and Larson et al. (1994) investigated late Holocene southern California paleoclimate through analysis of tree-ring records from the Transverse Ranges of central Santa Barbara County and the San Gorgonio Mountains. Michaelsen et al. (1987) used tree ring samples obtained from a stand of big cone spruce (*Pseudotsuga macrocarpa*) in the Transverse Ranges to develop a dendrochronological record extending from A.D. 1600 to A.D. 1980. Larson and Michaelsen (1989) extended this climatic reconstruction further back in time through a regression analysis performed using tree-ring data from San Gorgomio Peak in San Bernardino County. This latter record begins at A.D. 400. Bivariate regression equations were used to predict precipitation rates for the region. These were verified through calibration with historic records and comparisons with other reconstructions. In this way, it was possible to assign estimates of annual precipitation for those prehistoric years for which only tree-ring data were available.

Their analysis shows that between A.D. 500 and 650, climatic conditions were distinguished by moderately low precipitation levels (Larson and Michaelsen 1989). Very low rainfall levels followed this period from A.D. 650 to 800, with extreme drought experienced between A.D. 750 and 770. The succeeding 200 years (A.D. 800 to 1000) marked a sustained high-precipitation interval unmatched in the entire 1600-year reconstruction. Between A.D. 1100 and 1250, climatic conditions maintained sustained low precipitation levels for a period of more than 150 years. The interval between A.D. 1120 and 1150 was particularly harsh. Consistent with the San Joaquin Marsh pollen record, the interval from A.D. 1100 to 1300 is reconstructed as one of extreme drought conditions.

The trends reconstructed by Davis (1992) and Larson and Michaelsen (1989) are corroborated by paleoclimatic evidence from other regions of southern California. Enzel et al. (1989) report that shallow lakes existed twice in the Silver Lake playa of the Mojave Desert during the late Holocene. The Silver Lake playa at the terminus of the Mojave River now receives water only from extreme floods, with water from smaller floods filtered out by the Mojave River before reaching this terminal playa. A core from Silver Lake playa produced lacustrine sediments indicative of two lake-forming episodes during the late Holocene; these are interpreted to result from atmospheric patterns that allowed unusually severe North Pacific storms to enter southern California. These two Silver Lake flood episodes again correspond to intervals of comparatively high moisture at San Joaquin Marsh. In the eastern Sierra Nevada, bristlecone pine (*Pinus longaeva*) tree-rings show decreased moisture accompanied by a sharp rise in temperature at about A.D. 1100 (Mehringer 1986). Based on analysis of fossil pack rat middens from the eastern Mojave Desert, Cole and Webb (1985) conclude that the area was drier than at present between 500 and 2,000 years B.P.

Other important evidence of climatic deterioration during the period is provided by Stine (1994) in the form of radiocarbon dates from drowned trees in Sierra Nevada lakes, streams, and marshes. These trees grew during dry-period low-water stands and were killed as water levels rose with the return of wetter conditions. Dry periods occurred at the same time in four study locations, indicating a regional drought. Stine (1994) found that two protracted droughts occurred at about A.D. 892 to 1112 and A.D. 1209 to 1350, climatic events lasting more than 220 years and 140 years, respectively. However, the latter event has only an incomplete overlap with the lowest moisture levels recorded at San Joaquin Marsh and in Larson and Michaelsen's tree-ring data, while the former has almost none. There are clearly inter-regional differences in the synchrony of paleoenvironmental change across western North America (Jones et al. 1999).

A comparison of paleoclimatic reconstructions by Stine (1994) and Larson and Michaelsen (1989) shown in Figure 4.2 illustrates this interregional variability. While there are obvious parallels between the two reconstructions, their synchrony is skewed. Some of this variation may come from differences in temporal resolution between the radiocarbon dates used by Stine (1994) and the dendrochronological analysis conducted by Larson and Michaelsen. There may also be variability in larger climatic patterns due to differences in latitude. Overall, these differences in chronology suggest that these Sierran data have little direct utility for southern California.

Evidence for environmental variability during the Medieval Climatic Anomaly also comes from various locations beyond the limits of California, especially including the Southwest Puebloan area and the Great Basin (Jones et al. 1999). Paleoclimatic data from various settings in these areas show the period between ca. A.D. 800 and 1350 to be

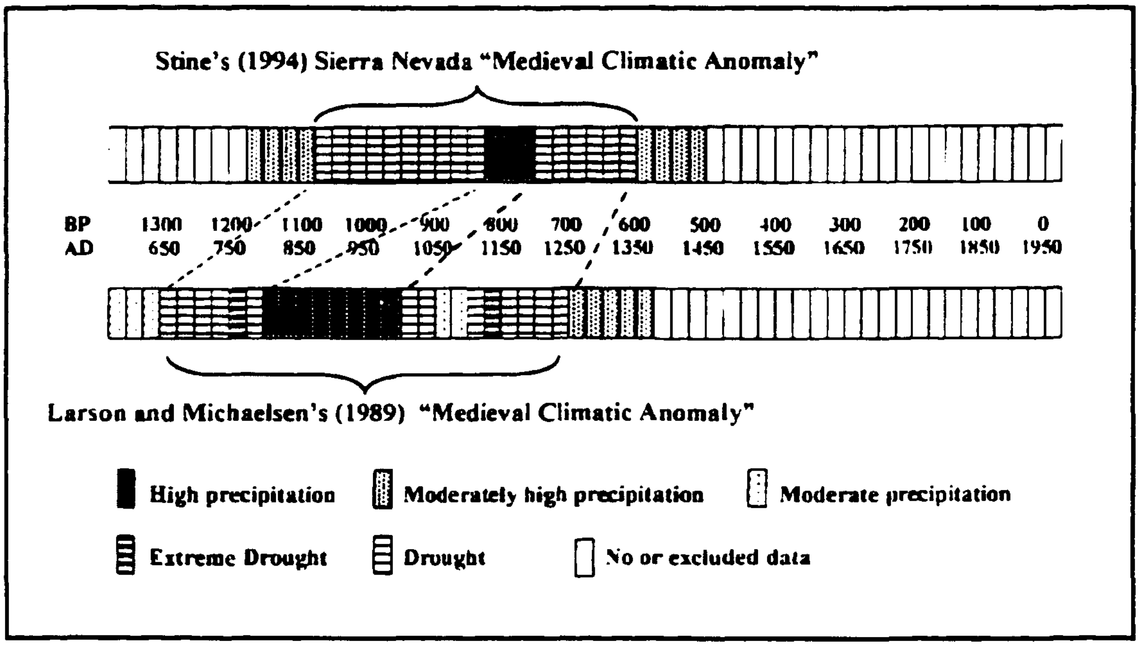

Figure 4.2. Synchrony of two California paleoclimatic reconstructions for medieval droughts

a time of generally warm climate (Hughes and Diaz 1994). However, the entire 600-year period was not consistently warm and dry throughout the larger region. Rather, it was punctuated by two intervals of extreme drought with locally differentiated durations (Graumlich 1993; Stine 1994). In some localities (Leavitt 1994), including the Sierra Nevada and Transverse Ranges, these periods of drought bracketed a shorter intervening period of high rainfall. The range of the high resolution Holocene paleoenvironmental record presented by Jones et al. (1999) suggests that high climatic variability was more the rule than the exception.

In sum, these data suggest that (1) southern California coastal tree-ring and pollen records reflect terrestrial paleoenvironmental conditions that affected the near coastal regions; (2) rainfall totals across southern California between about A.D. 500 and 1350 fluctuated significantly but were depressed for more years then they were elevated; and (3) late Holocene climatic deterioration was probably severe enough at times to disrupt cultural systems (Raab and Larson 1997).

Discussion and Hypotheses

This project investigates the spatial and temporal relationships between the distribution of dated island sites and localities of available surface water. Droughts during the Medieval Climatic Anomaly described by Larson and Michaelsen (1989) and others would have had direct effects on San Clemente Island's terrestrial ecosystems by impacting available water sources while also likely reducing the production of terrestrial food resources (Jones et al. 1999). These extended drought periods should minimally have resulted in patterns of settlement restricted by the need to be near a reduced number of year-round water sources. Island residents may have also transported water from hard-to-access sources over limited distances. Other mechanisms for dealing with the island's aridity might have been employed, including selecting residential sites near places where water loss could be reduced through the use of natural windbreaks. Rock outcrops, ridges, dunes, and other natural features that block the prevailing west and northwest winds almost invariably were associated with occupation sites in their sheltered lee.

The Nursery Site (CA-SCLI-1215) is an example of the latter phenomenon; this large, complex deposit is sheltered in the lee of a fossil dune formation. Despite the fact that this site is one among a significant number of occupation loci present across this area of the island's Plateau, there are no permanent or even intermittent water sources currently observable. Elsewhere on the island, significant clusters of site loci also occur at the heads and/or mouths of the major canyons near natural water catchments that currently represent the most apparent persistent water sources on the island (see Figure 4.3). However, with the presence of prehistorically abundant shrub vegetation now lost to historic overgrazing, the fossil dune terrains on the central Plateau (encompassing the Nursery Site and Old Airfield areas) could have held small aquifers with the potential to create perennial seeps or springs. Recent microclimatic research on Santa Cruz Island has shown that leafy vegetation can triple the amount of annual precipitation dripping directly under it (E. McIntire, personal communication, 1993). Similar mechanisms on San Clemente Island could have amplified the local fog banks and the normally sparse precipitation, charging and maintaining small aquifers in these fossil dunes. Overgrazing and other historic alterations of the island's ecosystem have also accelerated erosion in these upland terrains, promoting arroyo cutting in the soft eolian deposits. Along with vegetation loss, arroyo cutting has likely further decreased the aquifer potential of these eolian deposits in ways similar to historic desertification in the American Southwest (see Cooke and Reeves 1976; Dobyns 1981).

Any prehistoric occurrences of spring activity associated with the eolian deposits of the Plateau have disappeared in the modern period. However, some artificial water collection structures (earthen dams, collection boxes, etc.) constructed during the island's historic ranching period (ca. 1870 to 1934) are situated at the edges of these fossil dune deposits and in locations that appear likely to have been associated with now absent

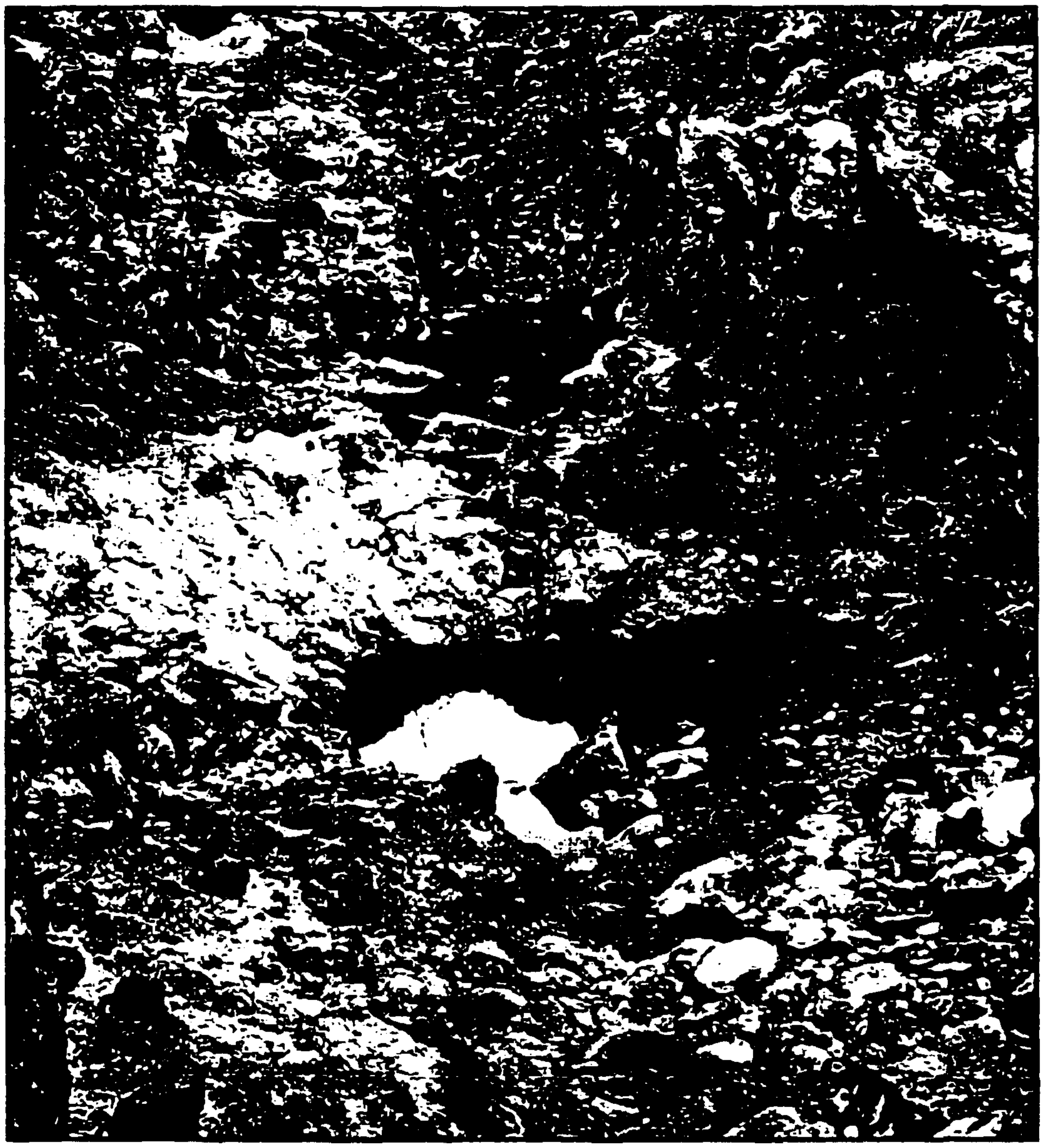

Figure 4.3 Surface water held in bedrock basins in lower Eel Cove Canyon, San Clemente Island, May 1999.

springs or seeps. These suspected prehistoric water sources represent areas with potential for the concentration of aboriginal occupation during periods of reduced rainfall. Dates for sites near these loci should have a higher relative frequency during periods of assumed climatic stress as defined by Larson's (1987) dendroclimatic curve. An absence of sites in these locations (and elsewhere on the island) dating from periods of climatic stress would be seen as indirect evidence of island abandonment.

Hypotheses

Based on the geographic and hydrologic variables discussed, I have proposed two alternative hypotheses for the prehistoric population's response to limited water availability during the Medieval Climatic Anomaly.

The first proposes that the pattern of residential settlement during the Medieval Climatic Anomaly involved a reduced number of sites concentrated around a small number of good water sources. Evidence for this will be found in a reduced frequency in site dates from periods of persistent drought between about A.D. 650 to 800 and A.D. 1100 to 1250 during the Medieval Climatic Anomaly. The frequency of dates will be higher, and the distribution of dated sites more spatially dispersed, during moister periods.

The alternative hypothesis is that the prehistoric populations on San Clemente Island migrated off island in response to punctuated periods of worsening drought during the Medieval Climatic Anomaly. A complete absence of dated sites dates during the period would constitute evidence in support of this hypothesis.

These hypotheses impose two data requirements. First, a new, supplemental sample of sites must be chosen for their spatial affinities to assumed prehistoric water sources and dated. The sample must be distributed across the different hydrological potentials of the island. Second, the resulting spatial-temporal data must be analyzed to identify any correlation with the island's different hydrological conditions. Strategies used for collecting these required data are discussed next under Research Methods.

Chapter 5

Research Methods

Research methods employed in the collection of San Clemente Island site data for testing of the hypotheses fall into four general categories: (1) regional sampling to select areas of San Clemente Island from which to draw archaeological sites for testing; (2) site survey to locate site populations in these sampled areas; (3) selection of a sample of sites for testing; and (4) intra-site testing to recover datable carbon-source materials.

The first step, critical to the collection of the required data, is the survey sampling design for the island as a whole. Because this research grew directly from the Probabilistic Survey, it is important to first review the Probabilistic Survey's approach to sampling across San Clemente Island.

The Island-wide Sampling Design

Thomas (1974) suggests that the collection of prehistoric settlement data should address three criteria in order to be anthropologically relevant. First, it is not enough to generalize from an individual site or localized group of sites. Rather, all ecological aspects potentially influencing site location must be delineated for the region sampled. Second, because capricious sampling techniques affect interpretation of the relative importance of site categories, the data collection process should be as unbiased as possible. Finally, to the extent possible, the sampling design must provide useful *negative* evidence to show not only where specific activities took place, but also where they did not.

To obtain the statistically valid island-wide sample, my design of the Probabilistic Survey followed the recommendations of Thomas (1975) and others (Judge et al. 1975; Read 1975; Schiffer et al. 1978) for probabilistic sampling. Among the more efficient approaches to regional probability sampling, these researchers suggest systematic or stratified random transect survey (Judge et al. 1975; Read 1975). However, my past work over San Clemente Island's rugged topography demonstrated significant constraints to both site survey efficiency and provenience control for linear sampling (Yatsko 1989; Zanhiser 1981). For these reasons, I selected quadrats as the Probabilistic Survey's sample units, distributed as a stratified random sample (Yatsko 1991).

The island's terrain provinces provided a logical basis for stratifying the sample (Yatsko 1996c). Already observed differences in site density and distribution among these topograhically-defined strata suggested that they present an unequal range of residential and subsistence opportunities to prehistoric residents (Yatsko 1989). But not all terrains provide comparable opportunities for survey. For instance, while the Eastern Escarpment and Major Canyons terrains are known to contain isolated archaeological loci (e.g., occupied rock shelters), their steep, dissected topography does not provide survey conditions comparable to the island's dominant terraced topography. They were excluded as sampling strata.

The Sand Dunes terrain province was also excluded because the discrete character typical of midden sites on the island's other terrains has been compromised in deposits on this unstable terrain by significant deflation. This has resulted in sites on the Sand Dunes consisting largely of deflated, surface-only artifact scatters with very little comparability to loci in the three remaining terrains – the Coastal Terrace, the Upland Marine Terraces, and the Plateau.

These other three landscapes contain abundant level ground suitable for habitation and provide good topographic comparability for sampling. On the Coastal Terrace and Upland Marine Terraces, the terrace platforms and fossil sea cliffs are sharply defined. These terrains have clearly-defined boundaries in the form of fossil sea cliffs and sharply incised canyons (Yatsko 1996c). Finally, all three are somewhat ecologically differentiated and were likely more so before historic grazing affected their botanical communities (Bruce 1994).

As discussed earlier, assessment of the aborted 10% island-wide survey (Smith 1988) revealed its sample size to be insufficient to adequately investigate variability across the terrains (Yatsko 1988), so I selected 15% as the size of the Probabilistic Survey sample. Sample units were proportionally drawn from the approximately 79% of the island encompassed by the Coastal Terrace, Upland Marine Terraces, and Plateau terrains. The 15% sample was distributed as 2 km^2 of the Coastal Terrace, 8.5 km^2 of the Upland Marine Terraces, and 7.75 km^2 of the Plateau. To select individual sample units, each terrain stratum was overlain with a 500-meter-square (25 ha) grid oriented on the Universal Transverse Mercator (UTM) system. Grid squares within each terrain stratum were numbered sequentially, with a table of random numbers used to select a 15%

sample. Figure 5.1 shows the distribution of the resulting 73 sample units.

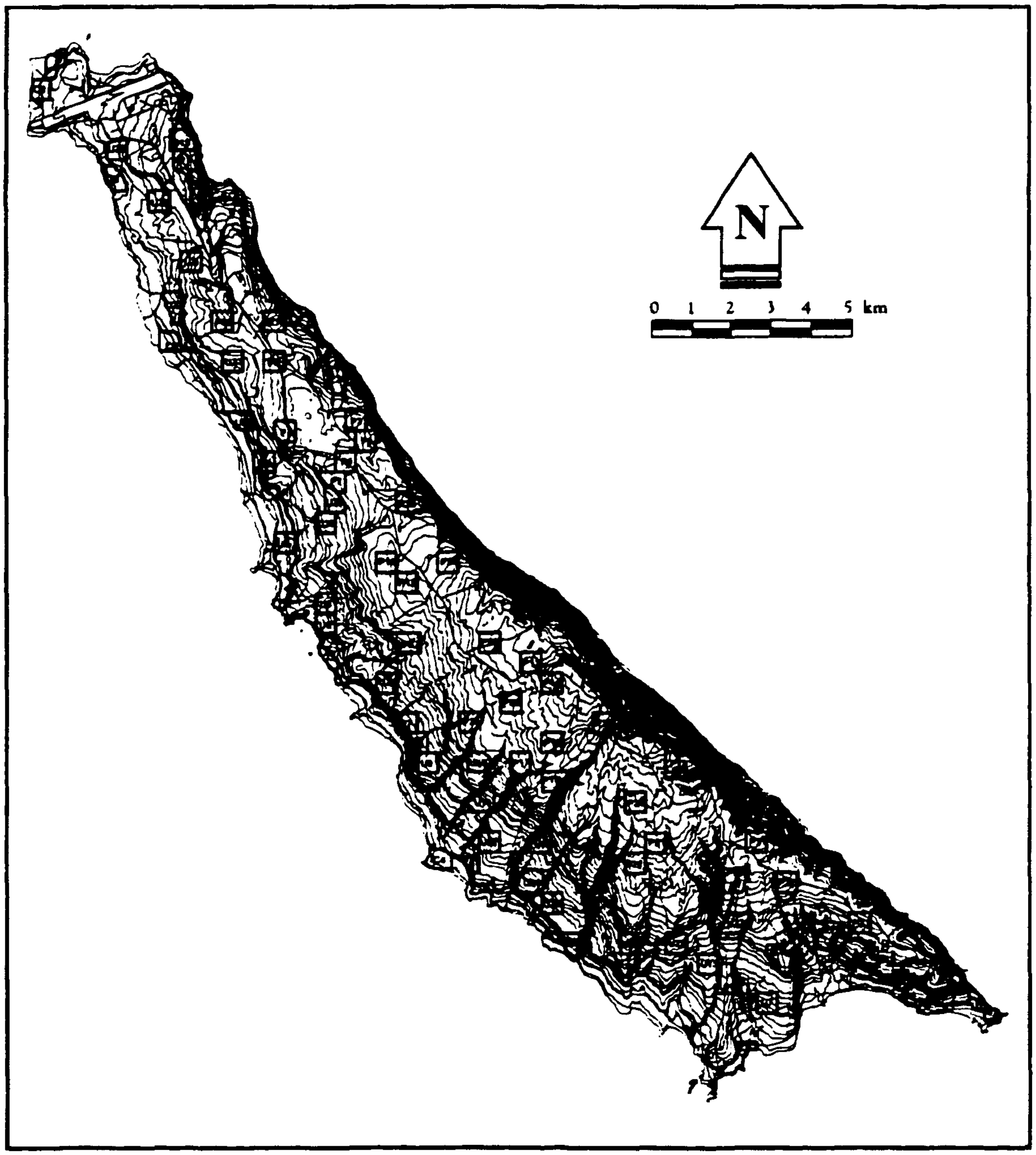

Figure 5.1 Distribution of Probabilistic Survey sample units

Inter-Site Sampling

The Probabilistic Survey documented 1,143 sites within the 73 sample units (Yatsko and Raab 1997). I selected a stratified random sample of 30 sites for testing, defining the sampling criteria within the site-description typology described earlier. Selection started at the sample unit level. Fifteen Probabilistic Survey sample units were randomly selected, with these proportionately distributed by area among the three sampled terrains. Two sites were then randomly selected from each of these fifteen sample units. These were proportionately chosen from the sites within each terrain stratum for each of the two site types (carbonaceous and deflated) expected to produce datable charcoal and shell.

Defining a New Sampling Strategy

Developing a sampling approach for testing temporal and spatial correlation between site locations and island water sources first required close examination of the three terrain strata. As described earlier, the Probabilistic Survey indicated the presence of site clusters at the upland heads and coastal mouths of the major canyons in probable association with natural water-catchments (e.g., bedrock basins, plunge pools, gravel lenses) (Yatsko and Raab 1997). Similarly, the Probabilistic Survey and other contiguous surveys show site clusters in association with fossil dunes over the northern island. As noted, these eolian deposits currently show no evidence of semi-permanent water sources (e.g., springs or seeps). The working assumption is that these fossil dunes prehistorically held small, perched aquifers which produced perennial or seasonal springs at their margins' contacts with the underlying volcanic bedrock. Differentiating terrain according to these two potential water sources (i.e., surface-held runoff vs. groundwater) provides a basis for stratifying a new sampling design.

My original dissertation proposal (Yatsko 1994b) suggested two alternatives for expanding the surveys. These were at first intended to test whether the depressed frequency of Probabilistic Survey radiocarbon dates during the Medieval Climatic Anomaly is a valid representation of the island's chronology or a sampling error. To accomplish this, I could have either drawn an additional random sample from the existing Probabilistic Survey sample units or used the Probabilistic Survey's regional sampling parameters to select several additional 25-ha sample units. However, my decision to use hydrological conditions as regional sampling strata superceded both approaches.

I did not consider the standard 25-ha sample unit used in the Probabilistic Survey large enough to adequately represent hydrology-correlated patterning, especially in areas of the Plateau known to have low site density. Therefore, I developed an alternative strategy to sample larger, contiguous areas of each hydrologic stratum. To maintain comparability with the Probabilistic Survey, I initially chose to retain the three terrains (Coastal Terrace, Upland Marine Terraces, and Plateau) as the primary sampling strata. However, comparability also required that the survey areas be proportional in size to the three strata. This would have required multi-km^2 sample units. It was apparent to me that the size of the samples from the Plateau and Upland Marine Terraces would have been very large and that surveying across all three terrains would have required a field effort beyond what was practical for this research. To establish reasonable limits, I therefore chose to restrict the investigation to upland drainage catchments along the Plateau's crest and drainage channels as these flow across the Coastal Terrace.

This excluded the intervening Upland Marine Terraces terrain from the expanded survey sample. This decision reduced fieldwork by almost half and can be justified as follows. Where drainage catchments coalesce on the Plateau, their dissection of the terrain is relatively shallow and water is readily accessible. However, as these drain off the Plateau and across the Upland Marine Terraces, canyons rapidly become steeply incised into the terraces and accessibility is difficult. Accessibility to water improves again as these drainages open onto the Coastal Terrace. I assume that investigation of the Upland Marine Terraces would not produce site data comparable to those from the Plateau or the Coastal Terrace regarding human access to water.

Defining hydrologically differentiated sampling strata requires examination of water source areas (e.g., surface-held water vs. groundwater) and their geological associations. The presence or absence of fossil dune deposits on the Plateau was used to differentiate upland source areas. Geologically mapped areas of the Plateau overlain by fossil dune deposits constituted one sampling stratum, and Plateau bedrock areas constituted another (see Figure 2.2). On the Coastal Terrace, sampling strata were defined on the basis of the corresponding upland geology. In taking this approach, I assume that the geologic character of different drainages' upland source areas create different potentials for water availability along their lower courses. For example, fossil dune source areas are expected to buffer the release of precipitation to the associated downstream areas of the Coastal Terrace. On the other hand, drainages originating within bedrock uplands, where rapid runoff releases water more quickly downstream, would be more episodic and less persistent in flow.

However, because it is within the range of possibility that periods of persistent drought might limit water availability in both hydrologic systems, one system type is not ranked higher than the other with regard to expected water availability during climatic stresses. For instance, prehistoric aquifers that may have existed in upland fossil dune deposits might have had normal precipitation amplified by fog drip. Such a situation would have provided more potential for collecting and discharging water during periods of reduced precipitation than would be expected in bedrock areas. Nevertheless, potential aquifers in these fossil dune deposits are relatively small and possibly sensitive to protracted periods of drought. By contrast, drainage systems originating on bedrock uplands depend on annual precipitation to keep their catchment pools filled and may persist quite variably from year-to-year. During drought years in the mid-1980s, however, these bedrock catchment systems required only one significant rainfall episode to be recharged. Even so, this recharging process might not reliably occur during any rainy season that did not produce significant rainfall episodes.

The sample surveyed for each hydrological stratum needed to cover portions of the Plateau and the Coastal Terrace sufficiently large to investigate the correlation of archaeological sites and likely ancient water sources within any individual drainage. To do this, I defined the survey coverage by first determining average areas of the Plateau terrain encompassed within dendritic drainage catchments originating on fossil dune and bedrock geologies. Mapped extents for both upland geological contexts suggest that a survey area of approximately 4.0 km^2 each is required to cover both bedrock and eolian drainage catchments on the Plateau (see Figure 2.2). The Plateau terrain stratum is roughly four times larger than the Coastal Terrace (Yatsko 1996c). A proportional sample of the Coastal Terrace is therefore approximately 1.0 km^2. To maximize dispersal of the expanded sample across the island, the study areas selected represent different drainages for each terrain province rather than both ends of a single drainage system. These criteria were used to define four hydrologically-based study areas, two on the Plateau and two on the Coastal Terrace.

Plateau Study Areas

Two Plateau study areas were judgmentally selected, one each from eolian and bedrock terrains. These are respectively referred to as the Old Airfield Study Area and the Middle Ranch-Box Study Area.

Old Airfield (OAF) Study Area

The 400-ha (988 acre) OAF Study Area covers the larger portion of a mid-Pleistocene fossil dune deposit overlying the north-central Plateau around the island's Old Airfield (see Figure 2.2). Its topography consists of two parallel northerly-trending

Figure 5.2. OAF Study Area viewed from the northwest. The study area lies across the rounded terrain in the background. The rolling character of this area of the northern Plateau results from its overlying fossil dune deposits.

ridges that rise toward the south between 180 m and 275 m elevation. The majority of the study area is drained to the northeast coast of the island by a deeply incised gorge, Chamish Canyon. Numerous minor arroyos drain the western margin across adjacent UplandMarine Terraces to the Coastal Terrace. The area's deep, fine-grained soils have only minor dissection by dendritic erosion channels, probably indicating that rainfall is rapidly absorbed. The study area's rolling, gradually-sloped terrain is presently covered with annual grassland vegetation (Figure 5.2). However, early historic sources indicate that the vegetation was originally a perennial grassland-shrubland mosaic (Bruce 1994). Past disturbance by World War II-era development of the "Old Airfield" has significantly affected the OAF Study Area's southwestern quadrant, but the largest portion of the study area appears undisturbed.

I selected the OAF Study Area over other areas of fossil dune geology on the Plateau (like that surrounding the Nursery Site) partly because it had already been subject to adequate archaeological site surveys. Two recent projects conducted stratified, random sampling of study area sites for evaluation of National Register eligibility. Included in the Mesa College survey of the late 1970s, the study area was resurveyed under contract in 1988 and 1990 (Axford 1984; Berryman and Berryman 1988; TMI Environmental Services1990) and includes all or part of Probabilistic Survey sample units P3, P4, and P5 (Yatsko and Raab 1997). A 1993-94 contracted study by M. Raab and the NCPA entailed testing 18 selected OAF Study Area sites to determine their National Register of Historic Places eligibility and produced 10 radiocarbon dates (Raab et al. 1997).

Middle Ranch - Box (MRB) Study Area.

The MRB Study Area covers a 3.95 km^2 (975 acre) portion of Plateau bedrock terrain encompassing the upper Norton Canyon drainage between upper Middle Ranch Canyon to the northwest and the head of Box Canyon to the southeast (Figure 2.2). This area of the island Plateau, with its topography carved into andesitic and dacitic bedrock, contains no Pleistocene eolian deposits. The study area's slightly stepped topography rises to the northeast between elevations of 400 m and 565 m (Figure 5.3). The sparse vegetation is transitional between Maritime succulent scrub and Grassland. Except for two minor roads and one small antenna facility, the study area is undisturbed.

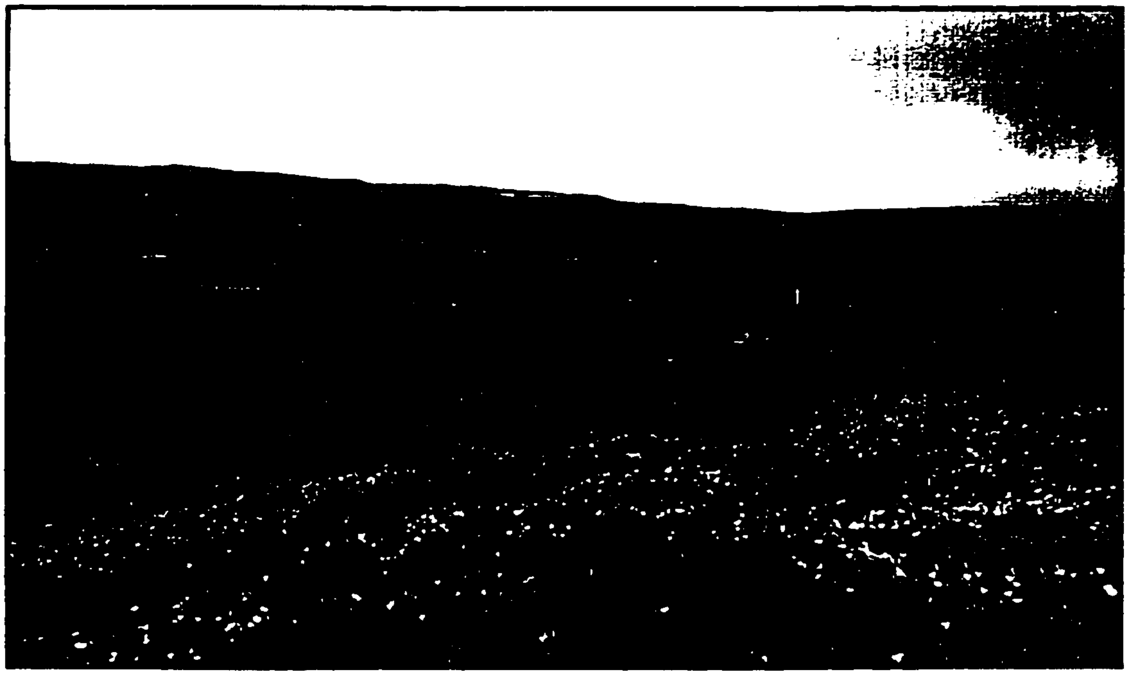

Figure 5.3. Central portion of MRB Study Area viewed from the north. The upper Middle Ranch Canyon drainage crosses the foreground.

What bedrock soils exist here are thin and clayey, creating local hydrologic conditions where the expansive soils and the abundant exposed bedrock quickly direct rainfall as sheet flow into intersecting arroyos that coalesce into the three named canyons. These arroyos and canyons dissect the generally rolling, flattened terrain, and create innumerable scoured or gravel-filled basins in their bedrock bottoms. Their bedrock water catchments hold quantities of runoff ranging from hundreds to thousands of liters. As described earlier, these drainages are relatively shallow and readily accessible as they cross the Plateau, but deepen and become progressively less accessible as they cross from the Plateau into their deeper gorges in the Major Canyons terrains that transect the adjacent Upland Marine Terraces.

I selected the MRB Study Area over other Plateau bedrock areas because it was cleared by an accidental fire that swept across this part of the south-central Plateau in July 1994. This serendipitous occurrence provided the opportunity to conduct site survey in the absence of masking vegetation. The distribution of archaeological sites in this area of the Plateau was previously known only from results of the Probabilistic Survey. The study area boundary consolidates all or parts of Probabilistic Survey sample units P14, P16, P17, P29, and P30.

Coastal Terrace Study Areas

For the research on the Coastal Terrace terrain, I defined two study areas based on their downstream relationship to different drainage types on the adjacent Plateau. These were also selected to represent upland sources different from those encompassed in the Plateau study areas. Referred to as the Shell-Abalone Study Area and the Mail Point Study Area, they respectively lie downstream from eolian and bedrock uplands.

Shell - Abalone (SA) Study Area

The SA Study Area covers a 2-km-long, 110-ha portion of the Coastal Terrace on the island's northwest coast (see Figure 2.2). As is characteristic of the entire Coastal Terrace (Yatsko 1992), the elevation of the study area's flat, regular terrain rises from sea level to the 30-meter contour (Figure 5.4). It is predominantly covered by *Lycium*-phase Maritime succulent scrub vegetation. The SA Study Area hydrology includes three streams that drain the fossil dunes on the adjacent Upland Marine Terraces and on the

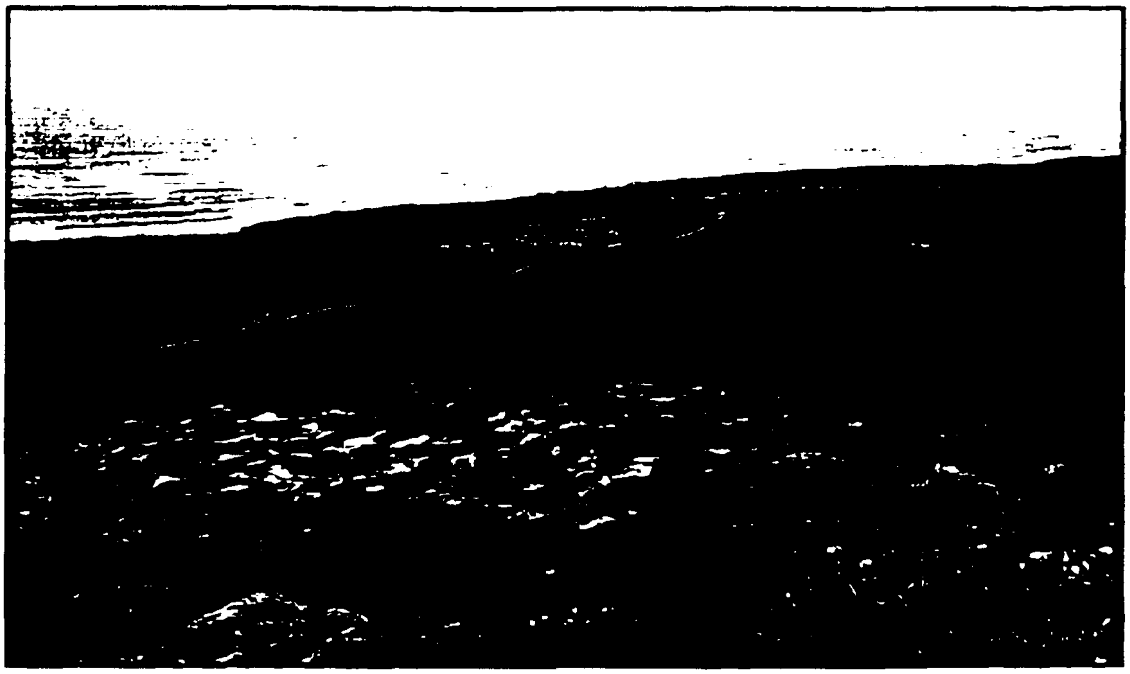

Figure 5.4. SA Study Area viewed to the northwest across the Upland Marine Terraces from the Plateau.

Plateau surrounding the Nursery Site. This stretch of Coastal Terrace is just south of the Sand Dunes area but contains no substantial eolian deposits. However, the easily eroded upland has contributed abundant fine alluvium to a large portion of the northern SA Study Area, burying the original terrace surface under two substantial alluvial fans. With the exception of a longitudinally transecting road, and some clustered WWII-era development in the study area's northwest quadrant, the area is largely undisturbed.

Like the OAF and MRB areas, the SA Study Area had been subject to earlier archaeological site surveys (Axford 1984; McKusick and Warren 1959; TMI Environmental Services 1992). The southern 40 ha of the study area were also one focus of my 1986-88 data verification resurveys (Yatsko 1989), of which 25 ha were selected as Probabilistic Survey sample unit C6. Five archaeological deposits in the southern part of the SA Study Area were subject to systematic testing as part of the Summer 1989 CSU Northridge field school (Raab 1993).

Figure 5.5. MP Study Area viewed from the northwest above Seal Cove. The study area occupies the narrow marine terrace between the shoreline and the base of the first fossil sea cliff.

Mail Point (MP) Study Area.

Located approximately 2 km southeast of Eel Point, the MP Study Area covers a 3.5-km-long, 102-ha segment of the Coastal Terrace south from Seal Cove along San Clemente Island's central west coast (Figures 2.2 and 5.5). The study area is generally covered with a *Lycium*-phase Maritime succulent scrub vegetation that still shows effects of turn-of-the-century over-grazing by cattle. The study area is transected by two named canyons (Wall Rock and Warren), with the southern margin defined by a third (Waynuk

Canyon). All three drain the bedrock Upland Marine Terraces and Plateau terrains adjacent to the MRB Study Area. The Coastal Terrace here includes no eolian deposits. However, where Warren and Waynuk canyons open onto the Coastal Terrace, they have mounded substantial, cobble-and-boulder alluvial fans across the flat terrace surface. The only modern disturbance is a single graded road along the axis of the study area.

This study area has been subject to three earlier, incomplete surveys, including coverage by McKusick and Warren (1959) and Axford (1984). The northern 25 ha of the MP Study Area corresponds with the Probabilistic Survey's sample unit C3.

Field Methods

Field methods used in the location and testing of sites for the collection of datable material are those generally used in all sanctioned archaeological research on San Clemente Island. Since 1984, an ongoing goal in my development of the island's cultural resources management program has been to codify standardized methods for most aspects of archaeological research. Using the collective crucible of field schools, contracted research, individual graduate projects, and my own management-related fieldwork, I developed standards and protocols for archaeological site survey, site testing, data collection, artifact and materials analyses, and curation. These have been explicitly defined in both individual research designs and guidance documents (e.g., Raab and Yatsko 1990, 1998; Yatsko 1986, 1996a, 1996b, 1996c) and as specifications in scopes of work for contracted projects (e.g., Yatsko 1994b, 1998).

Site Survey Standards

Study areas were intensively surveyed on foot in order to locate all archaeological site loci. Standard archaeological field methods were used, conforming to standards defined in the Secretary of the Interior's Standards and Guidelines on Archeology and Historic Preservation (National Park Service 1983). The level of survey intensity varied in accordance with what was necessary to identify known types of archaeological sites. Parallel transects were used, with intervals conditioned by ground visibility. Under field conditions with open or sparse vegetation cover, the standard minimum survey interval was 12-15 m. Areas with generally heavy vegetation were covered using a survey interval sufficient to identify the smallest known site size , usually 8-10 m.

All sites located during surveys were designated with temporary numbers, even previously known sites that had permanent state trinomials. This practice controlled for potential misidentification when differentiating among previously-recorded, known-but-undocumented, and previously-unknown sites during initial survey coverage. Final differentiation of sites' documentation status was usually delayed until completion of all location/relocation activities. The standard format for temporary field numbers was alphanumeric binomials combining a survey area acronym (e.g., "OAF" for Old Airfield, "MRB" for Middle Ranch-Box) and the sequential number for all sites located during the survey effort (e.g., OAF-1, OAF-2). All site records and other site documentation are on file with the Cultural Resources Management Program, Natural Resources Office, Navy Region Southwest, San Diego, California, with selected site records also filed with the

South Central Coast Information Center at UCLA.

Inter-Site Sampling Criteria

As with the Probabilistic Survey, I grouped archaeological sites in each study area by their descriptive midden category to create internal sampling strata. The selection of sites for testing involved (1) stratification of each study area's site population based on these descriptive midden categories (carbonaceous, deflating, and deflated); (2) exclusion of embedded and lithic scatter site categories; and, (3) random selection of a 10% sample from each remaining population of potentially datable loci.

Intra-Site Sampling

I conducted sampling within the sites selected for testing in two phases: auger probing to identify the subsurface presence and extent of carbonaceous materials and excavation testing to recover charcoal samples thus identified.

Auger Probing.

Auger probing began as a pair of perpendicular transects crossing at the site datum, probing at intervals of 2-3 m, depending on site size and time considerations. As necessary, supplemental transects were expanded outward at grid intervals of 4 m (for 2 m-interval probing) or 6 m (for 3 m-interval probing). Shorter-interval or arbitrarily-spaced probings were also used to better define a subsurface feature, to locate targeted materials, or to adjust to subsurface obstructions.

I conducted the probing using a standard, 10-cm-diameter (1 liter) bucket soil auger. Each bucket-full drawn from the deposit was screened through a 1/8" mesh augering screen which allows for quantification of relative ratios of ecofact/artifact densities by segregating coarse constituents in the screen and capturing the screened matrix in a graduated cylinder. The cylinder is graduated to indicate the volumetric percentage of coarse fraction caught in the screen. Each probing location was augered until sterile soil was encountered.

The locations of all auger boreholes were plotted on a base map for each site. The provenience (grid location and depth), coarse fraction-matrix ratio, and gross shell species and artifact content of each sample were recorded on a standardized auger field form. Application of the auger probing protocol in the MRB and SA study areas established that sites with deposits categorized as *deflated* will *not* contain sufficient readily-recoverable quantities of charcoal for dating. Thus, deflated sites were removed from the sample population.

Excavation Testing.

I used the recorded auger data to determine where to test a site's deposit. A 0.5 m x 0.5 m test unit was excavated in each site tested to recover radiocarbon samples for dating. These test units were dug in arbitrary 10-cm levels, using standard archaeological excavation methods (e.g., Hester et al. 1997; McGimsey and Davis 1977). Test units were dug to sterile soil and the material excavated screened through 1/8" mesh screen.

Excavation testing was documented on standard level record forms. Information recorded included all appropriate provenience data and an itemization of all associated artifacts. A soil sample was attached for later Munsell color identification, and a sketch was made of unit level features. In most instances, at least one profile of each excavated unit was also recorded. Level record forms and other documentation are on file with the Cultural Resources Management Program, Natural Resources Office, Navy Region Southwest, San Diego, California.

Data Collection

My comparison of dates from paired charcoal and shell samples collected during the Probabilistic Survey has revealed major inconsistencies in their temporal correlation. Whether this resulted from problems with the Survey's field sampling procedures or reflected actual variability through time in San Clemente Island's approximately 200-year local reservoir effect had not yet been determined at the time I initiated fieldwork. Research on this issue by the Radiocarbon Lab at UC Riverside is ongoing. Analysis of new, paired stratigraphically-controlled samples from the Eel Point Site indicate that the island's reservoir effect is variable over time (C. Prior, personal communication, 1995). Although these results are not yet conclusive, I consider shell dates from the island problematic and did not use them in this research. Thus, datable material for each tested locus is limited to samples of charcoal only. Where practicable during excavation, samples of charcoal were collected from each 10-cm level. Results of data collection are presented in the following chapter.

Chapter 6

Results of Data Collection

My data collection occurred between 1994 and 1998. Some of the data sets that I employed came from work accomplished prior to the dissertation research, including data from the OAF Study Area, which had been completely surveyed and sampled between 1991 and 1993. All or parts of the other three study areas also had been subject to earlier site surveys. All study areas contained between one and five Probabilistic Survey sample units, some with dated sites. The data that I have collected or compiled includes: (1) a comprehensive inventory of all surface archaeological sites in each study area; (2) information on the three-dimensional extent and contents of sampled sites from auger probing; (3) stratigraphic information from excavation testing; and (4) radiocarbon dates from charcoal collected in situ.

OAF Study Area

The OAF Study Area had already been subject to comprehensive site surveys, including contracted studies in 1988 and 1990 (Berryman and Berryman 1988; TMI 1990), the 1991-92 Probabilistic Survey (Yatsko and Raab 1997), and the 1993 OAF Site Evaluation Project (Raab et al. 1997). These earlier efforts had cumulatively documented 91 site loci (recorded as 80 sites), for an average density of 20 sites per km^2 (Figure 6.1). The Probabilistic Survey tested four site loci in sample units P3 and P4, resulting in five radiocarbon dates from charcoal, and the OAF Site Evaluation Project's site testing produced an additional seven ^{14}C charcoal dates (Table 6.1). The OAF Site Evaluation Project used site selection criteria comparable to those outlined for the Probabilistic Survey.

However, during analysis of OAF Study Area data from the 1993 site evaluation project, I determined that some sites tested had problems of data comparability with other tested sites. While military disturbances (e.g., airfield construction, roads) are apparent across the study area, some site deposits appear to have been displaced by other processes. Department of Interior records document U.S. Coast and Geodetic Survey (USC&GS) triangulation markers in the OAF area being displaced by "plowing" between 1878 and 1933 (Bruce 1994). Direct observation of plow marks in the ground surface in 1994 corroborated this account. A sharp demarcation separating disturbed and intact midden areas in site OAF–43 provided direct evidence for a boundary of the plowed terrain. This understanding cast doubt on the comparability of data recovered from plowed sites with those from undisturbed deposits nearby. As a consequence, the one charcoal-dated OAF Evaluation Project site (OAF-42) affected by plowing has been excluded from the sample.

All but two of the dated OAF loci are single-component deposits that fall within the "small" midden category, and each is assumed to represent one temporal occupation. Of the two multi-component sites, OAF-22 is a large cultural deposit consisting of four carbonaceous and deflating midden loci recorded collectively because of their connecting artifact scatter. OAF-22A's carbonaceous midden area and OAF-22C's small, one-

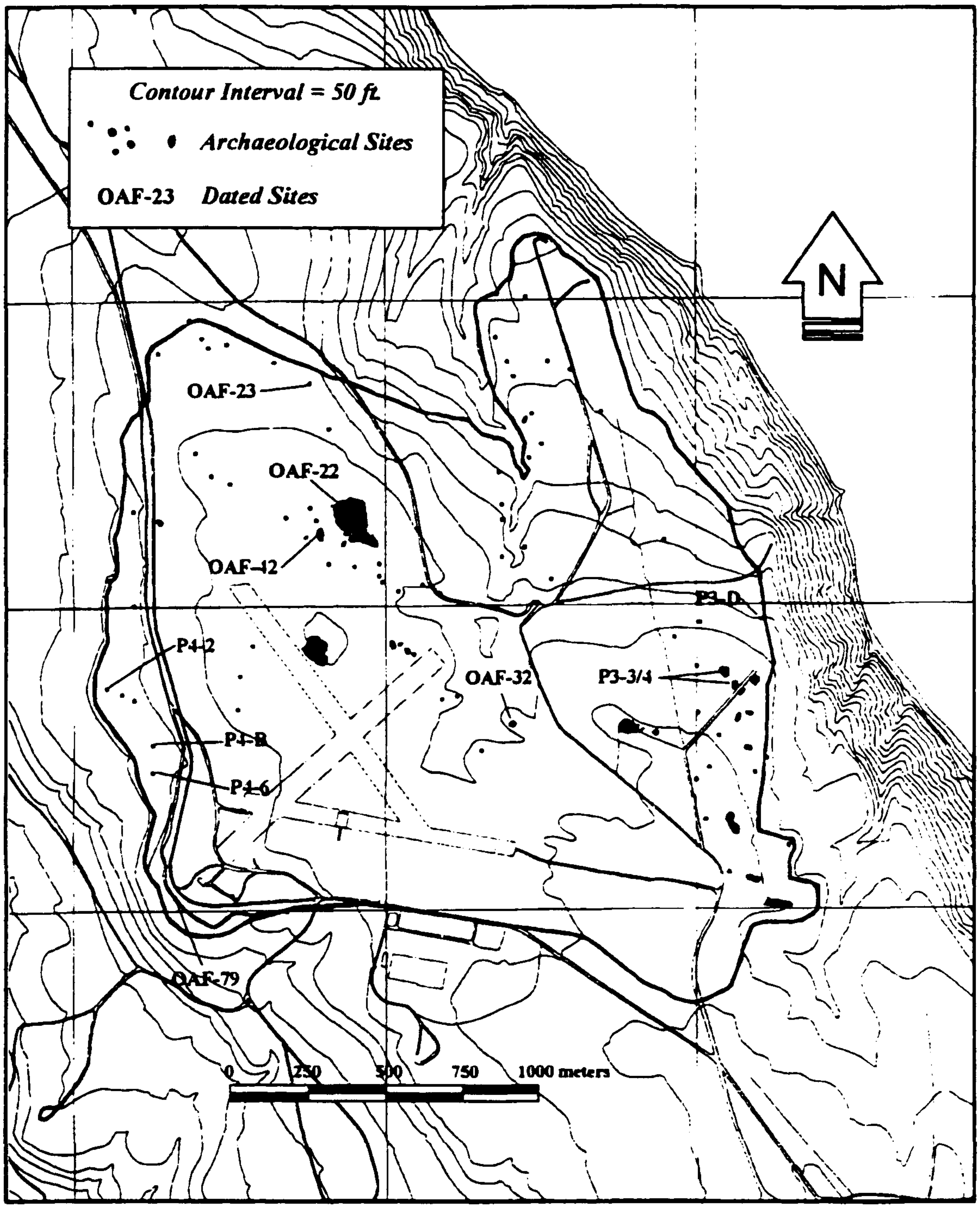

Figure 6.1 OAF Study Area and archaeological sites

component deflating midden were tested and dated during the OAF Site Evaluation Project (Raab et al. 1997). Site P3-3/4C is a moderate-size locus consisting of two, overlapping carbonaceous and deflated midden areas, both of which were tested and dated during the Probabilistic Survey (Yatsko and Raab 1997).

Beta No.	NRO No.	^{14}C Age[1]	$\sigma^{13}C$	^{13}C Adj.[2]	Calib. YBP[3]	Calendar Age[4]
76785	OAF-79	220 ± 60	-24.9	220 ± 60	308 – 271 (290)	*cal AD* 1642 - 1679 (1660)
51146	P4-B	320 ± 60	-23.9	340 ± 60	478 - 303 (381)	*cal AD* 1472 - 1647 (1569)
76777	OAF-23	350 ± 70	-26.6	320 ± 70	466 - 294 (403)	*cal AD* 1484 - 1656 (1547)
76780	OAF-22C	450 ± 70	-25.9	440 ± 70	526 - 340 (507)	*cal AD* 1424 - 1610 (1443)
51141	P4-2	490 ± 70	-23.1	520 ± 70	552 - 506 (529)	*cal AD* 1398 - 1444 (1421)
76782	OAF-32	610 ± 70	-24.6	620 ± 70	659 - 539 (587)	*cal AD* 1291 - 1411 (1363)
76778	OAF-22A	600 ± 80	-24.5	610 ± 80	659 - 539 (601)	*cal AD* 1291 - 1415 (1349
51137	P3-3/4-C	670 ± 60	-24.8	670 ± 60	664 - 557 (650)	*cal AD* 1286 - 1393 (1300)
51139	P3-3/4-D	1080 ± 70	-24.0	1100 ± 70	1065 - 936 (977)	*cal AD* 885 - 1014 (973)
51132	P3-3/4-C	1570 ± 80	-20.1	1650 ± 80	1683 - 1415 (1535)	*cal AD* 267 - 535 (415)
76776	P4-6	3020 ± 70	-13.6	3200 ± 80	3275 - 3472 (3398)	*cal BC* 1522 - 1325 (1448)

Notes:
1. All from charcoal, processed by Beta Analytic. Dates are in RCYBP (radiocarbon years before present; present = 1950 A.D.) Errors represent 1 standard deviation (68% probability).
2. C13/C12 ratios were calibrated relative to the PDB-1 international standard, and the RCYBP ages were normalized to -25 per mil
3. Dendrocalibrated age in YBP (years before present; *present* = A.D. 1950), with 1-σ range, and mean intercept in parenthesis; calibrated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993)
4. Dendrocalibrated calendar years, with 1-σ range, and mean intercept in parenthesis; calibrated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993)

Table 6.1 OAF Study Area radiocarbon dates

MRB Study Area

Approximately 1 km^2 of the MRB Study Area had previously been surveyed during the Probabilistic Survey in 1991 as all or parts of sample units P14, P16, P17, P29, and P30. One MRB Study Area site (P14-B) had been charcoal dated during the Probabilistic Survey. In late 1994, the remaining 3.0 km^2 was surveyed under contract as the Burned Area Survey (Gross et al. 1996; Yatsko 1994b). The 1994 survey results were combined with those from the Probabilistic Survey for a cumulative total of 142 archaeological loci, recorded as 132 sites for an overall site density of 33 per km^2 (Figure 6.2).

Ninety-four datable loci were initially identified as the sampled population (Yatsko 1995). A random, 10% sample of nine sites was selected for auger probing, with five alternates in case some of the primary sample did not produce charcoal. Six carbonaceous, four deflating, and seven deflated sites were auger probed. In application, however, the selection protocol for types of sites considered to be "datable" (i.e., carbonaceous, deflating, and deflated deposits) proved problematic. Probing the initial MRB site sample established that deflated loci consistently failed to produce quantities of charcoal sufficient for dating. Consequently, I adjusted the sampling protocol to eliminate deflated sites from the sampled population. This reduced datable MRB loci to 64 and the sample to be dated to seven. Of the 17 sites probed, seven (five carbonaceous and two deflating) produced sufficient quantities of charcoal to warrant testing. In late October 1997, all seven (MRB-A, -8, -54, and -61, P17-3, P30-11, and WMR-1) were tested and charcoal samples collected. Only P30-11 failed to produce a datable charcoal sample. The six resulting dates and the date from Probabilistic Survey sample unit P14 are presented in Table 6.2, and their corresponding sites labeled on Figure 6.2.

All but one of the MRB Study Area loci tested are small, single-component midden deposits. The exception is MRB-54, a large cluster of three deflating and deflated midden loci connected by their surrounding artifact scatters. The central,

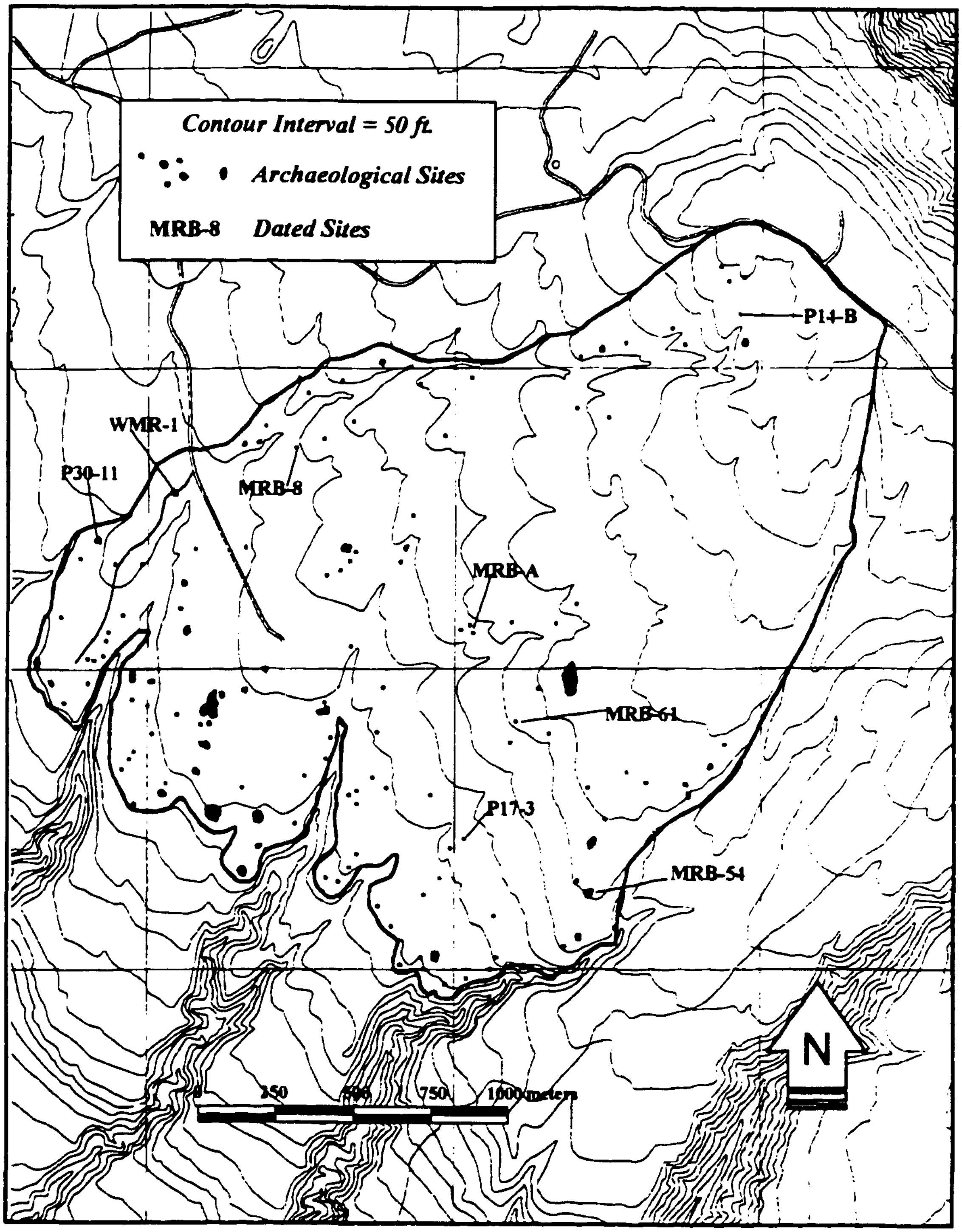

Figure 6.2 MRB Study Area and archaeological sites

deflating locus includes what is likely a house depression. Test excavation conducted in this depression recovered a charcoal sample and confirmed a compacted floor surface at the base of the cultural fill.

Beta No.	NRO No.	^{14}C Age[1]	$\sigma^{13}C$	^{13}C Adj.[2]	Calib. YBP[3]	Calendar Age[4]
120897	MRB-8	90 ± 50	-26.1	70 ± 50	130 – 30 (N/I)[5]	*cal AD* 1820 – 1920 (N/I)[5]
120896	MRB-61	70 ± 60	-24.9	70 ± 60	135 – 30 (N/I)[5]	*cal AD* 1815 – 1920 (N/I)[5]
120900	MRB-54	160 ± 40	-23.6	180 ± 50	225 – 135 (180)	*cal AD* 1725 – 1815 (1770)
120898	WMR-1	210 ± 50	-24.6	210 ± 50	285 – 270 (280)	*cal AD* 1655 – 1680 (1670)
120899	MRB-A	260 ± 60	-25.9	240 ± 60	310 – 275 (290)	*cal AD* 1640 – 1675 (1660)
120901	P17-3	270 ± 40	-25.0	270 ± 40	310 – 285 (300)	*cal AD* 1640 – 1665 (1650)
51121	P14-B	1500 ± 60	-24.8	1500 ± 60	1413 – 1315 (1354)	*cal AD* 537 – 635 (569)

Notes:

1. All from charcoal, processed by Beta Analytic. Dates are in RCYBP (radiocarbon years before present; present = 1950 A.D.) Errors represent 1 standard deviation (68% probability).
2. C13/C12 ratios were calibrated relative to the PDB-1 international standard, and the RCYBP ages were normalized to -25 per mil
3. Dendrocalibrated age in YBP (years before present; *present* = A.D. 1950), with 1-σ range, and mean intercept in parenthesis; calibrated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993)
4. Dendrocalibrated calendar years, with 1-σ range, and mean intercept in parenthesis; calibrated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993)
5. N/I = no intercepts. *Calib rev. 3.0.3* (Stuiver and Reimer 1993) plotted no intercepts for these recent conventional dates. However, Beta Analytic's calibration analysis provided the indicated YBP & cal AD/BC range based on -σ range for proximity to the dendrocalibrated curve.

Table 6.2 MRB Study Area radiocarbon dates

SA Study Area

Earlier surveys of the SA Study Area (Axford 1984; McKusick and Warren 1959; Yatsko 1989) had previously documented 163 archaeological loci, recorded as 150 sites. During late 1995 and early 1996, I resurveyed the northern half of the study area, which had not been covered during my 1986 resurvey of southern study area (Yatsko 1989). The 1995-96 effort located five previously undocumented site loci. I concurrently reviewed the overall SA area site inventory and refined the earlier total to178 discrete occupation loci, recorded as 160 sites (Figure 6.3). The majority of these loci are deflated or embedded deposits. Exclusion of embedded deposits and artifact scatters (n = 47) from sampling left 131 loci provisionally identified as datable. A random, type-stratified sample of 11 sites and 6 alternates was selected. Eight carbonaceous, four deflating, and five deflated site deposits were probed, of which 10 (seven carbonaceous and three deflating) produced sufficient evidence of charcoal for testing. As in the MRB Study Area, it was evident that deflated loci were not likely to be "datable." Exclusion of deflated SA site loci (n = 46) from the sampled SA population further reduced the number of datable loci to 85.

Nine sites were tested for recovery of charcoal, with eight producing sufficient amounts for dating. However, two of these samples (from SAN-27 and WSR-18) were subsequently misplaced. Fortunately, supplemental ^{14}C charcoal samples had been collected from three other SA Study Area sites (SA-59, SA-61, and SA-62) during the 1989 CSU Northridge field school. These sites had been selected using the criteria applied in the Probabilistic Survey (Raab 1993) and dissertation research, and I included them in the dating sample. The nine dates are presented in Table 6.3, and their corresponding sites are labeled on Figure 6.3.

An important finding during my 1995-96 resurvey was the number of buried site deposits exposed in stream bank profiles of the drainages transecting the northern SA Study Area. In this same area, my failure to relocate one site (CA-SCLI-243) that had been recorded in 1976 by Mesa College suggests that it has been buried under alluvial

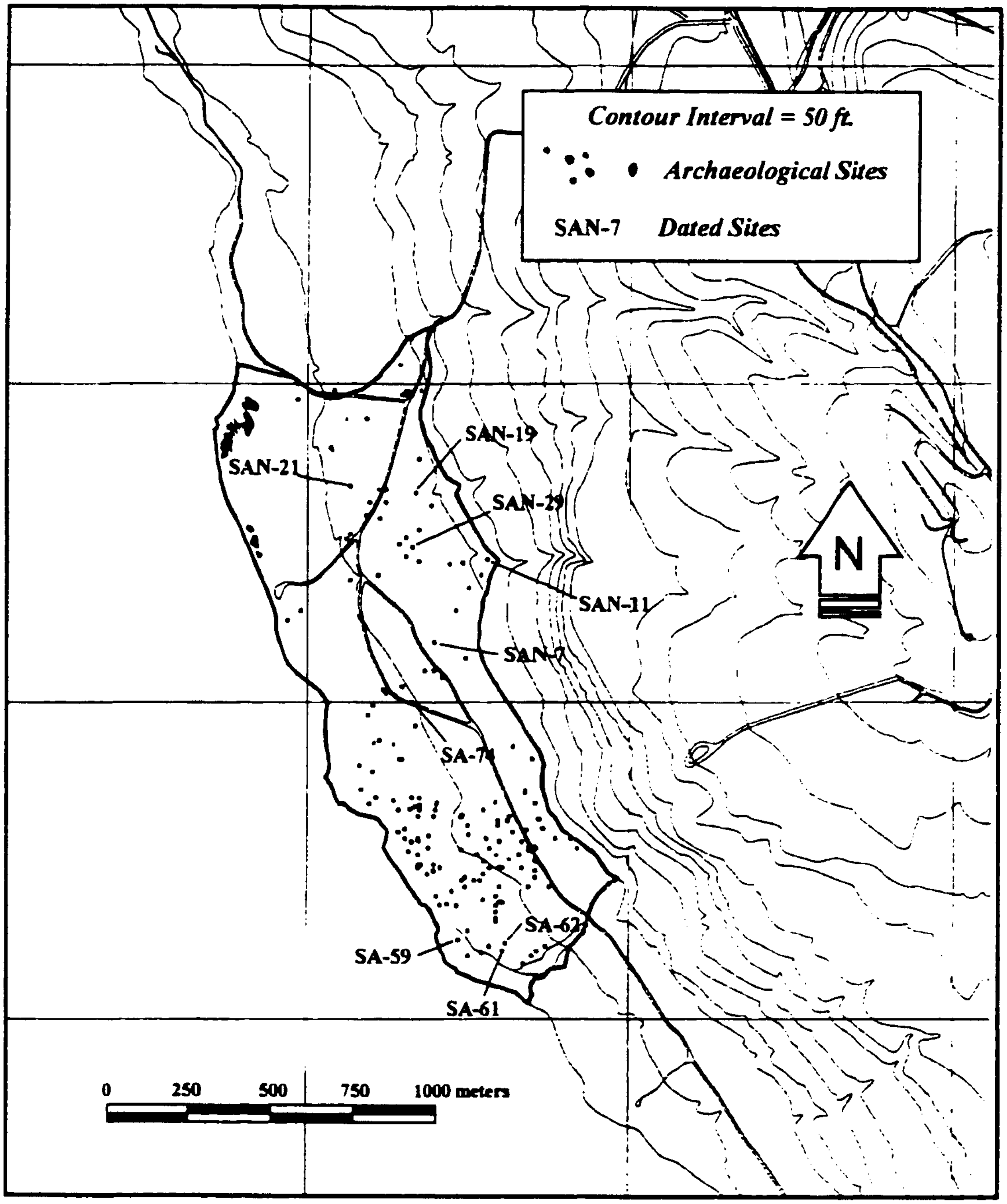

Figure 6.3 SA Study Area and archaeological sites

deposits in the last decade. These observations provide clear evidence of rapid, progressive burying of this terrain under sandy alluvial fans.

Beta No.	NRO No.	^{14}C Age[1]	$\sigma^{13}C$	^{13}C Adj.[2]	Calib. YBP[3]	Calendar Age[4]
120906	SAN-19	80 ± 50	-25.3	80 ± 50	135 - 30 (N/I)[5]	*cal AD* 1815 - 1920 (N/I)[5]
120910	SAN-21	380 ± 50	-26.4	340 ± 50	475 – 305 (380)	*cal AD* 1475 - 1645 (1570)
120911	SA-74	510 ± 60	-24.9	510 ± 60	545 – 505 (525)	*cal AD* 1405 - 1445 (1425)
120912	SA-61	520 ± 40	-23.1	550 ± 40	550 – 525 (540)	*cal AD* 1400 - 1425 (1410)
120902	SAN-7	620 ± 70	-24.6	630 ± 70	660 – 540 (595)	*cal AD* 1290 - 1410 (1355)
120909	SAN-29	880 ± 70	-23.3	910 ± 70	920 – 730 (785)	*cal AD* 1030 - 1220 (1165)
93264	SAN-11	990 ± 110	-25.2	990 ± 110	980 – 760 (923)	*cal AD* 970 - 1190 (1027)
120914	SA-62	1560 ± 50	-24.8	1560 ± 50	1515 – 1375 (1415)	*cal AD* 435 - 575 (535)
120915	SA-59	3460 ± 50	-21.0	3520 ± 50	3850 – 3705 (3755)	*cal BC* 1900 - 1755 (1805)

Notes:

1. All from charcoal, processed by Beta Analytic. Dates are in RCYBP (radiocarbon years before present; present = 1950 A.D.) Errors represent one standard deviation (68% probability).
2. C13/C12 ratios were calibrated relative to the PDB-1 international standard, and the RCYBP ages were normalized to -25 per mil
3. Dendrocalibrated age in YBP (years before present; *present* = A.D. 1950), with 1-σ range, and mean intercept in parenthesis; calibrated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993)
4. Dendrocalibrated calendar years, with 1-σ range, and mean intercept in parenthesis; calibrated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993)
5. N/I = no intercepts. *Calib rev. 3.0.3* (Stuiver and Reimer 1993) plotted no intercepts for these recent conventional dates. However, Beta Analytic's calibration analysis provided the indicated YBP & cal AD/BC range based on 1-σ range for proximity to the dendrocalibrated curve.

Table 6.3 SA Study Area radiocarbon dates

All tested SA Study Area loci are in the "small" size category. All but one are single-component deposits. The one exception is SAN-21, a small site with a lower component of weathered shell midden separated by a thin layer of alluvium from a more carbonaceous upper component. The lower component contained no recoverable charcoal, but its weathered character is very analogous to that of SA-59, which was tested and dated (3850-3705 CYBP) during the 1989 CSU Northridge field school.

MP Study Area

Three earlier surveys of the MP Study Area had documented 149 sites along this 2.5-km extent of the central Coastal Terrace (Axford 1984; McKusick and Warren 1959; Yatsko and Raab 1997). The northern 25-ha portion of the Study Area corresponds to Probabilistic Survey sample unit C3. This sample unit alone contains 93 documented cultural loci, recorded as 68 sites, the highest density (approximately 270 sites per km^2) observed in any of the Probabilistic Survey sample units (Figure 6.4). The remaining 77 ha were known to contain 58 sites. I resurveyed approximately two-thirds of this remaining area during early 1996. Thirty known sites were relocated as 35 discrete loci, and an additional 25 previously unknown sites were documented.

However, my resurvey fieldwork in the southern quarter of the study area encountered physical obstacles that significantly limited the comparability of this sub-area's site inventory. The northern and central portions of the MP Study Area are covered with a fairly open maritime desert scrub over generally level terrain, while the southernmost 23 ha of the study area are overlain by substantial alluvial fans. These mounded cobble and gravel deposits hold moisture that might normally quickly traverse the terrace into the sea. This enhanced moisture and the rocky substrate have fostered a much higher than normal growth of prickly pear cactus (*Opuntia littoralis*) and island morning glory (*Calystegia macrostegia*) over the fan deposits. This presents a continuous, nearly impenetrable, vegetation cover that substantially masks the sites

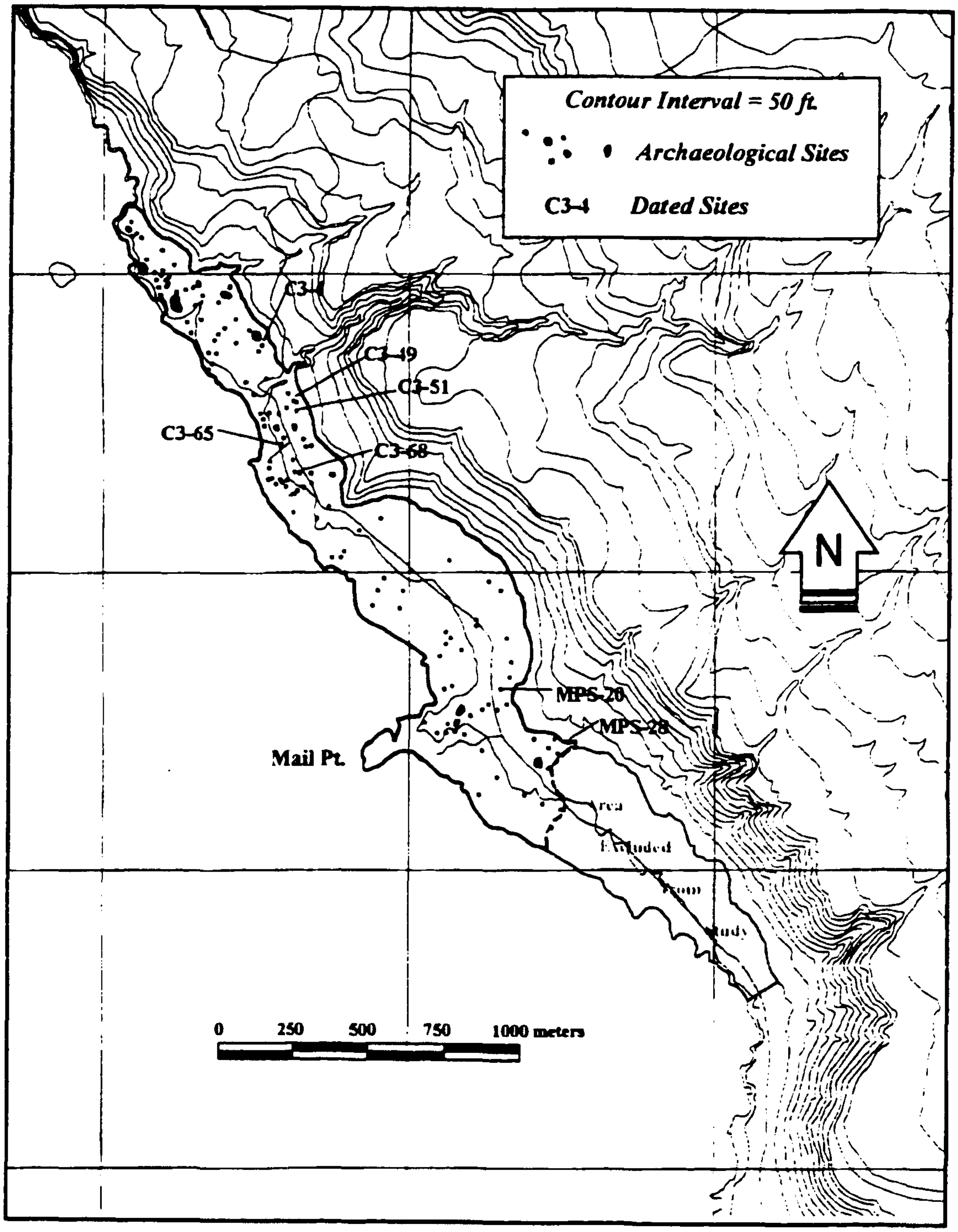

Figure 6.4 MP Study Area and archaeological sites

recorded earlier by UCLA (McKusick and Warren 1959) and Mesa College (Axford 1984).

Approximately 28 archaeological sites are known for this southern area (Axford 1984), recorded when visibility was better because grazing pressure from goats suppressed the vegetation cover. Because of my concerns about excessive field time requirements due to the remoteness of the southern MP Study Area (up to 6 km and 350 m elevation change from the nearest road), this 23 ha zone was removed from the dissertation sample. Extending the study area to the north to bring the overall area back to 1 km^2 could not be done because the Coastal Terrace pinches out in that direction at Seal Cove.

The MP Study Area's reconfigured 2.5-km-long, 79-ha area of the Coastal Terrace contains a still-substantial sample population of 145 discrete cultural loci, recorded as 115 sites (Figure 6.4). The largest number of these loci are deflated (n = 37) or embedded (n = 53) deposits, along with 10 lithic or artifact scatters and four historic Chinese abalone processing sites (Berryman 1995). Because auger probing occurred in the MP Study Area after the earlier experience with unproductive deflated sites in the SA and MRB study areas, selecting MP sites for sampling was refined to include only carbonaceous and deflating loci. These number some 36 sites (six carbonaceous and 30 deflating deposits). A primary sample of five sites (one carbonaceous and four deflating) was selected, with three alternates (one carbonaceous and two deflating). Six sites were augered (C3-4, C3-49, C3-51, C3-65, MPS-20, and MPS-28), and five were found to contain suitable quantities of charcoal for dating. Because of the small number of sites sampled compared with the overall MP Study Area site count, all five selected sites were tested and dated. Including the one Probabilistic Survey site in C3 (C3-68) with a charcoal date, all six MP Study Area loci tested are small, single-component deposits. Resulting radiocarbon dates are presented in Table 6.4, with corresponding sites labeled on Figure 6.4.

Beta No.	NRO No.	^{14}C Age[1]	$\sigma^{13}C$	^{13}C Adj.[2]	Calib. YBP[3]	Calendar Age[4]
120907	C3-051	130 ± 50	-26.4	100 ± 50	140 – 20 (60)	*cal AD* 1810 - 1930 (1890)
120908	MPS-28	230 ± 50	-26.4	220 ± 50	300 – 270 (285)	*cal AD* 1650 - 1680 (1665)
120904	C3-49	310 ± 50	-26.5	280 ± 50	320 – 285 (300)	*cal AD* 1630 - 1665 (1650)
120903	C3-4	310 ± 50	-24.3	320 ± 50	455 – 300 (405)	*cal AD* 1495 - 1650 (1545)
120905	MPS-20	540 ± 50	-24.0	550 ± 50	555 – 525 (540)	*cal AD* 1395 - 1425 (1410)
51115	C3-68	1390 ± 70	-25.2	1390 ± 70	1333 – 1269 (1293)	*cal AD* 617 – 681 (657)

Notes:
1. All from charcoal, processed by Beta Analytic. Dates are in RCYBP (radiocarbon years before present; present = 1950 A.D.) Errors represent 1 standard deviation (68% probability).
2. C13/C12 ratios were calibrated relative to the PDB-1 international standard, and the RCYBP ages were normalized to -25 per mil
3. Dendrocalibrated age in YBP (years before present; *present* = A.D. 1950), with 1-σ range, and mean intercept in parenthesis; calibrated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993)
4. Dendrocalibrated calendar years, with 1-σ range, and mean intercept in parenthesis; calibrated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993)

Table 6.4 MP Study Area radiocarbon dates

Summary

Data collection involved systematic survey of 9.85 km^2 in four areas of the Plateau and Coastal Terrace topographic provinces. These areas collectively contain 559 cultural loci, documented as 497 archaeological sites. Fifty-two of these sites were tested for the presence of charcoal for radiocarbon dating. Thirty-three charcoal samples from 33 sites were radiocarbon dated. Fourteen of these dates are derived from work done prior to this research. The mean intercept ages from these dates range from *cal BC* 1805 to *cal AD* 1890.

The data collected during this research and Probabilistic Survey provide a representative sample of the island's prehistoric cultural loci. The chronological and geographic ranges of these radiocarbon dates provide for the spatial and temporal analyses of settlement patterns on San Clemente Island across the Medieval Climatic Anomaly. These analyses are presented in the next chapter.

Chapter 7

Data Analysis

My analysis of the temporal site data presented in Chapter 6 proceeds as a largely graphic exercise. First, radiocarbon date frequencies are plotted per time interval as markers of population during different periods of time. Second, after grouping these dates with regard to the island's topographic and hydrological provinces, I evaluate their geographic distribution to identify variability in settlement patterns through time. Finally, I discuss the significance of these frequency distributions and address ways in which they may parallel responses by prehistoric populations to environmental stresses in other regions of western North America during the Medieval Climatic Anomaly.

Use of Radiocarbon Date Frequencies

I paid close attention to operating assumptions for the use of radiocarbon date frequency distributions in determining population trends. Such assumptions and related biases need to be carefully assessed. Glassow (1998) cites three basic assumptions drawn from Rick's (1987) examination of the Peruvian radiocarbon record:

1. The size of a prehistoric regional population is correlated with the volume of organic material useful for radiocarbon dating produced per time interval.

2. The volume of datable organic material that survives until the time of archaeological collection is proportional to the volume of production.

3. The selection of organic samples for radiocarbon dating is proportional to the surviving volume of datable material per prehistoric time interval (Glassow 1998:7).

Rick (1987:57-58) suggests that biases occur within each of these three domains. For example, a prehistoric population may have deposited more organic material per capita during one time interval than during others. Alternatively, erosion or deposition may have affected site environments through time by differentially burying or removing deposits. Another potential bias is fluctuation through time in the number of sites created or used by a prehistoric population's basic social unit, which potentially precludes use of simple site counts (Glassow 1998). Because some of these sources of bias may significantly influence evaluation of frequency distributions in the radiocarbon date record, Rick (1987:58) suggests that analysis should always include an assessment of sources of potential bias so they can either be controlled or eliminated. Glassow suggests that some sources of bias cannot be eliminated or controlled, so evaluations of radiocarbon date distributions must be covered by a series of rules or expectations that take into account the existence of uncontrollable sources of bias.

In his evaluation of frequency distributions for dates in the Santa Barbara Channel region, Glassow (1998:8) includes "rules" he used to reduce some of the bias. Specifically, he describes procedures employed to reduce some of the biases in raw date distributions presented in *California Radiocarbon Dates* (Breschini et al. 1996). I use his discussion to focus on sources of bias pertinent to the San Clemente Island context and how I dealt with them in analyzing these data.

First, dates considered suspect by Breschini et al. (1996) were eliminated from consideration by Glassow (1998:9). In selecting sites for the dissertation research, I identified and eliminated one previously dated site in the OAF Study Area because it had been plowed. Throughout my field research, I attempted to detect any previous mechanical disturbance to the sites. When a disturbed site was selected by the random sampling protocol, it was excluded from the sample and another was chosen.

Glassow (1998:10) also recommends that dates derived from marine shell should be corrected to be comparable with dates derived from charcoal. As noted earlier, non-symmetrical variation between Probabilistic Survey dates from paired shell and charcoal samples led to my decision not to include dates from shell in this research. Consequently variation in the marine reservoir effect on radiocarbon dating of shell is not relevant here. This will likely change in time, pending final definition of a specific San Clemente Island correction curve for shell dates.

Glassow (1998:11) further suggests that where two or more dates are obtained from one site or one stratigraphically discrete site component, these should be evaluated to determine whether differences between them are statistically insignificant. Except for paired shell and charcoal samples collected from sites during the Probabilistic Survey, all dates are consistently the only charcoal-derived ones from their respective sampled site loci.

Glassow (1998:10) points out that dates derived from wood charcoal also are subject to bias, because some of the prehistoric wood collected may have already been a few hundred years old. Because this "old wood" bias is difficult to establish without consideration of other chronological information, no correction of the dissertation and Probabilistic Survey charcoal dates has been attempted here.

Another potential bias identified by Glassow (1998) results from possible variations in settlement mobility through time, as this might affect the number of sites created by a social unit. He suggests that radiocarbon samples are typically selected in proportion to the volume of deposits produced during a given time period, and it makes relatively little difference whether this volume is distributed among a few large sites or many smaller sites. Counting only relatively large sites as likely to have served as primary residential bases or giving such sites greater weight over smaller deposits will introduce a bias greater than that derived from treating all sites equally. In Glassow's study, this concern relates to an understanding that small residential loci containing relatively low densities of cultural remains and datable organic materials may have been selectively omitted from some dating programs (Glassow 1985, 1998:13). However, because the severity of this bias is difficult to reconstruct for the data drawn from *California Radiocarbon Dates*, Glassow assumes that the omission of such sites is not so significant as to obscure more obvious fluctuations in population size. For both the current research and the Probabilistic Survey, regional samples were specifically designed to identify and investigate all loci containing datable organic materials, no matter how large or small these deposits. This should result in a representative sample of variation in settlement systems through time and eliminates most potential bias.

Consistency in the field collection of radiocarbon materials obviates another source of bias: what Glassow (1998:13) calls the "random noise" factor. Dates are often drawn from organic samples collected from within an entire test unit level as opposed to a discrete feature. One discrete piece of charcoal or individual shell likely represents one point in time, but numerous fragments of charcoal in a level may represent hundreds or even thousands of years. This is especially a problem where rodent disturbance mixes deposits of different ages. The latter is not a factor on San Clemente Island. Moreover, the large majority of my site loci consist of small, discrete, one-component middens, so this type of random noise factor would seem moot. Even so, samples in both the current research and the Probabilistic Survey project were drawn as multiple charcoal fragments from only very localized proveniences within each deposit sampled. Most small occupation deposits on the island are only 30 cm to 50 cm thick. This is true of even most multi-component deposits. Nearly all charcoal samples were recovered between 15 cm and 40 cm depth and all from contexts that were clearly undisturbed.

Lastly, Glassow (1998:14) suggests that the laboratory reporting of radiocarbon dates introduces a bias due to variability in the counting error specified. The date lists used by Glassow document counting errors ranging from 50 to 350 years, which implies 67% probability intervals ranging between 100 and 700 years. For the Probabilistic Survey charcoal dates, counting errors range between 50 and 90 years, with only two dates exceeding this (110 and 180 years, respectively). The average error is 70 years. The counting errors for dates from the current research range between 40 and 80 years, with one at 110 years. The overall average error is 60 years.

Given the size of his date samples and the range of potential sources for bias and noise, Glassow (1998:15) selected a 200-year interval for plotting date frequencies because he felt he was unlikely to discern meaningful patterns with a smaller interval. With a much narrower range for the San Clemente Island samples, I use a 100-year interval average for plotting of date frequencies (mean intercepts from150-250 CYBP are plotted as 200 CYBP, from 250-350 CYBP as 300 CYBP, etc.). This interval is not consistent with Taylor's (1987:141) conclusion that radiocarbon dating generally does not allow for distinguishing "temporal increments in units of less than 2-3 centuries at reasonable levels of precision." However, Taylor likely assumes the presence and influences of biases discussed above. These potential bias sources are largely accounted for in the current research, either by collection protocol or the particularity of doing archaeological research in the relatively less disturbed California Channel Islands. As a result, my operating assumption is that a 100-year interval provides an appropriate compromise between the calibrated intercepts for each date and the probability interval for the average counting errors. The resolution of distribution patterns from calibrated dates should allow effective comparison with the dendroclimatic curves provided by Larson and Michaelsen (1989). For the most part, these dates are presented in dendrocalibrated calendar years before present (CYBP).

Because the scope of this inquiry is limited to evaluating dates no earlier than the mid-Middle Period, my analysis eliminates collected dates earlier than 2,000 CYBP. This affected only two dates collected during the dissertation research and none of the charcoal dates from the Probabilistic Survey.

Distributions of Radiocarbon Dates

Temporal Distribution

For investigating the temporal distribution of the collective dates, I graph the number of dates within each 100-year interval. These are represented in the form of dates from the four project study areas and charcoal dates from the Probabilistic Survey. These are plotted against shaded bands showing periods of drought for the Santa Barbara region during the Medieval Climatic Anomaly (Larson and Michaelsen 1989).

Figure 7.1 compares frequency curves for the two suites of charcoal dates. These curves display synchronous frequency depressions coincidental with Larson and Michaelsen's (1989) drought periods. Because dated loci were selected using comparable regional sampling approaches, this tends to support the inference that, rather than being the product of sampling error, this and other San Clemente Island date curves represent actual, island-wide site frequencies across at least the last 1,500 years.

Figure 7.2 provides an alternative way of viewing the distribution of these dates by combining the project study area and Probabilistic Survey samples as a single frequency curve. This accentuates the amplitude of the curve and puts clearer emphasis on the depressed frequency during the drought periods. Plotted against this curve is Larson and Michaelsen's (1989) reconstructed precipitation curve for 50-year averages in the Santa Barbara region. There are obvious parallels between the two curves with depressed frequencies for the combined dates correlating with periods of below average rainfall. Important to discussions here, however, a small number of site dates continue to appear within the span of the Medieval Climatic Anomaly in apparent correlation with the wetter periods between persistent droughts. This significance of these dates is discussed in Chapter 8.

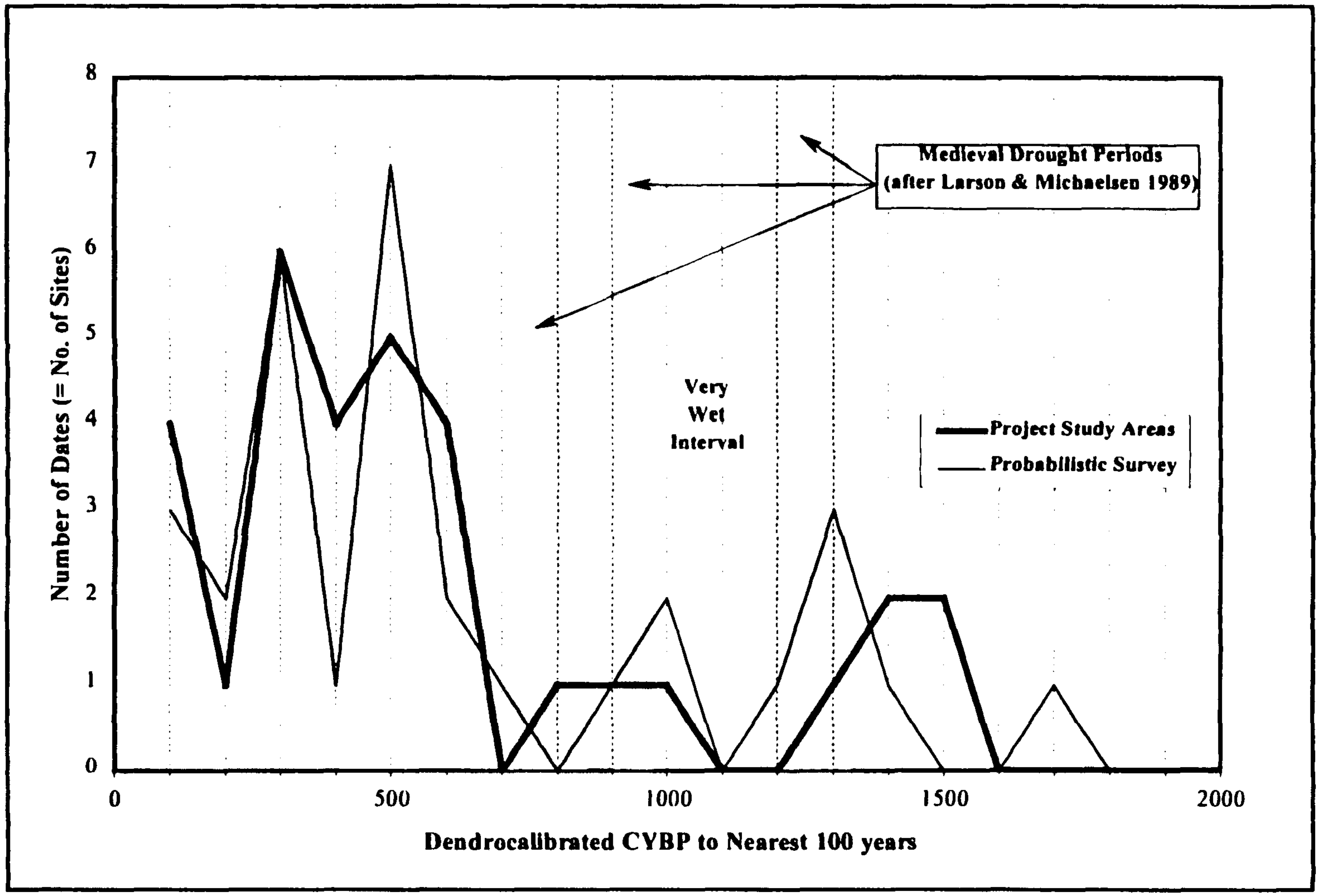

Figure 7.1 Frequency curves for study area and Probabilistic Survey charcoal dates

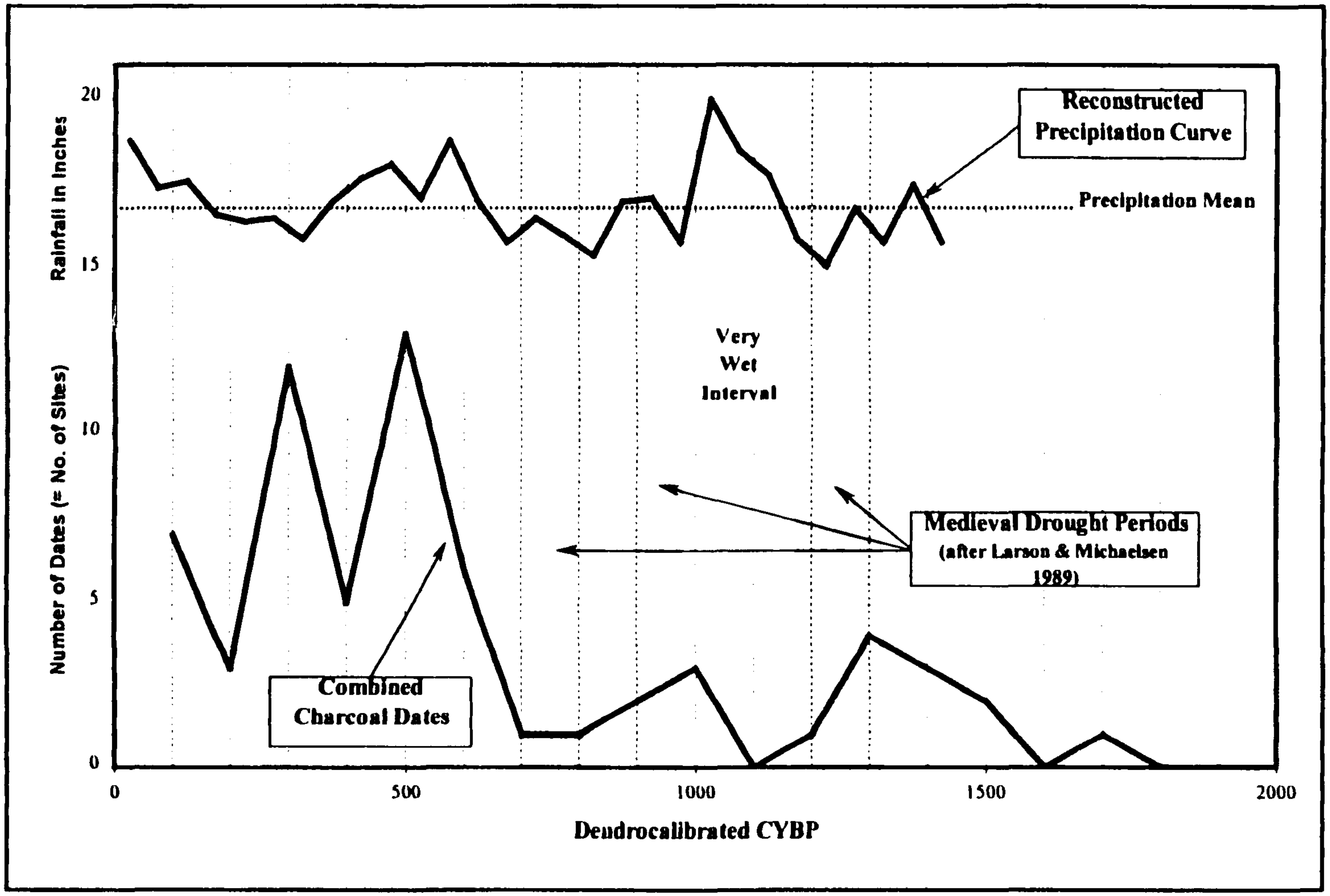

Figure 7.2 Combined frequency curve for study area and Probabilistic Survey charcoal dates compared with Larson and Michaelsen's reconstructed precipitation curve

Geographic Patterns

Site dates presented in the following figures plot the mean intercept of each calibrated date and the range of each calibrated date's counting error. As such, these graphed ranges represent one-sigma, 67% probability intervals for the individual dated sites. As before, these are plotted against shaded areas corresponding to Larson and Michaelsen's (1989) reconstructed medieval drought periods.

Figure 7.3 presents study area dates grouped by respective Plateau and Coastal Terrace topographic provinces. Their patterns are quite similar through the period following the close of the Medieval Climatic Anomaly. However, across Larson and Michaelsen's periods of medieval drought there are obvious hiatuses in both the MP and MRB study areas and reduced numbers of dates in both the SA and OAF study areas. These differences correlate with the respective study areas' hydrologic provinces. Study areas representing bedrock terrain drainages (MP and MRB) have no sites dated during the Medieval Climatic Anomaly drought periods. Study areas associated with eolian-source drainages (SA and OAF) produce a few dates during the Medieval Climatic Anomaly, although at a low frequency.

These same dates are grouped and compared by hydrologic province in Figure 7.4. The hiatuses shown indicate that spatial distributions of dated sites are influenced by factors related to their hydrological potentials. To accentuate this correlation, Figure 7.5 combines both the study area and Probabilistic Survey dates by hydrologic province. The additional dates only slightly increase frequencies for dated sites from bedrock terrains

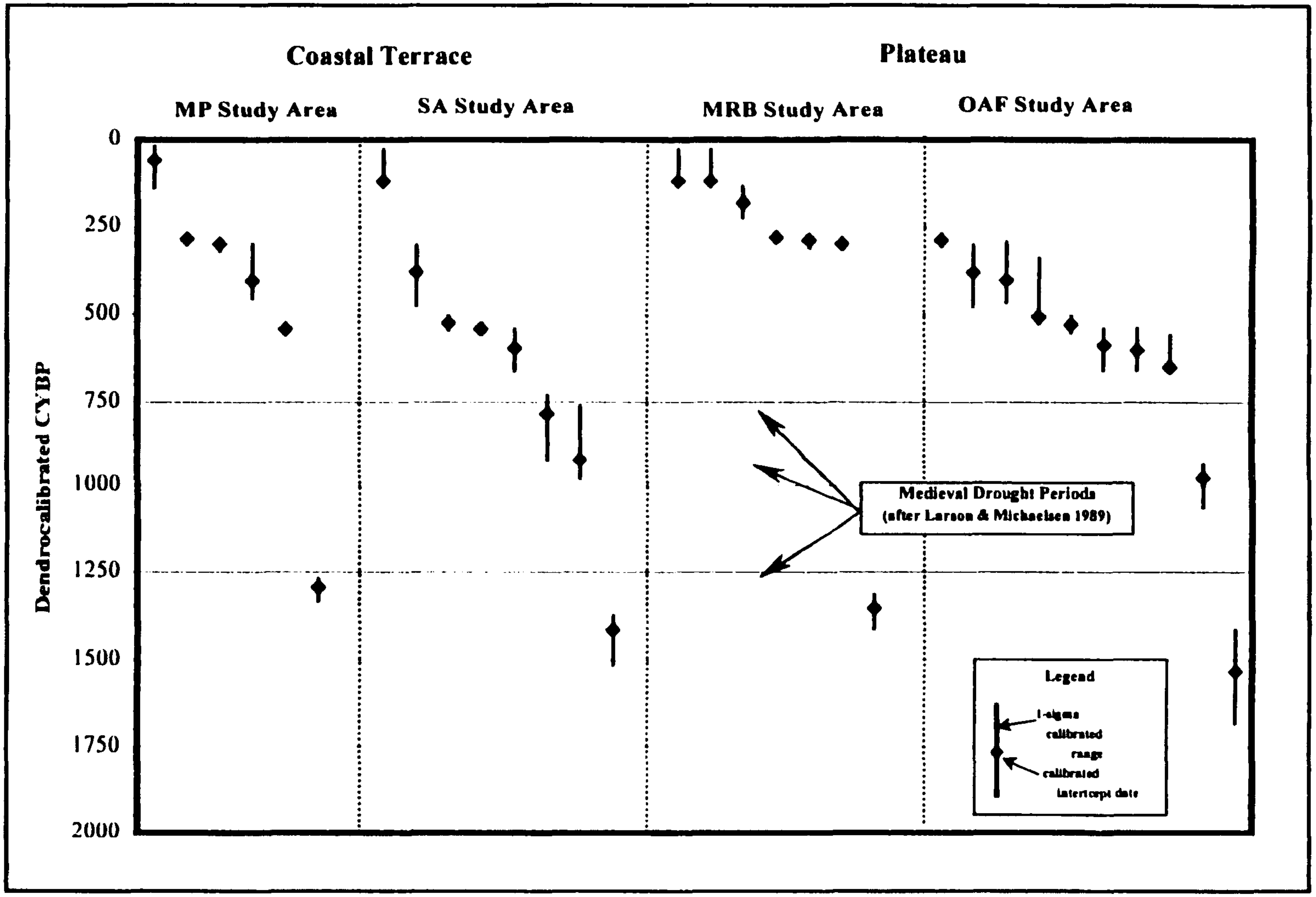

Figure 7.3 Temporal distribution of study area dates

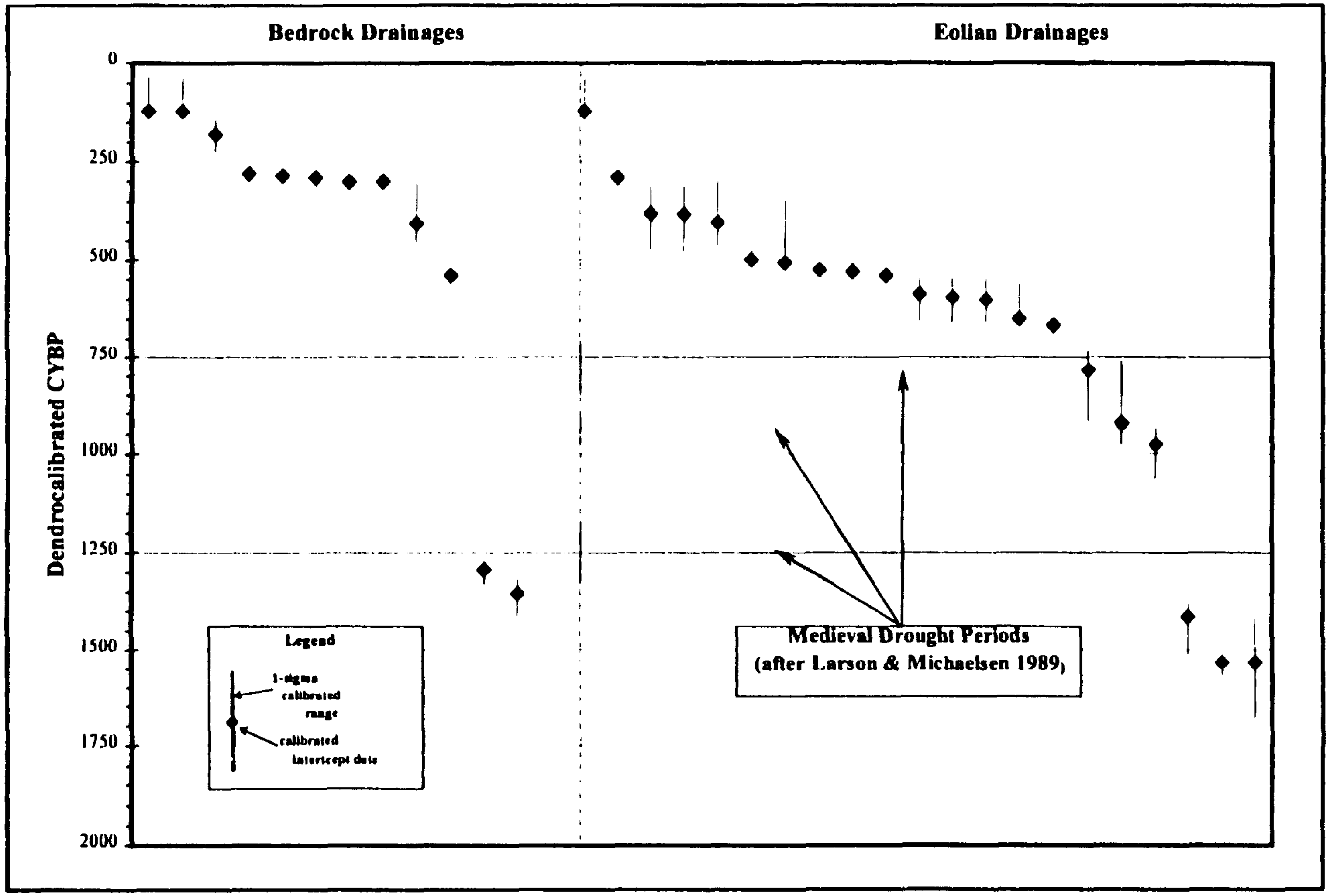

Figure 7.4. Temporal distribution of study area dates by hydrologic province

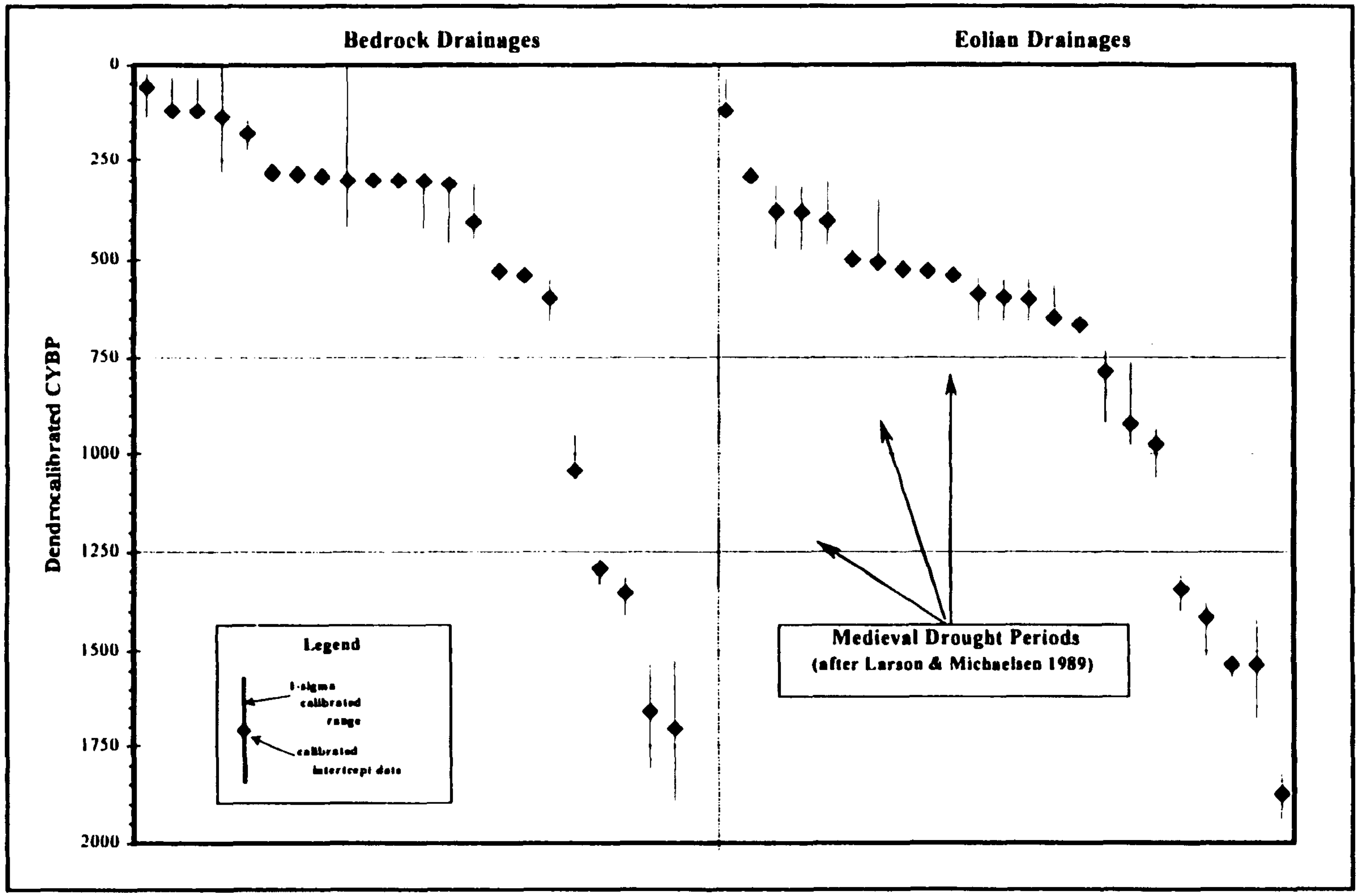

Figure 7.5 Temporal distribution of study area and Probabilistic Survey charcoal dates by hydrologic province

for periods during the Medieval Climatic Anomaly, and they continue to show higher site frequencies outside the periods of medieval droughts.

Finally, because the regional sampling approaches I used were topographically stratified, Figure 7.6 shows the combined study area and Probabilistic Survey charcoal dates from the two sampled topographic provinces (the Coastal Terrace and Plateau). I also include Probabilistic Survey charcoal dates from the Upland Marine Terraces, the topographic province not sampled during the current research. The number of Upland Marine Terraces dates is thus about half that in the other topographic provinces. We again see clear interruptions in the distributions of dates across the Plateau and Upland Marine Terraces provinces. By contrast, we see a relatively continuous sequence for the Coastal Terrace. These latter dates are associated with areas of the Coastal Terrace crossed by drainage off upland eolian terrain. This supports a model for eolian-source catchments being more likely to have available water during periods of drought than bedrock-source drainages.

Significance of Temporal and Spatial Patterns

One of my hypotheses is that the frequency of dated sites would have declined during the Medieval Climatic Anomaly. If that hypothesis is borne out by the data, I can then infer that there was a reduction in island population due to reduced availability of water. The frequency curves shown in Figures 7.1 and 7.2 support this hypothesis. I also expected that sites dated to the Medieval Climatic Anomaly would demonstrate a shift to areas with predictable water sources. The data presented suggest that settlement during these medieval drought periods contracted to areas of the Coastal

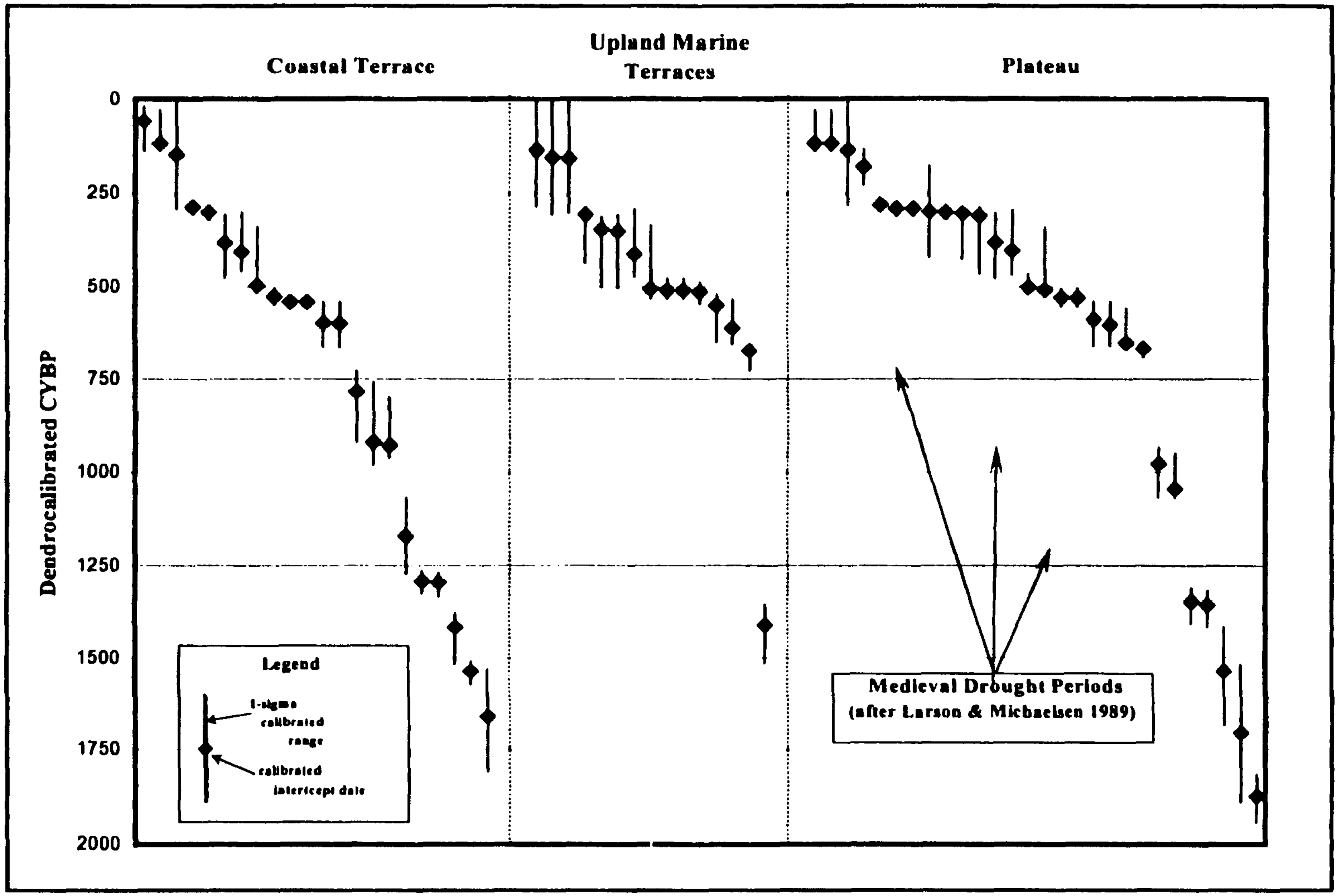

Figure 7.6. Temporal distribution of study area and Probabilistic Survey charcoal dates by topographic province

Terrace associated with eolian mantled upland terrain with the potential to hold water and buffer its release

However, I note an apparent departure from these expectations. The frequency of island dates remains depressed during the period of above average precipitation between about 1000 and 1150 CYBP (Figure 7.2), described by Larson and Michaelsen (1989: 22) as a "sustained high (precipitation) interval unmatched in the entire 1600-year reconstruction." This correlation does not meet expectations for a paleodemographic response to improved climatic conditions.

Chi-square Test

While the patterns in these data appear obvious, I performed a Chi-square (X^2) test on the data presented in Figure 7.5 to test whether the differences between these frequencies are significant enough to reject the hypothesis that these are due to chance. In the X^2 table, I look at dates in the Medieval Climatic Anomaly and those from 701 CYBP to the present, grouped in study areas associated with eolian and bedrock hydrologic provinces (Table 7.1). This test produces a X^2 value of 21.55. At two degrees of freedom, this is significant at the 0.001 level of probability. Even when only those dates occurring during the *late* Medieval Climatic Anomaly periods of drought are included (Table 7.2), the resulting X^2 value is 8.49. At two degrees of freedom, this is significant at the 0.005 level of probability.

	Eolian	Bedrock	Totals
100-700 CYBP	15	17	32
701-1300 CYBP	3	2	5
Totals	18	19	37
			$X^2 = 21.55$

Table 7.1. Chi-square table for test of significance of temporal distributions by hydrologic province for sites dated during and after the Medieval Climatic Anomaly

	Eolian	Bedrock	Totals
100-700 CYBP	15	17	32
701-950 CYBP	3	0	3
Totals	18	17	35
			$X^2 = 8.49$

Table 7.2. Chi-Square table for test of significance of temporal distributions by hydrologic province for sites dated during and after the late Medieval Climatic Anomaly drought periods

In both instances, the X^2 test demonstrates that differences among these observed frequencies are significant enough to reject the hypothesis that they are due to chance alone and suggests that selective factors were operating to create these differences. However, these tests compare frequencies between the Medieval Climatic Anomaly and the period of the late Holocene that followed. Testing for the significance in the frequency differences for site distributions between bedrock and eolian terrains during the Medieval Climatic Anomaly alone is not possible because the number of dated sites is too small during the period.

The foregoing analyses demonstrate the utility of this approach for investigating change in San Clement Island's prehistoric population through time. However, because these combined data represent a relatively small site sample, especially considering the estimated 7,600 sites for the island as a whole, some caution must be exercised in these interpretations. The two projects tested 62 sites, a sample that barely approaches 1% of sites assumed to exist across the island. Still, selection of dated sites was systematically pursued in ways that account for characteristics of the island's overall site population and that address many sources of bias that can plague this type of analysis. For these reasons, the date frequencies presented should be considered generally representative of the island's pattern of settlement over the span of time covered.

Discussion

These analyses of adverse paleoenvironmental conditions and changes in the size and distribution of San Clemente Island's populations during the Medieval Climatic Anomaly are illuminated by Keegan and Diamond's (1987) model for biogeographical influences on the human occupation of islands. Among the island properties they consider (distance, configuration, and area), distance from a mainland landform and the configuration, or spatial orientation, of islands and island groups as this relates to their likelihood to be encountered are likely not limiting factors in the case of San Clemente Island. Like the northern Channel Islands, San Clemente Island would have been visible and accessible from the mainland. In fact, prehistoric occupation of San Clemente Island would probably have benefited from the distance variable referred to as the "commuter effect." Islands too small or marginal to be self-sustaining can be occupied if they are within commuting distance of a mainland offering additional resources.

The effects of island area, however, appear to be more significant for islands like San Clemente. Keegan and Diamond (1987) suggest that larger islands are not only more likely to be encountered by colonizing groups, but because of inherently greater variety and quantity of resources necessary to human survival, an occupying group is more likely to remain on a large island than a small one. Small islands support smaller populations with higher levels of risk. They are quite susceptible to catastrophic events, an impoverished resource base (e.g., extended droughts or perturbed ecosystems), and/or population growth. Even as seemingly large a land area as San Clemente Island is significantly smaller than islands earliest colonized by humans in other regions, like Crete and Cyprus in the eastern Mediterranean (Cherry 1985) and the Solomon Islands of Melanesia (Terrell 1976). San Clemente Island can further be classified as marginal with high risk levels because it has a relatively depauperate terrestrial environment (Kirch 1983; Williamson 1981).

Small or marginal islands in contexts outside the California Channel Islands were sometimes only occupied late in prehistoric times. Studies of the earliest colonization of the Mediterranean islands demonstrate that, while Neolithic Europeans were clearly capable of reaching most Mediterranean islands by 11,000 B.C., it was not until much later in time that they chose to settle the smaller of these islands (Cherry 1984). It appears that such islands were not large enough to have supported a self-sustaining population until improved farming and animal domestication permitted denser human populations. A similar pattern occurs in the Caribbean islands. At least two distinct groups of prehistoric hunter-gatherers successively colonized the larger islands of the Greater Antilles, but they apparently established only temporary settlements on the smaller, intervening islands of the Lesser Antilles (Keegan and Diamond's 1987:63). These smaller islands acted as stepping stones from Central or South America and were settled during a migration beginning about 2000 B.C., but they were apparently abandoned 1000 years prior to the arrival of the agricultural Island Arawak around A.D. 1 (Goodwin 1978). Although these islands had available marine resources, distributions of resources have been interpreted as insufficient to support a permanent hunter-gatherer economy (Goodwin 1978).

Why San Clemente Island was occupied so early in prehistory may in part be deduced by reference to Cherry's (1985) discussion of favorable cultural adaptations for occupying marginal islands. These adaptations include residence in small, dispersed groups, exploitation of a broad spectrum of resources, and a high level of group mobility. The abundant and dispersed small sites that make up San Clemente Island's settlement patterning throughout prehistory appear to have been produced by populations organized in this way.

My analyses of the San Clemente Island settlement chronology also suggest parallels with archaeological sequences from other areas of western North America where regional abandonments and major population movements correlate with the Medieval Climatic Anomaly. Cultural responses vary among these regions, but each shows diachronic changes that, like those on San Clemente Island, are best explained as responses to environmental deterioration and related demographic stress (Jones et al. 1999).

The best known record is that of the Colorado Plateau, where a well developed archaeological and paleoenvironmental record portrays a conflict between increasing populations and drought-related environmental deterioration. Major abandonment of portions of the Colorado Plateau also shows strong temporal and ecological correlation with paleoclimatic changes during the Medieval Climatic Anomaly (Jones et al. 1999). Between A.D. 1050 and 1300, the scale of these changes appears to have been significant (Jones et al. 1999). Accompanied by alluvial instability with a shift toward increased erosion and depressed water tables, climatic conditions appear to have degraded enough to have adversely affected all traditional subsistence systems. Before this time, droughts certainly would have periodically curtailed upland dry farming. After A.D. 1050 in some parts of the region, however, severe paleoclimatic deterioration would have compounded the effect on both farmers and hunter-gatherers, partly because of the high population density on the Colorado Plateau at this time (Dean et al. 1985; Larson and Michaelsen 1990).

There are some exceptions to this pattern. Population centers like that at Chaco Canyon thrived during this period (A.D. 1050-1175), probably due to more favorable local conditions and through the maintenance of regional and pan-regional exchange systems based on the banking of status-related goods (exotic birds, turquoise, shell, etc.) for food (Neitzel 1989). Control of these exchange activities is thought to have raised the carrying capacity of such areas by providing external inputs of food in times of need. However, regional agricultural failures related to persistent droughts may have eventually contributed to the failure of these exchange relationships, with the large populations in these major centers either having to move to other areas or returning to more diversified subsistence strategies (Lipe 1995; Neitzel 1989).

Following successive droughts at the end of the 11th century and the beginning of the 12th century, the period A.D. 1130-1150 shows marked decreases in effective moisture over much of the Plateau, possibly signifying a shift from summer-dominant toward winter-dominant precipitation. Puebloan occupation in some portions of the Colorado Plateau ended during the mid-1100s. These widespread abandonments preceded the Pueblo III period (ca A.D. 1150-1300) population aggregation in the northern San Juan-Mesa Verde region of the Colorado Plateau (Jones et al. 1999; Lipe 1995). This aggregation happened as formerly widely dispersed small habitation groups in open upland settings shifted to occupy larger pueblos situated at canyon and canyon-head settings (Lipe 1995). By A.D. 1300, all agricultural settlements in the northern Colorado Plateau and most in the central portion had been abandoned. Early Pueblo IV period (ca. A.D. 1300-1450) occupation is represented in only a few areas on the southern edge of the Colorado Plateau and occurs almost exclusively toward the south and east, in places receiving greater summer precipitation.

Other areas of western North America sharing the arid conditions of San Clemente Island also experienced the effects of the Medieval Climatic Anomaly. Changes in technology, settlement patterns, and exchange systems during the Medieval

Climatic Anomaly on the Monterey-Big Sur coast of central California are inconsistent with expectations for incremental population growth and models of economic intensification (Jones et al. 1999). While cultural changes preceding the Medieval Climatic Anomaly are consistent with subsistence intensification models, diets did not continue to broaden and trade horizons contracted between A.D. 1000 and 1400 in that region. Punctuated technological change (i.e., the emergence of bow-and-arrow technology) in the Big Sur area is correlated with the interval of medieval-era droughts (Jones 1995). This technological transition is contemporaneous with a major disruption in settlement indicated by radiocarbon sequences. These sequences show few, if any, dated sites being continuously occupied through the Medieval Climatic Anomaly. Those occupied earlier than A.D. 1200 show signs of abandonment, while settlements first inhabited afterwards are single-component sites with no evidence of earlier occupation. It is likely that these changes reflect demographic problems that were not solvable by adaptive adjustment or further intensification. [Cultural conditions were very different in the Santa Barbara Channel area, where trade expanded tremendously during this time and populations, while shifting, did not decline. There was no abandonment of this much richer region (Arnold 1992).] According to Jones et al. (1999), these shifts in settlement and deterioration of exchange systems in marginal parts of California reflect large-scale population movements akin to those of the Colorado Plateau. The correlation between environmental dynamics and cultural change implies a causal relationship between the two processes (Jones et al. 1999).

The effects of climatic shifts during the Medieval Climatic Anomaly on aboriginal populations in the Mojave Desert of California probably best parallel the San Clemente Island example. As in most desert areas of the world, water, not food, would have been the critical factor in foraging decisions under extremely arid conditions in the Mojave (Kelly 1995). In response to the uncertainty of water dependability, desert-based hunter-gatherers typically tie themselves to more reliable water sources, sometimes sacrificing foraging efficiency.

Frequencies of occupation dates for the Mojave Desert during three periods between ca. A.D. 300-1800 show settlement patterns that indicate a significantly reduced use of the desert between A.D. 800 and 1300 (Jones et al. 1999). This period matches the Medieval Climatic Anomaly defined by Stine (1994), Leavitt (1994), and others for the Great Basin and Sierra Nevada. Of 84 radiocarbon-dated archaeological components spanning these 1,500 years, 25 date to A.D. 300-800, 12 date to the Mojave Medieval Climatic Anomaly itself, and 47 date to the 500-year period that followed (A.D. 1300-1800) (Jones et al. 1999). Spatial distribution of these dated site components also shows that occupations between A.D. 800 and 1300 are closely associated with major springs and oases along the Mojave River. These patterns suggest that hunter-gatherers of the central Mojave Desert were affected by the uncommon aridity of the medieval-era droughts.

As with the San Clemente Island chronological data, fewer dated components from this period suggest a reduction in population size as well as a tighter focus on reliable water sources. In the Mojave Desert, declining annual rainfall leads to a reduction in the number and reliability of water sources, a critical factor in a region characterized by vast, waterless expanses. My observations during short-term droughts in the 1980s suggest that similar conditions could have existed over the bedrock uplands of San Clemente Island during periods of persistent medieval drought.

In summary, the evidence for population shifts on San Clemente Island during the Medieval Climatic Anomaly has parallels in several other regions. It is an important example of the widespread demographic crisis documented across western North America during the period. The situation on San Clemente Island is important because it occurred within the confines of an island on which the diversity of resources available to human populations can be fairly accurately assessed and measured. This provides many opportunities for continued investigation into the influences of paleoenvironmental stress on the island's prehistoric populations and an improved understanding of late Holocene occupation of the island.

Chapter 8

Late Holocene Prehistoric Occupation on San Clemente Island

This research was conducted within the U.S. Navy's ongoing, integrated program for the study of San Clemente Island's archaeology. The Navy program is designed to provide both greater insights into the history of the island's prehistoric occupation and better interpretation of its archaeological resources to ensure their proper regulatory management. In this project, I use multi-disciplinary tools and ideas drawn from archaeology, anthropology, geography, geology, biology, and paleoclimatology. Substantial primary archaeological data were gathered during survey and test excavation. Surface survey, auger testing, and small-scale excavation were used to establish typological and chronological control of the sites studied. While San Clemente Island archaeological research has traditionally focused on large, complex sites, emphasis in this research was placed on systematic, probabilistic investigation of the small sites more characteristic of the coastal and upland areas. During the testing phase of this study, 33 charcoal samples from 33 sites were radiocarbon dated, allowing sites to be classified chronologically. Studies on the northern Channel Islands have principally focused on sites at or very near the coast, in selected districts, and along selected drainages (e.g., Arnold 1987, 1992; Kennett 1998; Peterson 1994), making this project's controlled, regional approach to collecting chronological data a singular example for coastal California.

Archaeological data generated during this research were incorporated and compared with other data from San Clemente Island. Observed changes in settlement patterning for the island were investigated with regard to paleoclimatic data for the general southern California region. These data clearly indicate that dramatic changes occurred in prehistoric settlement on San Clemente Island during the late Holocene Medieval Climatic Anomaly. That the southern Channel Islands experienced shifts in settlement patterning at the same time as those described for the northern Channel Islands and other regions of western North America during the Medieval Climatic Anomaly (Arnold 1992; Kennett 1998; Peterson 1994) is confirmed by the chronological evidence presented here.

The influence that persistent medieval-era droughts had on regional settlement patterns (Jones et al. 1999; Raab and Larson 1997) was perhaps more severe on San Clemente Island's than elsewhere in the Channel Islands. The data presented support my hypothesis that a significant decline in prehistoric population occurred on San Clemente Island during the Medieval Climatic Anomaly. This is archaeologically expressed in a dramatic decline in the number of sites dated during the period. Concurrent with this decline is a significant geographic shift in the pattern of residential settlement indicating a depopulation of San Clemente Island's upland bedrock terrains. Furthermore, fewer sites were occupied on lower elevation terrain associated with eolian-source hydrologic provinces. This population decline appears not to have reached the point of island abandonment. Radiocarbon dates are present, if in very low frequency, across the period of the Medieval Climatic Anomaly. Consequently, the hypothesis for total island abandonment during the overall Medieval Climatic Anomaly can be rejected.

However, these radiometric data are not sufficiently fine-grained to discern whether occupation occurred during the Medieval Climatic Anomaly's periods of drought or during chronologically adjacent periods of wetter climatic conditions. Within the overall span of Larson and Michaelsen's Medieval Climatic Anomaly (A.D. 650 – A.D. 1250), there are two periods of favorable, even optimal, precipitation (see Figure 4.2). The precipitation regime between about A.D. 800 and A.D. 1000 is described as a "sustained high-interval unmatched in the entire 1600-year reconstruction" (Larson and Michaelsen 1989:22) Another 70-year period of normal rainfall occurred from about A.D. 1030 to A.D. 1100, between the two late Medieval Climatic Anomaly drought periods . Even with the narrow radiocarbon counting error probabilities used here, error ranges overlap periods of moist conditions and periods of drought, making it difficult to link some dated sites with one of these climatic periods over another. In the end, it is not possible to say whether the sites corresponding with these medieval-era droughts represent a persistent occupation by a small island population or periodic re-occupation of the island during shorter, favorable climatic intervals within the Medieval Climatic Anomaly.

Such limitations in the data have obvious implications for future research. The most interesting aspects of this new perspective of San Clemente Island paleodemography are the periods of depressed date frequencies concurrent with the Medieval Climatic Anomaly. Because interpretation of fluctuating frequencies in radiocarbon dates is best focused on either frequency peaks or frequency depressions rather than a combination of the two (Glassow 1998), further investigations should focus on collection of site dates from localities potentially demonstrating occupation during the period. This should also include more specific investigation of the character of site deposits dating within the Medieval Climatic Anomaly to ascertain how or if these are differentiated from those dated before or after. My research developed only limited information in this regard.

The restriction of the settlement pattern during the Medieval Climatic Anomaly involved an apparent residential focus in the SA Study Area. Site testing in the SA Study Area produced two site dates correlated with the late Medieval Climatic Anomaly between about 700 cal BP and 950 cal BP. These are SAN-11 (CA-SCLI-259), a buried and eroded midden locus dated at 980-760 cal BP (mean intercept = 923 cal BP), and SAN-29 (CA-SCLI- 244), a partially buried and intact carbonaceous midden dated at 920-730 cal BP (mean intercept = 785 cal BP).

Site SAN-11 is a remnant deposit in a streambed. Originally thought to be two superimposed midden lenses protruding from the stream bank (Yatsko 1996d), investigation of this deposit's stratigraphic context after recovery of the date sample established that the site's organic deposits represent one laterally-discontinuous component. The SAN-11 midden was buried within an alluvial deposit in the channel of a narrow arroyo. The drainage re-entrenched to bedrock, removing this alluvial fill along with most of the occupation midden. Remnants of the original alluvium, including profiles of shallow, stratified cultural deposits, are left attached to the original stream bank.

Site SAN-11 is located in the principal drainage of the upslope fossil dune terrain surrounding the Nursery Site (see Figure 2.2 and 6.3). During periods of normal rainfall, this drainage concentrates significant quantities of water from this upland area and carries it across the Coastal Terrace. That this site deposit was created directly in a streambed and in alluvium since removed by erosion suggests that the hydrologic regime at the time of occupation had relatively less volume than has since been the case. This implies a period of occupation with a relatively lower-than-average precipitation rate. The subsequent erosion of the streambed deposits may have resulted from increases in runoff due to historic overgrazing of the upland tributary terrain.

The other site, SAN-29, lies on the open, flat Coastal Terrace terrain west of SAN-11. It is situated between the stream channel associated with SAN-11 to the south and a merging stream channel that drains the northwest slope of the same eolian upland. Together these two streams have built the fine-grained alluvial fans described earlier. The small (12 m x 15 m), shallow (15-30 cm), carbonaceous deposit at SAN-29 is largely undisturbed, but it has been partially obscured by its margins having been buried under alluvium washed from the northern drainage.

The alluvial dynamics observed in the SA Study Area have implications for future research elsewhere on the Coastal Terrace and the island as a whole. Having initially assumed that San Clemente Island's topography was created primarily by erosional processes, with little potential for buried cultural deposits, I expected that all small site loci would be visible at the surface (Yatsko 1989). However, a number of recent intensive surveys, other site-specific investigations (e.g., Gallegos 1994), and the current resurveys suggest otherwise. It is now apparent that the island's terraces have substantially more potential for alluvial transport and redeposition than earlier assumed. Over time, the sheet wash hydrology characteristic of the island's terraced terrains has the capacity to bury surface deposits by its process of broad, incremental alluvial transport. This is especially true on the lower terraces. In specific cases like the SA and MP study areas, streams discharging across the Coastal Terrace are building up significant alluvial fan deposits that have successively buried middens. Sites located near the base of fossil sea cliffs at the rear of emergent marine terraces are also subject to progressive burial by colluvial deposits that build up at the base of these cliffs.

Considerable direct evidence for these geological processes has emerged from the current research. In the case of the coalescing alluvial fans in the northern SA Study Area, my resurvey identified a minimum of eight midden deposits buried in the banks of streams. Some of these middens are buried as much as 1.5 m below the present terrace surface. These deposits appear to have been buried relatively quickly, and as a result they have good integrity and a high charcoal and artifact content.

From the examples of SAN-11 and -29, one may suppose that other deposits in this study area date from the Medieval Climatic Anomaly. Their geographic distribution further implies that occupation during the Medieval Climatic Anomaly was a consequence of reliable water availability due to the area's hydrologic association with upland eolian deposits. Prehistoric water availability was enhanced by down-slope discharge directly onto the occupied Coastal Terrace.

The Coastal Terrace near the SA Study Area provides the best place to extend the search for sites dating within the Medieval Climatic Anomaly. Sampling may be further improved by modifying the auger-sampling protocol to systematically probe alluvium- and colluvium-covered areas of the Coastal Terrace for buried deposits. It will also be germane to systematically sample other areas of San Clemente Island suspected of harboring buried cultural deposits. An expanded, geographically dispersed set of dated cultural deposits will refine the island-wide chronology and better delimit the scope of the island's Medieval Climatic Anomaly occupation. An improved accounting of buried deposits should also expand the number of earlier dates. Most early dates are currently only associated with the deeply stratified Eel Point Site.

These findings have wider research implications for studying prehistoric human population dynamics in the late Holocene for the southern Channel Islands as a whole. While it is already understood that substantial settlement reconfigurations occurred on the northern Channel Islands during the Medieval Climatic Anomaly (Arnold 1992; Peterson 1994; Walker and Lambert 1989), there is little comparable evidence from the southern Channel Islands group. No comparable chronologies are available from neighboring Santa Catalina and San Nicolas islands. However, considering the cultural, social, and economic relationships that existed prehistorically among the southern Channel Islands (Johnson 1988; Walker et al. 1993), it is likely that settlement changes apparent on San Clemente Island have some counterparts on both Santa Catalina Island and San Nicolas Island. Even small-scale site-dating studies on these other islands would go a long way toward addressing broader regional research questions focused on the southern Channel Islands during the Medieval Climatic Anomaly.

The current research demonstrates how well-preserved archaeological records like those from San Clemente Island and the other Channel Islands can chronicle prehistoric human population responses to large-scale paleoclimatic shifts in geographically-circumscribed contexts. Compared with the southern California mainland and many of the other regions of western North America discussed here, the use of date distributions in the Channel Islands has shown great potential to identify temporal disruptions in the study of settlement patterns (Glassow 1998). Even with a relatively small number of site dates, observed differences among dates in various time periods are more meaningful than comparable mainland distributions because various sources of bias in the date sequences have been reduced in the San Clemente Island samples. The current research further suggests that San Clemente Island has an even greater potential for resolving the chronology of regional prehistoric population responses to periods of paleoenvironmental stress than the other Channel Islands because its hydrology is highly sensitive to minor climatic fluctuations. San Clemente Island preserves a fine-grained record of prehistoric human population responses to medieval-era droughts. The ongoing study of these sites will continue to improve our understanding of these processes on the other Channel Islands and the southern California mainland.

Appendix 1

1994 and 1996 Eel Point Radiocarbon Dates (Raab et al. 1997a)

Lab Number	Provenience	^{14}C Age[1]	^{13}C Adj.	Material	Calibrated YBP[2]
Beta-77956	Unit 24.5S/77E, Stratum 3	580 ± 60	570 ± 60	Charcoal	523-629 (544)
Beta-76144	Unit 2N/35E, Stratum 3	1020 ± 50	1020 ± 50	Charcoal	803-961 (944)
Beta-76141	Unit C, Stratum 2b	1380 ± 60	1390 ± 60	Charcoal	1262-1340 (1297)
Beta-76142	Unit C, Stratum 3c	1620 ± 100	1640 ± 100	Charcoal	1409-1689 (1530)
Beta-77957	Unit 24.5S/77E, Stratum 8	1770 ± 150	1800 ± 150	Charcoal	1533-1915 (1709)
Beta-76145	Unit 2N/35E, Stratum 4	1890 ± 50	1900 ± 50	Charcoal	1732-1916 (1851)
Beta-76146	Unit 2N/35E, Stratum 5	1970 ± 60	2010 ± 60	Charcoal	1885-2000 (1935)
Beta-76132	Unit A, Stratum 4a	2000 ± 90	2020 ± 90	Charcoal	1874-2112 (1967)
Beta-76147	Unit 2N/35E, Stratum 6	1990 ± 90	2020 ± 90	Charcoal	1874-2112 (1967)
Beta-76134	Unit B, Stratum 5a	2360 ± 70	2800 ± 70	Shell	2129-2324 (2273)
Beta-76148	Unit 2N/35E, Stratum 7	2490 ± 60	2510 ± 60	Charcoal	2364-2737 (2566)
Beta-76133	Unit A, Stratum 5a	2540 ± 60	2540 ± 60	Charcoal	2389-2742 (2716)
Beta-76153	Unit 2N/35E, Stratum 11	2890 ± 50	2910 ± 50	Charcoal	2956-3158 (3011)
Beta-76149	Unit 2N/35E, Stratum 8	3050 ± 90	3030 ± 90	Charcoal	3004-3356 (3230)
Beta-76150	Unit 2N/35E, Stratum 9	3240 ± 80	3250 ± 80	Charcoal	3362-3626 (3446)
Beta-76151	Unit 2N/35E, Stratum 10	3320 ± 110	3320 ± 110	Charcoal	3402-3681 (3504)
Beta-76135	Unit B, Stratum 6	3560 ± 70	4010 ± 70	Shell	3609-3819 (3693)
Beta-79612	UCLA 1986 Unit B	3560 ± 80	3600 ± 80	Charcoal	3726-3981 (3872)
Beta-76136	Unit B, Stratum 6a	3990 ± 80	4370 ± 90	Urchin	4066-4346 (4202)
Beta-76137	Unit B, Stratum 6b	4000 ± 100	4000 ± 100	Charcoal	4295-4776 (4421)
Beta-100566	Units D-G, floor profile	4110 ± 60	4560 ± 60	Shell	4380-4528 (4432)
Beta-76138	Unit B, Stratum 7b	4090 ± 90	4090 ± 90	Charcoal	4421-4816 (4547)
Beta-76140	Unit B, Stratum 10	4860 ± 190	4860 ± 190	Charcoal	5327-5854 (5597)
Beta-75092	Unit B, Stratum 11	5060 ± 50	5510 ± 50	Shell	5580-5701 (5631)
Beta-100565	Unit 27N/21E, Lower floor	5220 ± 60	5660 ± 60	Shell	5717-5890 (5827)
Beta-76139	Unit B, Feature 2	5260 ± 80	5700 ± 80	Shell	5734-5926 (5869)
Beta-76143	Unit C, Stratum 6	5330 ± 80	5780 ± 90	Shell	5856-6031 (5919)
Beta-75555	Unit B, Stratum 11	5470 ± 160	5500 ± 160	Charcoal	6063-6436 (6290)
Beta-100564	Unit 27N/21E, Upper floor	5700 ± 60	6140 ± 60	Shell	6265-6395 (6302)
Beta-95900	Unit 28/29N-16E, Stratum 4B	5140 ± 80	5590 ± 80	Shell	6298-6448 (6365)
Beta-95898	Unit 28/29N-16E, Stratum 120A	7150 ± 210	7160 ± 210	Charcoal	7714-8130 (7930)
Beta-75093	Unit C, Basal stratum	7490 ± 70	7910 ± 70	Shell	7988-8159 (8096)
Beta-76130	Unit A, Stratum 6,	7500 ± 70	7930 ± 70	Shell[3]	8009-8178 (8111)
Beta-100567	Unit F, Stratum 6	7530 ± 80	7960 ± 80	Shell	8055-8252 (8130)
Beta-95899	Unit 28/29N-16E, Stratum 120A	7670 ± 90	8110 ± 90	Shell	8178-8384 (8312)
Beta-76152	Unit 2N/35E, Stratum 11	7720 ± 130	8140 ± 130	Shell	8171-8435 (8332)
Beta-95897	Unit 28/29N-16E, Stratum 120A	7790 ± 60	8210 ± 60	Bead	8331-8443 (8384)
Beta-76021	Unit C, Basal stratum	8120 ± 310	8110 ± 300	Charcoal	8547-9432 (8989)

[1] Radiocarbon years before present, uncorrected for fractionation in nature ($\delta^{13}C$).
[2] Dendrocalibrated age of samples in years before present (present= A.D. 1950), with 1-σ age range and mean intercept in parenthesis, calculated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993).
[3] All shell dates calibrated as follows: *Calib rev. 3.0.3* marine reservoir corrected (ΔR) shell dates involve two components: (1) a time-dependent global ocean correction (402 years) incorporated into the program's marine calibration curve, and (2) a local ocean offset of 225 ± 35 years for southern California (Stuiver and Braziunas 1993:138; 155-156; see also Taylor 1987:129).

Appendix 2

1991-92 Probabilistic Survey Radiocarbon Dates (Yatsko and Raab 1997)

Lab Number	Provenience (Site Number)	^{14}C Age[1]	^{13}C Adj.	Material	Calibrated YBP[2]
Beta-51120	C5-6	320 ± 60	750 ± 60	Shell[3]	80-267 (132)
Beta-51127	P27-10	130 ± 70	140 ± 70	Charcoal	0-281 (137)
Beta-51158	U10-3	130 ± 80	140 ± 80	Charcoal	0-284 (137)
Beta-51117	C5-6	190 ± 60	180 ± 60	Charcoal	0-290 (149)
Beta-51156	U10-2	190 ± 80	205 ± 80	Charcoal	0-304 (156)
Beta-51160	U10-3	190 ± 60	215 ± 60	Charcoal	0-301 (159)
Beta-51124	P20-C	260 ± 50	270 ± 50	Charcoal	0-421 (299)
Beta-51131	P27-7	240 ± 50	280 ± 50	Charcoal	287-425 (303)
Beta-51116	C3-68	500 ± 80	920 ± 80	Shell	261-430 (306)
Beta-51172	U6-12	290 ± 60	290 ± 60	Charcoal	287-435 (306)
Beta-51126	P20-C	280 ± 50	300 ± 70	Charcoal	287-463 (309)
Beta-51176	U6-8	365 ± 60		Charcoal	311-500 (345)[4]
Beta-51168	U4-12	350 ± 70	360 ± 70	Charcoal	306-502 (350)
Beta-51146	P4-B	320 ± 60	340 ± 60	Charcoal	303-478 (381)
Beta-51167	U32-2	290 ± 70	320 ± 70	Charcoal	293-473 (413)
Beta-48996	SCLI-970	610 ± 60	1050 ± 60	Shell	408-502 (462)
Beta-51119	C5-6	400 ± 50	420 ± 50	Charcoal	339-512 (496)
Beta-51421	U10-2	430 ± 80	440 ± 80	Charcoal	334-530 (504)
Beta-51162	U17-1	420 ± 60	460 ± 60	Charcoal	477-530 (509)
Beta-51422	U17-1	430 ± 60	440 ± 80	Charcoal	477-530 (509)
Beta-51169	U4-12	480 ± 70	480 ± 70	Charcoal	487-543 (514)
Beta-51141	P4-2	490 ± 70	520 ± 70	Charcoal	506-552 (529)
Beta-51129	P27-7	490 ± 70	520 ± 70	Charcoal	506-552 (529)
Beta-51118	C5-6	760 ± 90	1190 ± 90	Shell	487-631 (538)
Beta-51154	U10-1	550 ± 80	580 ± 80	Charcoal	519-648 (550)
Beta-48995	SCLI-970	590 ± 90	630 ± 90	Charcoal	540-662 (597)
Beta-51166	U32-2	580 ± 80	610 ± 80	Charcoal	534-655 (610)
Beta-51137	P3-3/4-C	670 ± 60	670 ± 60	Charcoal	557-664 (650)
Beta-51171	U4-3	780 ± 60	770 ± 60	Charcoal	660-725 (672)
Beta-51125	P20-C	1390 ± 55	1390 ± 55	Shell	648-750 (687)
Beta-51170	U4-3	960 ± 80	1410 ± 80	Shell	648-794 (706)
Beta-51147	P4-B	1210 ± 80	1620 ± 80	Shell	862-1008 (927)
Beta-49765	C5-10	1000 ± 60	1010 ± 60	Charcoal	800-961 (930)
Beta-49766	C5-10	1240 ± 60	1650 ± 60	Shell	904-1029 (948)
Beta-51139	P3-3/4-D	1080 ± 70	1100 ± 70	Charcoal	936-1065 (977)
Beta-51138	P3-3/4-C	1440 ± 80	1730 ± 80	Shell	941-1145 (1042)
Beta-51123	P20-3	1110 ± 60	1120 ± 60	Bulk Soil	952-1067 (1044)
Beta-51155	U10-1	1320 ± 90	1740 ± 90	Shell	942-1162 (1050)
Beta-49764	C5-10	1410 ± 50	1830 ± 50	Shell	1075-1227 (1156)
Beta-49762	C5-10	1240 ± 70	1250 ± 70	Charcoal	1067-1270 (1171)
Beta-51179	U9-1	1510 ± 70	1940 ± 70	Shell	1183-1313 (1264)
Beta-49763	C5-10	1370 ± 70	1380 ± 70	Charcoal	1264-1323 (1290)
Beta-51115	C3-68	1390 ± 70	1390 ± 70	Charcoal	1269-1333 (1293)

Lab Number	Provenience (Site Number)	^{14}C Age[1]	^{13}C Adj.	Material	Calibrated YBP[2]
Beta-51145	P4-B	1420 ± 50	1480 ± 50	Bulk Soil	1309-1403 (1345)
Beta-51121	P14-B	1500 ± 60	1500 ± 60	Bulk Soil	1315-1413 (1354)
Beta-51135	P3-D	1650 ± 70	2090 ± 70	Shell	1306-1492 (1386)
Beta-51163	U17-1	1500 ± 50	1550 ± 50	Bulk Soil	1353-1513 (1409)
Beta-51132	P3-3/4-C	1570 ± 80	1650 ± 80	Charcoal	1415-1683 (1535)
Beta-51140	P3-3/4-D	1760 ± 70	2190 ± 70	Shell	1404-1588 (1510)
Beta-48993	SCLI-970	1730 ± 110	1750 ± 110	Charcoal	1530-1810 (1661)
Beta-51136	P3-D	1760 ± 180	1790 ± 180	Charcoal	1518-1891 (1706)
Beta-51142	P4-2	1970 ± 70	2380 ± 70	Shell	1625-1822 (1720)
Beta-51144	P4-2	1940 ± 65	1940 ± 65	Charcoal	1817-1942 (1874)
Beta-51143	P4-2	2090 ± 70	2520 ± 70	Shell	1807-1977 (1882)
Beta-51177	U6-8	2160 ± 70	2600 ± 70	Shell	1884-2086 (1978)
Beta-51173	U6-12	2430 ± 80	2850 ± 80	Shell	2174-2356 (2308)
Beta-48994	SCLI-970	2590 ± 110	3020 ± 110	Shell	2337-2708 (2493)
Beta-51133	P3-3/4-C	2770 ± 80	3150 ± 80	Shell	2643-2758 (2713)
Beta-51130	P27-7	3290 ± 80	3730 ± 80	Shell	3283-3462 (3367)
Beta-51175	U6-12	4540 ± 70	4960 ± 70	Shell	4844-5047 (4957)

[1]Radiocarbon years before present, uncorrected for fractionation in nature ($\delta^{13}C$).
[2] Dendrocalibrated age of samples in years before present (present= A.D. 1950), with 1-σ age range and mean intercept in parenthesis, calculated by *Calib rev. 3.0.3* (Stuiver and Reimer 1993).
[3]All shell dates calibrated as follows: *Calib rev. 3.0.3*marine reservoir corrected (ΔR) shell dates involve two components: (1) a time-dependent global ocean correction (402 years) incorporated into the program's marine calibration curve, and (2) a local ocean offset of 225 ± 35 years for southern California (Stuiver and Braziunas 1993:138; 155-156; see also Taylor 1987:129).
[4] AMS date, automatically corrected for $\delta^{13}C$.

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