People in a Changing Land

The Archaeology and History of the Ballona in Los Angeles, California

VOLUME 1

Paleoenvironment and Culture History

edited by Jeffrey A. Homburg,
John G. Douglass, and Seetha N. Reddy

Statistical Research, Inc.
Technical Series 94

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with contributions by

Jeffrey H. Altschul
Richard S. Boettcher
Eric C. Brevik
Richard Ciolek-Torello
Owen K. Davis
Diane L. Douglas
John G. Douglass
Dennis R. Gallegos
Christopher P. Garraty
Donn R. Grenda
Jeffrey A. Homburg
Stanley A. Kling
Antony Orme
Manuel R. Palacios-Fest
Seetha N. Reddy
Steven D. Shelley
Patrick B. Stanton
Anne Q. Stoll
Mark Q. Sutton
Caroline Tepley
Sarah Van Galder
Benjamin R. Vargas
Peter E. Wigand

Submitted to
U.S. Army Corps of Engineers
Los Angeles District
Los Angeles, California

Technical Series 94
Statistical Research, Inc.
Tucson, Arizona • Redlands, California

2014

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ABSTRACT

Sponsor: Playa Capital Company, LLC

Volume Title: Paleoenvironment and Culture History. People in a Changing Land: The Archaeology and History of the Ballona in Los Angeles, California.

Project Location: The project area is located in the former Ballona Lagoon, a prehistoric wetland complex in west Los Angeles that is known collectively as the Ballona. This area is today bound roughly by Playa del Rey to the west, Marina del Rey to the north, the Ballona Escarpment (a high bluff) and Del Rey Hills/Westchester Bluffs to the south, and Interstate 405 to the east. It is located approximately 0.5 km east of the Pacific Ocean, 1.3 km west of the Baldwin Hills, and 1.6–2.6 km north of Los Angeles International Airport. Ballona Creek, a drainage that is now channelized, crosses the project area; Centinela Creek, a spring-fed drainage, once ran along the southern portion of the project area along the base of the Ballona Escarpment.

Project Description: Statistical Research, Inc. (SRI), conducted research, including data recovery, at five sites in the Ballona: CA-LAN-54/H, CA-LAN-62/H, CA-LAN-193/H, CA-LAN-211/H, and CA-LAN-2768/H. This involved the creation of research designs for the investigations, a paleoenvironmental study of the Ballona, and hand and mechanical excavation of the sites themselves. These five sites were recommended eligible for listing in the National Register of Historic Places (NRHP) (Altschul et al. 1991, 1998, 1999, 2003; Keller and Altschul 2002; Van Galder et al. 2006; Vargas and Altschul 2001; Vargas et al. 2005). A sixth site, CA-LAN-2676, was recommended eligible and underwent data recovery but was found to have been redeposited. This volume provides an introduction to and background for the project; it includes an introduction to the Playa Vista Archaeological and Historical Project (PVAHP), an environmental setting for the Ballona and the Southern California Bight, an updated culture history for the southern California coast, a description and discussion of previous research in the Ballona, an updated research design for the PVAHP, and the results of our paleoenvironmental study of the Ballona Lagoon area's evolution over the past 8,000 calendar years.

Project Summary: This volume presents several important research findings on the paleoenvironment and prehistory of the Ballona. An updated culture history for the Southern California Bight allows a deeper understanding of regional trends over the past 10,000 years and how those trends compare to those in the Ballona. The updated research design offers new insight regarding the research topics and theories first proposed for the PVAHP and how they have evolved through time. Over the course of 20 years, research goals and objectives have changed to adapt to data recovery at NRHP-eligible sites, as well as to research trends and topics in California archaeology and in the discipline as a whole. The paleoenvironmental study was conducted as part of the PVAHP to provide insight regarding prehistoric use of the Ballona Lagoon over the past 10,000 years. It was designed to complement the archaeological excavations at sites in the PVAHP and aimed at providing a geoarchaeological context for interpreting the distribution of habitats and the evolution of landscapes used by ancient peoples who lived in the Ballona. Stratigraphic reconstruction of the Ballona Lagoon indicates a system that was probably in static equilibrium with sea-level rise after about 7000 B.P. and a lagoonal evolution driven primarily by sediment in-filling rather than by sea-level transgression or regression. Paleoenvironmental and archaeological data indicate that both biological productivity and human occupation in the Ballona reached a peak between about 3000 and 2000 B.P.

ACKNOWLEDGMENTS

In 2014, Statistical Research, Inc. (SRI), began its 23rd year n 2016, Statistical Research, Inc. (SRI), began its 25th year of work on the Playa Vista Archaeological and Historical Project (PVAHP), the project that ultimately resulted in this five-volume series. These final reports offer a broad, as well as specific, understanding of more than 8,000 years of human occupation of the Ballona region and of the relationship between that occupation and the evolution of the Ballona environment. Over the long course of the project, a large number of extraordinary people contributed to its success; to all these people, we are deeply indebted. Although we cannot adequately thank everyone here, below we acknowledge the contributors to the research presented in these report volumes.

First and foremost, we thank the project sponsors for giving us the opportunity to conduct this important work. In 1989, two years before the PVAHP proper began, SRI was hired by Camp, Dresser, McKee (CDM, now CDM Smith) and Planning Consultants Research (PCR) to survey the project area and develop a research design as part of the environmental review process; Jane Yager (PCR) was our initial contact person for the project. After the completion of the initial environmental impact report, SRI was retained by Maguire Thomas Partners (MTP), then the developer of Playa Vista. Robert Miller of MTP ably provided SRI with corporate assistance and was a strong supporter of the PVAHP. In the late 1990s, MTP was replaced by Playa Capital Company, LLC[1], as the project developer. We are indebted to Bruce Harrigan, Marc Huffman, Randy Johnson, Pat Larkin, Cliff Ritz, Patricia Sinclair, Steve Soboroff, and Catherine Tyrrell, who oversee or have overseen the implementation of the PVAHP. Patti Sinclair worked closely with SRI during much of the field and postfield efforts and deserves an advanced degree in archaeology for the amount of knowledge she has gained over this time. During field efforts, Cliff Ritz offered many helpful suggestions on using heavy equipment for the efficient collection of required information on the sites. Specifically, Cliff designed and built a large-diameter coring system that helped us recover buried archaeological sites below groundwater. Marc Huffman has worked side-by-side with SRI on a number of matters related to the implementation of the PVAHP over the years and has been a great facilitator for the project. In 2012, Playa Capital Company, LLC, was purchased by Brookfield Residential.

Compliance with Section 106 of the National Historic Preservation Act was accomplished through a Programmatic Agreement (PA). The signatories to the PA for the PVAHP are the U.S. Army Corps of Engineers (Corps), the California State Historic Preservation Officer (SHPO), and the Advisory Council on Historic Preservation (ACHP). The lead federal agency for this work is the Corps. We appreciate the help of a number of current and former Corps employees, including Aaron Allen, D. Stephen Dibble, John Killeen, Patricia Martz, Pamela Maxwell, Roderic McLean, and Richard Perry. Three consecutive SHPOs, Knox Mellon, Milford Wayne Donaldson, and Carol Roland-Nawi served as important guides for this project; the current SHPO is Julianne Polanco. We thank both of these agencies, as well as members of the ACHP who participated in the project, including the current chairperson, Milford Wayne Donaldson, and Reid Nelson, the director of Federal Agency Programs. Phillip de Barros, John McAlister, and William Want were all instrumental in drafting the PA, and Hans Kreutzberg, Chief of Review and Compliance for the California Office of Historic Preservation helped bring it to a successful conclusion. George Mihlsten and others at Latham and Watkins were a great help with advice on particular aspects of the project.

Peer review has been an integral part of the PVAHP from beginning to end—during prefield research-design creation and fieldwork and during postfield analysis and report writing. The peer-review team reviewed the research design and treatment plans for various sites, met with us multiple times in the field during various excavations, offered important feedback during analysis, and gave critical review of reports. We appreciate and value the feedback from our peer reviewers, John Johnson, Patricia Lambert, Patricia Martz, Charles Rozaire, and the late Phillip Walker.

Two Tongva/Gabrielino tribal groups signed the PA as concurring parties: the Gabrielino People (represented by Vera and Manuel Rocha) and the Tongva/Gabrieleno Tribal Council of San Gabriel (represented by Cindi Alvitre). As discussed below, we have enjoyed working with these and other Gabrielino/Tongva tribal groups and appreciate the opportunities we have had to interact with them over the course of two decades. We have also enjoyed our interactions with Robert Dorame, who was named Most Likely Descendent for the project by the Native American Heritage Commission, and appreciate his recommendations. We also thank the Native American monitors who worked side by side with SRI on the PVAHP. These monitors, all representatives of various Gabrielino/Tongva Tribal groups, included Martin

[1] The several stages of the Playa Vista development project were overseen by a series of different corporate entities.

Alcala, Richard Alcala, Dana Alcala, Evan Alcala, Tonantzin Carmelo, Virginia Carmelo, Jordan David, Katy Dorame, Mat Dorame, Mercedes Dorame, Robert Dorame, George Dorame, Sam Dunlap, Adrienne Kinsella, Edgar Perez, Theresa Richau, and Abel Silvas. We are proud to have developed such a strong working relationship with these individuals during the PVAHP. We also thank the late Vera Rocha for blessing the PVAHP at the outset of the project.

A number of past and present SRI employees have contributed to project direction, oversight, and management, including Kenneth Becker, Su Benaron, Amanda Cannon, Christopher Doolittle, John Douglass, David Ferraro, Jeffrey Homburg, Janet Grenda, Angela Keller, David Maxwell, Seetha Reddy, Steven Shelley, and Anne Stoll. We are especially grateful to Benjamin Vargas and Sarah Van Galder Wollwage for their multiple roles directing fieldwork, analysis, and the writing of volumes. The initial survey for the PVAHP was directed by James N. Spain, while Mark Swanson conducted the initial historical research.

Laboratory direction was overseen by a number of different individuals, principally James Clark, Elizabeth Denniston, William Feld (who also did remarkable work with field logistics and setup of the water screening apparatus), Jennifer Howard, Scott Kremkau, LaShawn Lee, Katherine Pollock, and Susan Seifried. Database work (including the creation of a relational database that we have since adapted to use companywide) was essential for all aspects of investigation, and the diligence of Andrew Bean, Robert Heckman, Jim LoFaro, Carey Tilden, and Mark Woodson was indispensible to the project. We thank the many field crew and laboratory technicians who labored so assiduously on different aspects of the fieldwork, laboratory sorting, and analysis. Their efforts are truly appreciated.

The geoarchaeology and geomorphological work was accomplished by many individuals. Led by Jeffrey Homburg, the geoarchaeology team included Eric Brevik, Diane Douglas, David Ferraro, Antony Orme, Manuel Palacios-Fest, Steven Shelley, Caroline Tepley, and Lance Wollwage. We are also indebted to many individuals at SRI who played crucial roles in support of the paleoenvironmental project. Richard Boettcher, Diane Douglas, John Douglass, David Ferraro, Dennis Gallegos, Paul Goldberg, Jeffrey Homburg, Stanley Kling, Doug Macintosh, Richard Macphail, Russell Morse, Manuel Palacios-Fest, Seetha Reddy, Neil Rhodes, Paul Sauder, Peter Wigand, and Steve Williams all played various roles in the field and postfield efforts. A number of consultants contributed to the paleoenvironmental study, including Matt Rowe, Roy Shlemon, Jacob Lipa, Douglas Howard, and William Nailling III, and surveyors at Psomas and Associates; they are acknowledged for mapping the original cores collected for this study. We thank Tracy Spilotro of West Hazmat Drilling Corporation and Tony Morgan of Quaternary Investigations for collecting these cores. Foothill Engineering also collected cores for this project, and we are grateful to Delta Group for sharing data on other cores with us throughout the years. The chronostratigraphical analysis for the project was conducted by William Deaver, Stacey Lengyel, Jill Onken, Benjamin Vargas, and Lance Wollwage.

Material culture studies were conducted by SRI archaeologists and consulting specialists. John Griswold and his associates helped a great deal in the field with conservation of fragile material culture. Lithic analysis was led by Kathleen Hull and Polly A. Peterson, with contributions from Amanda Cannon, Robert Elston, Henry Koerper, Scott Kremkau, Seetha Reddy, Mark Sutton, and Robert Wegener. Shell-bead analysis was conducted by Amanda Cannon after initial contributions from Angela Keller. During the initial identification of shell bead types, Angela Keller consulted with Chester King. Worked-bone studies were led by Janet Griffitts, with assistance from Tina Fulton and Justin Lev-Tov. Glass-bead studies were done by Lester Ross with assistance from Amanda Cannon, John Douglass, and Scott Kremkau. Basketry analysis was conducted by Judith Polanich, while Owen Davis and Peter Wigand conducted the pollen analysis and Seetha Reddy studied the macrobotanical remains. Christopher Garraty analyzed the Native American ceramics, and Karen Swope studied the historical-period artifacts in collaboration with John Douglass. Marcy Gray also analyzed selected historical period artifacts. Faunal analysis (vertebrate and invertebrate) was led by David Maxwell and Sarah Van Galder, with assistance from Justin Lev-Tov, John Goodman, and Robert Wegener. Ethnohistoric research has principally been conducted by John Douglass, Steven Hackel, and Anne Stoll. An important component of this research was conducted using the Early California Population Project database, housed at the Huntington Library and directed by its general editor, Steven Hackel.

Osteological analysis of remains from CA-LAN-62 was among the most important cultural and scientific components of the project. Osteological work was overseen by Patrick Stanton, with guidance from Phillip Walker. A number of other individuals were important to this analysis—namely, Rhonda Bathurst, Joseph Hefner, Mitch Keur, Tamara Leher, Lorrie Lincoln-Babb, Kenneth Maes, Christopher Nagle, Korri Turner, and Bonnie Yoshida. We acknowledge the generous support and consultation of the late Phillip Walker, who not only was a peer reviewer for osteology, but also offered important insight throughout excavation and subsequent analysis; we appreciate Patricia Lambert taking over as the osteological peer reviewer after his passing.

The PVAHP had several research components, and SRI archaeologists worked closely with a large number of consultants conducting specialized studies, including paleoenvironmental study, radiometric studies, chronological analysis, osteological analysis, ceramic analysis, lithic analysis, faunal analysis, micro- and macrobotanical studies, and historic-artifact analysis. We thank each of these scholars for their participation and their role in making the project a resounding success.

We appreciate the help of SRI's publications staff in completing these five volumes. We thank María Molina, SRI's director of publications for overseeing the many tasks involved. We are especially indebted to Steve Bradberry, John

Cafiero, Diane Holliday, Grant Klein, April Moles, Jason Pitts, Peg Robbins, Jennifer Shopland, Luke Wisner, and Linda Wooden for their work in editing, graphics, and production, which made the volumes read and look as they do. Others who helped with the massive amount of illustrations, graphs, and maps include Ileana Bradford, Marie Echevarría-Delgado, Cindy Elsner-Hayward, William Hayden, Steve Norris, Nicholas Reseburg, James Wallace, and Deland Wing. Seetha Reddy and John Douglass deserve special recognition for coediting and coordinating all five volumes through various drafts and peer and regulatory review, with help from colleagues Jeff Homburg, Patrick Stanton, and Benjamin Vargas on specific volumes.

Finally, we thank Wendy Teeter, curator of the Fowler Museum at the University of California, Los Angeles, for guiding us as we prepared the massive collection of non-burial-related PVAHP material for curation at the Fowler. Wendy was a great help throughout the entire process.

Donn R. Grenda, Richard Ciolek-Torello, and Jeffrey H. Altschul
Series Editors

LIST OF ABBREVIATIONS AND ACRONYMS

AAR	amino-acid racemization
ACHP	Advisory Council on Historic Preservation
AMSL	above mean sea level
ASA	Archaeological Survey Association of Southern California
BLAD	Ballona Lagoon Archaeological District
b/s	below surface
Corps	U.S. Army Corps of Engineers
FAR	fire-affected rock
HIHD	Hughes Industrial Historic District
LAX	Los Angeles International Airport
LGM	last glacial maximum
LIA	Little Ice Age
LMU	Loyola Marymount University
MTP	Maguire Thomas Partners–Playa Vista
mya	million years ago
NRHP	National Register of Historic Places
PVAHP	Playa Vista Archaeological and Historical Project
SCCIC	South Central Coastal Information Center
SHPO	State Historic Preservation Officer
SRI	Statistical Research, Inc.
UCLA	University of California, Los Angeles
USGS	U.S. Geological Survey
WPA	Works Progress Administration/Work Projects Administration

Note: Dates presented in this volume as years before present (B.P.) are assumed to be radiocarbon years unless noted as calibrated years (e.g., “cal B.P.”).

The Playa Vista Archaeological and Historical Project

John G. Douglass, Jeffrey H. Altschul, Seetha N. Reddy, Richard Ciolek-Torello, and Donn R. Grenda

The Playa Vista Archaeological and Historical Project (PVAHP) offers a unique opportunity to examine long-term human adaptations to a dynamic ecosystem in a coastal setting in western North America. In this project, Statistical Research, Inc. (SRI), has been able to trace the evolution of the ecosystem and human adaptations over 8,000 years and has uncovered much that is new about regional culture history and dynamics. The data derived for the PVAHP will have lasting importance to archaeologists, anthropologists, historians, and Native Americans as they pursue research to characterize and understand more fully the human history of the Southern California Bight. This work will also be of interest to scholars who are more generally interested in how humans have perceived coastal environments and adapted to them. This study seeks to integrate the environmental and sociocultural evolution of a coastal wetland, known regionally as the Ballona. The resulting interdisciplinary approach has led to a variety of methodological and theoretical studies that are individually compelling as well as mutually reinforcing and should be useful to others in comparative studies of coastal adaptation.

The project area originally consisted of 1,087 acres, a portion of which has been developed into the Playa Vista neighborhood of the city of Los Angeles. More than half of the original acreage has been conveyed to the State of California for permanent open space. The PVAHP area is located north of the community of Westchester, immediately east of the community of Playa del Rey, west of Culver City, and south of the communities of Venice and Santa Monica (Figure 1). This area is generally referred to as the Ballona region, being the former site of the prehistoric Ballona Lagoon (Figure 2).

Numerous archaeological sites have been documented in the greater Ballona region; however, the amount of information available about these sites varies. Some sites recorded several decades ago have site records with minimal information; other sites were found in highly disturbed contexts (for example, LAN-66, LAN-1714, and LAN-1118). By contrast, some sites (particularly within the PVAHP study area) have detailed descriptions; these are discussed in the PVAHP volumes.

The Ballona region became an attractive area for human settlement when the wetlands first formed, more than 8,000 years ago. For thousands of years, Native American inhabitants of the Ballona lived either on the edge of Ballona Lagoon or on the bluffs overlooking the prehistoric lagoon and wetlands. These peoples subsisted on the aquatic and terrestrial resources of the area and traded with local groups as well as very distant ones. By the early 1800s, the Ballona area was being used and occupied by newly arrived Hispanic colonists from Mexico. At first, the Ballona was simply used as pasture by the inhabitants of the newly established Pueblo of Los Angeles. However, soon afterwards, it was occupied and farmed by two ranchos, in turn: Rancho los Quintos and Rancho la Ballona. As these new Hispanic inhabitants were becoming established in the Ballona, the native inhabitants were recruited to nearby Missions. As a result, there is little evidence of continued Native American occupation in the Ballona after the late 1810s.

The area began to be developed in the early 1900s, but it was not until the famous aviator, engineer, and industrialist (as well as film producer) Howard Hughes began purchasing land in the Ballona in the 1930s that others took notice of the region. Between the early 1940s and his death in 1976, Hughes's company, the Hughes Tool Company, used the central portion of the project area as its Culver City plant for design, construction, and testing of a variety of aircraft. The Culver City plant included the longest privately owned runway in the United States. Outlying areas of land owned by Hughes, including those of the bluffs to the south, were used as buffers for airspace, as well as for the construction and use of radar installations related to the airstrip. Many of these unused buffer areas, including the land adjacent to the airstrip, were farmed, because farming land was taxed minimally (Altschul et al. 1991). Perhaps the most famous airplane to be designed and constructed at the Culver City Plant was the Hughes H-4 Hercules (also known as the "Spruce Goose"), the largest wooden aircraft ever designed and flown. In addition, the Culver City Plant created important technological and engineering innovations, from radar technology and helicopter manufacture to aircraft critical to the war in Vietnam. Beginning in the late 1970s, after the death of

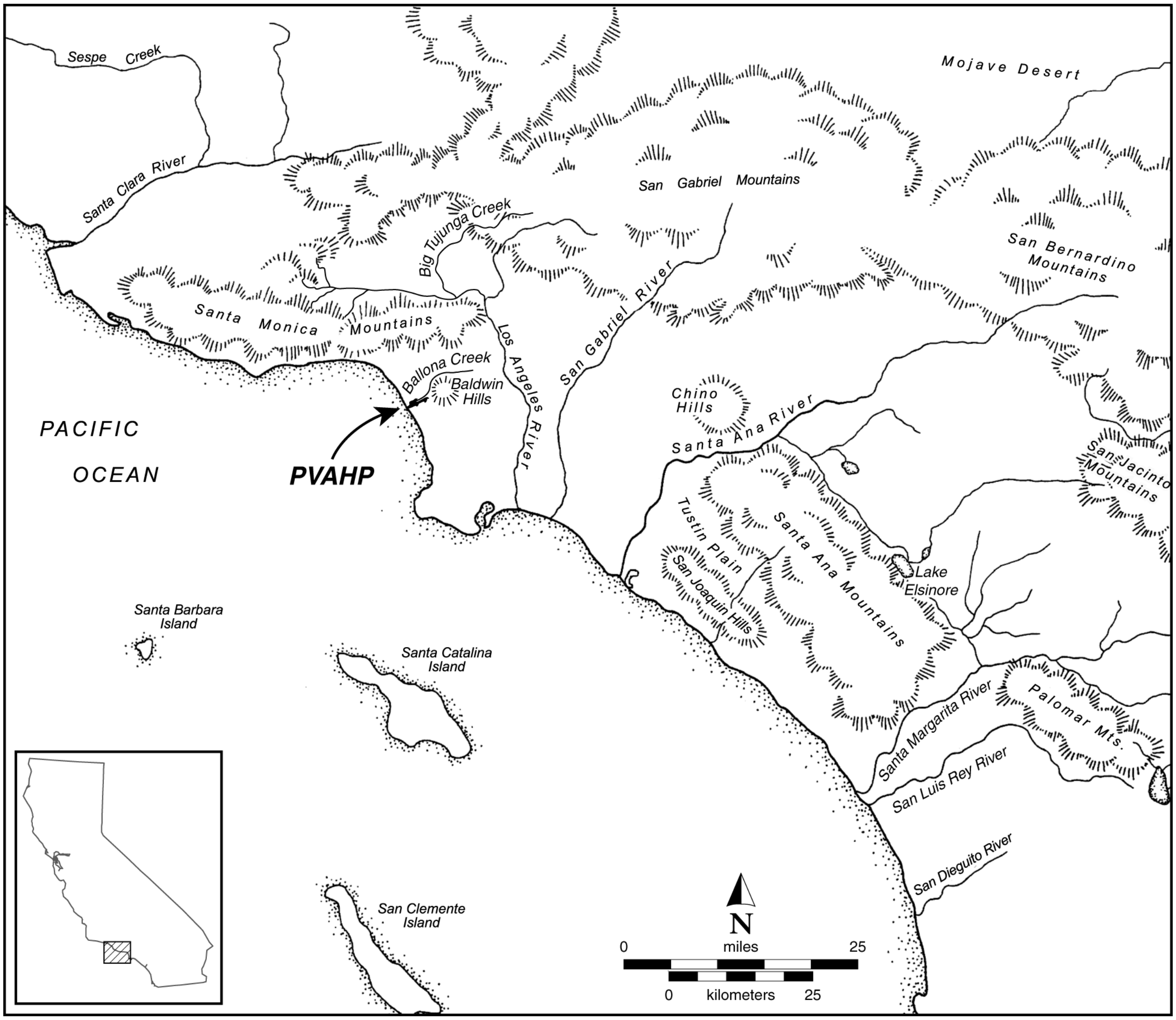

Figure 1. Location of the Playa Vista project area.

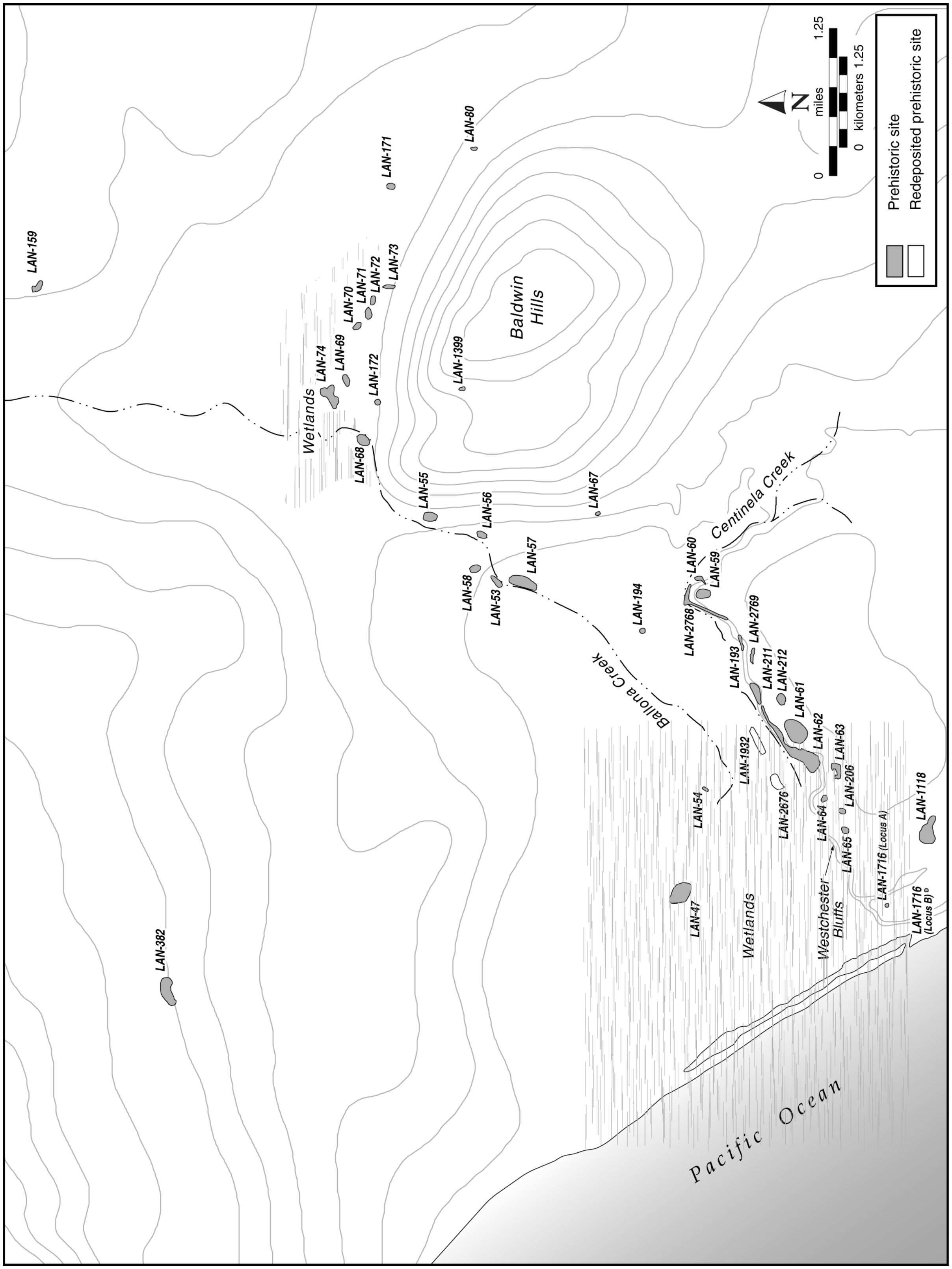

Figure 2. Prehistoric archaeological sites in the Ballona region.

Howard Hughes, plans for development of the project area were initiated. Over time, these plans evolved into a mixed residential-commercial development named Playa Vista.

SRI was hired in 1989 by Camp, Dresser, and McKee as part of the Environmental Impact Report team for the then-developer of Playa Vista, Maguire Thomas Partners–Playa Vista (MTP). In 1990–1991, SRI began working directly for MTP, at which point we developed the PVAHP as a phased archaeological and historical study designed to comply with federal, state, and municipal regulations protecting cultural resources. In 1997, the Playa Capital Company, LLC, took over ownership and development of Playa Vista. To facilitate management, planning, and research, archaeological and historical resources were grouped into two districts: the Ballona Lagoon Archaeological District (BLAD), which encompasses the prehistoric archaeological sites, and the Hughes Industrial Historic District (HIHD) (Altschul et al. 1991). Both districts were determined to be eligible for listing in the National Register of Historic Places (NRHP) by the U.S. Army Corps of Engineers (Corps), in consultation with the California State Historic Preservation Office (SHPO), the Advisory Council on Historic Preservation (ACHP), and two groups representing the Gabrielino/Tongva Tribe. All archaeological and historical work undertaken within these two districts contributes to the ultimate goal of documenting past human occupation and activities throughout the area. Although the Playa Vista development occupies only a portion of the original PVAHP area, archaeological and historical work was conducted over the entire 1,087-acre original project area.

This volume provides background data on the history of the PVAHP and synthesizes the results of long-term research on the paleoenvironment in the Ballona Wetlands area. The study area includes the Ballona Wetlands, historically a rich estuarine environment fed by Ballona and Centinela Creeks, as well as portions of the adjoining Westchester Bluffs. The estuarine resources of the Ballona have attracted human populations for thousands of years, and many settlements were established along the shores and creeks of the wetlands and surrounding upland areas.

Development and Regulatory Background

Soon after Howard Hughes's death, one of the many Hughes companies, Summa Corporation, began plans for developing the project area. Other portions of the Hughes property on top of the bluffs both east and west of Lincoln Boulevard were separate from the planned Playa Vista development and were later sold to separate entities. The PVAHP project area, containing 1,087 acres (nearly 2 square miles), was divided into four areas: Areas A, B, C, and D. Figure 3 illustrates the four areas of the PVAHP and the five archaeological sites that have undergone data recovery: CA-LAN-54,/H CA-LAN-62/H, CA-LAN-193/H, CA-LAN-211/H, and CA-LAN-2768/H (hereinafter, the prefix "CA-" and the suffix "/H" will be omitted from site trinomials). Area D is further subdivided into three subareas: Area D1 on the west, Area D2 in the middle, and what was originally known as the Entertainment, Media, and Technology District and is now known as The Campus in the east. Area D2 is now known as The Village. By the mid-1980s, the original development plans for Playa Vista by Summa Corporation had been approved by the City of Los Angeles and the California Coastal Commission. For many years, much of the 1,087 acres of the original Playa Vista property had been slowly surrounded by housing and other urban development.

When Howard Hughes purchased much of the project area in the 1940s and 1950s, there was still substantial open space surrounding it. By the 1980s, however, suburban housing and commercial development had encroached upon all sides, and open space was at a premium. As a result, the portion of the project area that was to be set aside as open space in the Summa Corporation plan was seen as inadequate by development opponents, and that plan was the subject of litigation.

By the late 1980s, the original plans for the project area were beginning to be restructured under a development team led by MTP. In 1989, MTP acquired the property and began new plans for developing the project area that included a reduction of development plans and an increase in open space. SRI's initial responsibility as part of the Environmental Impact Report team for the Playa Vista development was to conduct a pedestrian archaeological survey, compile and summarize archival sources on the history of the project area and its cultural resources, and develop a comprehensive research design that would aid in the identification, evaluation, and treatment of archaeological and historical resources known and anticipated to be found during the course of development (Altschul et al. 1991).

Between 1989 and 2014, SRI conducted its work in phases, beginning with a survey of the project area and the creation of a project research design and a programmatic agreement (PA) for the project. Later, SRI, along with Greenwood and Associates and Historic Resources Group, undertook historic building evaluations and testing of historical-period sites, subsurface inventory and testing, evaluation of sites for NRHP eligibility, data recovery of eligible sites, monitoring of ground-disturbing activity in the project area, public outreach, analysis, and report writing. The PVAHP series is designed to detail the data recovery phase of work for all aboriginal sites recommended eligible for listing in the NRHP as contributing members of the BLAD and to offer an understanding of what the accumulated archaeological material and prehistoric and historical patterns suggest about the use of the Ballona over the past 8,000 years.

Because the project required a permit from the Corps to comply with the Clean Water Act, the project also had to comply with the National Environmental Policy Act and the National Historic Preservation Act. Additionally, the

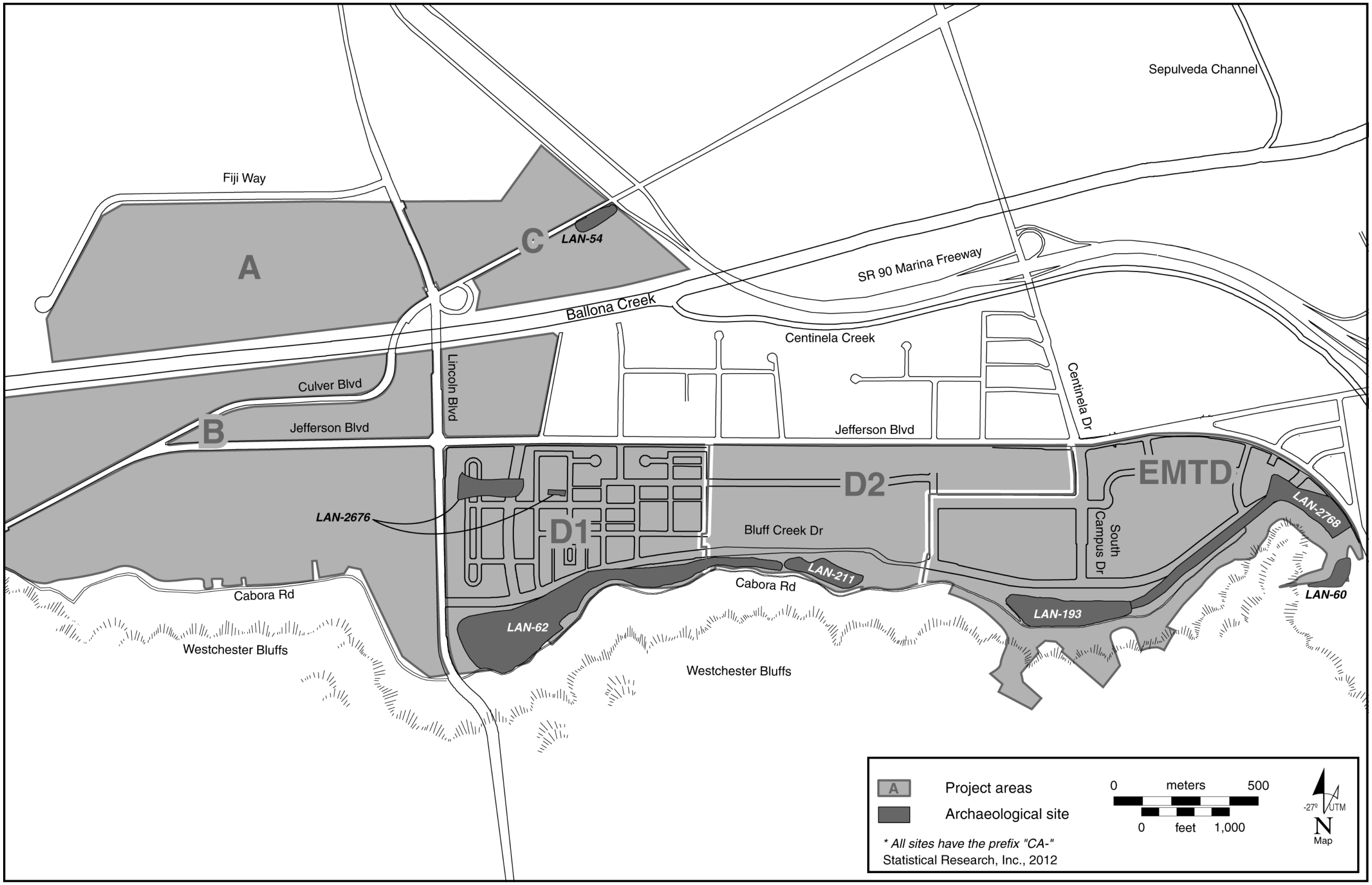

Figure 3. Map of the original Playa Vista development area, showing Areas A, B, C, and D and the Entertainment, Media, and Technology District (EMTD) and prehistoric archaeological sites eligible for inclusion in the NRHP.

project had to comply with state and local laws, most notably the California Environmental Quality Act and, for the portions of the project in the coastal zone, the California Coastal Act. A comprehensive program was developed to ensure that compliance with federal, state, and local laws and regulations was met. Acting as the lead federal agency, the Corps, in consultation with the SHPO, the ACHP, and two groups representing the Gabrielino/Tongva (a state-recognized but not federally recognized tribe), first determined that the entire 1,087 acres would be considered. The parties then determined that two districts on the PVAHP were eligible for listing in the NRHP. The HIHD was determined eligible for its importance to the history of the country, through its association with the development and construction of military technology and aircraft as well as its relationship with a person of singular importance in the twentieth century, Howard Hughes. Impacts to the HIHD were mitigated through the preparation of a Historic American Engineering Record that documented the buildings, the development and implementation of a management plan for those buildings that could be saved, and the preparation of a detailed history (Greenwood and Associates 1995; Historic Resources Group 1998; SRI et al. 1991).

The BLAD, which includes all sites eligible for listing in the NRHP within the PVAHP, was determined eligible for the potential of its resources to contribute to our understanding of the prehistory of the Southern California Bight. The BLAD is the subject of the five volumes in this series, which fulfills the obligation to report on our findings and to place these findings in their proper cultural and historical context. This volume, the first, is an introduction to the PVAHP that details the project history and paleoenvironmental reconstruction undertaken in the project area. Volume 2 presents the methods and results of data recovery excavations and elucidates the chronology and chronostratigraphy of the various properties in the project area. Volume 3 contains analyses of both material culture and food remains and discussion of their continuity and change through the past 8,000 years of human occupation in the Ballona area. Volume 4 presents the bioarchaeological studies conducted for the PVAHP; it describes in detail the human remains identified, analyzed, and reburied in the project area, most of which were identified in a confined burial area in the western portion of LAN-62. Finally, Volume 5 examines the results of ethnohistoric research in the region, presents a mortuary analysis, and provides a synthesis of the research for the PVAHP.

Research Goals and Objectives of the PVAHP

The PVAHP research design (Altschul et al. 1991) outlined a number of historic-context themes for the project. Three broad research themes were presented in the research design: (1) human-land relationships, (2) culture history and cultural dynamics of prehistoric settlement, and (3) historical-period development of the Ballona. In addition to the research design (Altschul et al. 1991), SRI has expanded these themes within the context of specific site investigations (Altschul et al. 2003; Vargas et al. 2003). They are discussed briefly here and detailed in Chapter 5 of this volume.

An important point to be made here is that although the research design for the project has laid a strong framework for research on the PVAHP over the past 20 years, it has been used as a guide for research, not as a rigid structure that could not be further developed or built upon. Below, we detail the original themes of the research design, including more-recent information on what has been learned, as well as research interests that developed subsequently.

Human-Land Relationships

A major goal of this portion of the work was to reconstruct the paleoenvironment of the Ballona to determine whether additional work was warranted to search for buried cultural deposits. By the time SRI began working in the Ballona, numerous archaeological surveys, spanning nearly 40 years, had been conducted in the region. All of these surveys focused on the surface. Although many sites were found on the bluff tops, few were encountered in the wetlands or along the banks of Ballona or Centinela Creek. Our work at the Admiralty site (LAN-47) on the northern edge of the Ballona Lagoon outside the PVAHP (Altschul et al. 1992; Altschul et al. 2007), however, convinced us that more sites might be found along edges of the lagoon and the banks of the creeks. Moreover, we hypothesized that as sea level rose and more sediment from Ballona and Centinela Creeks filled the lagoon, the border of the lagoon would have retreated westward during the Holocene, stabilizing every so often as climatic and tectonic conditions dictated. If we could define these stable lagoon edges, then through methodological studies, we should be able to define a suite of techniques that could find buried sites that had no surface expression.

The first step in meeting our overall objective was to develop a study that could obtain data for paleotopographic and paleoecologic reconstruction. The Quaternary history of the Ballona Lagoon was thought to be characterized by dynamic environmental changes. Most important was the change from an open lagoon to an estuarine environment and migrations of the Los Angeles River channel (see Altschul et al. 2007). These changes were the result of the complex interaction of lowering sea level, rapid tectonic uplift, and subsidence. These environmental changes, in turn, had profound effects on prehistoric settlement and resource procurement in the region. Several chapters in this volume address research questions related to the paleoenvironmental reconstruction of the Ballona and how it related to prehistoric occupation in the area.

Prehistoric subsistence was also seen as important. At the time we developed the research design, it was thought that there was a shift from terrestrial to aquatic resources between the late Millingstone period and the Late period (Altschul et al. 1991). This shift was thought to be associated with a change in settlement preference from the bluffs to the lagoon. Although we documented shifts in subsistence through time, they are much more complex than previously thought, with apparent differences both above and below the bluffs as well as changes through time in subsistence strategies.

Culture History and Cultural Dynamics of Prehistoric Settlement

Research questions related to this theme are subdivided into chronology, technology, and cultural affiliation. Like most archaeologists, we began with time and space. Where and when did people live? Chronological data available in 1991 suggested that occupation of the nearby Westchester Bluffs began during the Millingstone period, sometime between 5500 and 3000 B.C., and ended at the beginning of the Late period, around A.D. 1000. Below the bluffs, occupation appeared to have begun when the bluffs were abandoned, around A.D. 1000, with the possible exception of the area where Centinela Creek empties into the Ballona Lagoon. It was unclear at the time of the research design whether the hints of early occupation found at LAN-62, which was recorded in this section of the wetlands, constituted an anomaly or the rule.

Today, we know that the earliest occupation in the Ballona occurred on the bluff tops on either side of a natural cut in the sand dunes known as the Lincoln Gap, which sits just above LAN-62. Radiocarbon dates from LAN-64—on the bluff tops at West Bluffs, on the edge of the Lincoln Gap—provide strong evidence that small groups camped in this area, probably seasonally, more than 8,000 years ago. All sites below the bluff were occupied at least as far back as the Intermediate period (1000 B.C.–A.D. 1000); some sites (including LAN-62) were occupied thousands of years earlier. At the other end of the chronological span, our research found no evidence for the Mission period village of Sa'angna (Stoll et al. 2003), which was reported to have been present in the Ballona (Altschul et al. 1991; Johnston 1962). Instead, archaeological investigations revealed substantial evidence for a Mission period occupation that our ethnohistoric research suggests was associated with the village of Guasna (Stoll et al. 2009).

When initial testing at LAN-62 and LAN-211 found strong evidence of occupation during the Protohistoric and Mission periods, we created a cultural-adaptation model to guide subsequent intensive archaeological investigations at these sites (Vargas et al. 2003). Three scenarios were proposed that differed in terms of the inferred degree of interaction with Missions San Gabriel and San Fernando Rey, the fledgling Pueblo of Los Angeles, or one of the Hispanic ranchos in the area (such as Rancho los Quintos). These scenarios are Gentile or Renegade, Mission Support, and Rancho or Pueblo Support. Partly through the identification of a living surface at LAN-211 and a burial area containing hundreds of burial features at LAN-62, we explore and discuss these different scenarios of cultural adaptation in Volume 5 of this series.

From chronology, we moved on to technology. Previous work by David Van Horn and his colleagues at bluff-top sites (Van Horn 1987a; Van Horn and Murray 1984, 1985; Van Horn and White 1997a), as well as SRI's work at nearby LAN-47 (Altschul et al. 1992), suggested that the Ballona area was characterized by a material culture unlike that found elsewhere along the coast. The development of a small-flaked-stone-tool, or microlith, industry apparently unrelated to the one developed on Santa Cruz Island suggests that cultural adaptation in the Ballona area involved a unique economic adaption. Based on more recent work as part of the PVAHP and other, related Ballona data recovery excavations (including work presented in the PVAHP series), it is apparent that the microlith technology was not as prevalent as previously thought. Research questions related to technology centered on how prevalent and localized this tradition was, whether there were other facets of culture that distinguish the Ballona from other groups and help explain why this tradition may have appeared, and how the technology of the Ballona relates to inland sites, both economically and socially.

Finally, we tackled the critical question of who the people of the Ballona were. According to various sources (Johnston 1962; McCawley 1996), the Ballona was occupied by the Gabrielino/Tongva at the time of Spanish contact. Van Horn (Van Horn and Murray 1985), however, has argued that the Takic (a branch of Northern Uto-Aztechan) influence in the region is much older than previously recognized. Research questions related to cultural affiliation of indigenous groups in the Ballona area included whether the groups that occupied sites below the bluffs were culturally related to those that resided on the bluff tops, whether there was evidence for pre-Gabrielino/Tongva or pre-Takic occupation in the area, whether any sites in the area could be associated with the possible village then referred to as Sa'angna, and, finally, how far back in time Gabrielino/Tongva cultural traits can be identified in the Ballona. Previous investigators had argued that, throughout prehistory, the Ballona was used by small groups, none of whom lived there year-round. Today, we believe that the contemporaneous settlements above and below the bluffs formed a single, larger community that was largely sedentary (Altschul et al. 2007). With the identification and excavation of the burial area at LAN-62 and the living surface dating to the Mission period at LAN-211, we are able to test complex models of cultural adaptation discussed above (Vargas et al. 2003). Both material culture and bioarchaeological data will offer bases for answering these important questions of cultural affiliation.

Historical-Period Development of the Ballona

Historical-period development of the Ballona can be divided into two broad themes: agricultural use and industrial and commercial development. Although the project area has been exploited for many purposes, the earliest historical-period use was agriculture and ranching. The earliest farmer and rancher in the Ballona was Pío Quinto Zuñiga, who named his property Rancho los Quintos (Stoll et al. 2009). The Zuñigas were likely in the Ballona for 6 or more years, from 1802 to 1808 (Stoll et al. 2009). During this period, it is clear from Mission records that the Native American inhabitants of the Ballona had contact and interaction with the Zuñigas. Zuñiga children were godparents to several inhabitants of Guaspet, the Native American *ranchería* located somewhere in the Ballona (Stoll et al. 2009). Prior and subsequent to the Quinto Zuñigas, the inhabitants of the Pueblo of Los Angeles used the Ballona as a communal *paraje* (or pasture) (Mason 2004). The first Hispanic people to reside in the Ballona for a long, continuous period of time were Agustín Machado and Felipe Talamantes, who established Rancho La Ballona in 1819 (Altschul et al. 1991; Stoll et al. 2003).

Agriculture persisted in the project area until recent times. This theme includes at least three research issues: the development and persistence of the Hispanic tradition, the impact of the Anglo-American influx, and the twentieth-century development of specialized agriculture tailored to the needs of an urban population.

Industrial and commercial development of the area was apparent by the late 1800s and early 1900s. First came the railroads—in coordination with resort communities like Port Ballona and Ocean Park—then oil and gas development. Throughout this period, there was a persistent but selective use of the project area for recreational purposes catering to an increasingly urbanized population. As noted above, automobile racing was another important activity in the Ballona in the early 1900s. Even the film industry moved into the communities around the project area by the 1910s and 1920s, making selective use of open spaces provided by the Ballona area. Finally, in the 1940s, Howard Hughes built an aviation complex at the east end of the project area. Research questions posed in the research design relate to the advent of the railroads in the Ballona area, oil and gas development, recreational uses, early film-industry use, and, finally, the era of Howard Hughes.

Report Organization

This volume is divided into eight chapters. In Chapter 2, we outline the environmental setting of the project area, including climate, hydrology, and geology. In Chapter 3, we detail and discuss the culture history of the western Los Angeles Basin and adjacent cultural areas, as well as the local history of the Ballona region. Chapter 4 outlines previous research in the area, from the history of archaeological research in west Los Angeles and the Ballona area to a brief history of the PVAHP and its accomplishments to date. Chapter 5 summarizes and synthesizes the research design originally written for the project (Altschul et al. 1991) and the updated research design related to the Protohistoric and Mission periods (Vargas et al. 2003); it also incorporates and presents new data and additional models and paradigms for research direction of the PVAHP. Chapter 6 presents the paleoenvironmental background and stratigraphic reconstruction of the PVAHP area. This topic continues in Chapter 7, which documents landscape evolution and includes reconstruction of the paleolandscape and a discussion of paleostudies performed for the PVAHP. Finally, in Chapter 8, we discuss the connection between people and the environment in the Ballona Lagoon area and look more broadly at the relationships between people and changing coastal environments across southern California, drawing on work from the PVAHP and seminal research on other lagoon environments.

Environmental Setting

Jeffrey A. Homburg and Richard Ciolek-Torello
with contributions by Eric C. Brevik, Caroline Tepley, Antony Orme, and Steven D. Shelley

The PVAHP is located near the Pacific Ocean and alongside the Ballona, a low-lying estuary and wetland area on the edge of Santa Monica Bay in west Los Angeles, California (see Figure 1). This area is situated between the Ballona Escarpment formed by Pleistocene dunes known as the Westchester Bluffs on the south, the Beverly Hills and Santa Monica Mountains to the north, and the Baldwin Hills to the east (Figure 4). At one time a drowned river valley and lagoon, today this area is part of the City of Los Angeles, with the communities of Marina del Rey to the northwest, Playa del Rey to the west, Culver City to the northeast and east, and Westchester and Loyola Marymount University (LMU) on the bluffs to the south. Topography within the project area slopes gently downward toward the base of the bluffs with an elevation range of 3.7–5 m (12.2–16.5 feet) above mean sea level (AMSL). The bluffs rise abruptly to a maximum height of 56 m (185 feet) AMSL.

Estuarine environments, such as the Ballona, are among the most complex and productive ecological systems (Barnes 1977; Day et al. 1989; Kennish 1986; Knox 1986). Before much of the area was developed in the early 1900s, the wetlands encompassed about 1,700 acres of brackish and freshwater marsh, lagoons, and ephemeral ponds. The abundance of water and associated plants and animals made the Ballona one of the most striking areas in the Los Angeles Basin for settlement during prehistory and the early historical period, attracting Native Americans, Hispanic ranchers, and, later, American farmers and tourists. The Gabrielino/Tongva used these wetlands (Caughman and Ginsberg 1987:296), and when the first Spanish ranchers grazed their herds in the area in the early 1800s, they found creeks covered with trees and thickets (Dillon et al. 1988:8). In an article published in the *Los Angeles Daily Star* in 1891, the Ballona area was described as a coastal retreat where “surf, and still-water swimming, baths, sailing, boating, fishing, and hunting . . . cannot be surpassed by any other in southern California” (cited in Freisen et al. 1981:M3).

The Ballona serves as the lower drainage basin for Ballona and Centinela Creeks, as well as, at various times in the past, the Los Angeles River. By the late 1800s, large areas of the wetlands were converted to agricultural fields, which in turn were overtaken by industrialization and urban development. By 1928, most of the few remaining bodies of freshwater had been drained, leaving a reservoir known as Lake Los Angeles (Altschul et al. 1992:11). When Ballona Creek was channelized in the 1930s by the Corps and the Works Progress Administration (WPA) for flood control, tidal flow into the remaining wetlands was also greatly reduced, and the composition of plants and animals was significantly altered. Growth of the community of Playa del Rey at the western edge of the Ballona and the Hughes Culver City Aircraft Plant at its eastern end led to further reductions of the remaining open-water areas and surrounding wetlands by midcentury. Construction of Marina del Rey, one of the largest manmade harbors in the world, in the early 1960s removed an additional 780 acres of land and water from the northwestern end of the wetlands. Despite the extensive modern development of the Ballona, the remaining wetlands continue to serve as an important sanctuary for migratory birds and other animals.

This chapter presents summary discussions of the climate, geology, soils, hydrology, and biota of the Ballona. These summaries are intended to provide a general background to the environmental setting of the area surrounding the PVAHP. The discussions highlight those conditions and resources that probably existed in the Ballona prior to the historical-period developments and are intended to provide a general background to the in-depth discussions of the paleoenvironmental reconstruction presented in Chapters 6 and 7 of this volume, and also to the other volumes in the PVAHP Series.

Climate

California’s coastal climate is classified as Mediterranean and is characterized by two seasons: a temperate, wet winter and a moderate, dry summer. Only about 1 percent of the world’s surface has this type of climate, and it does not occur anywhere else in the United States (Caughman and Ginsberg 1981). Most precipitation falls between October and March, and the majority is concentrated between December and February. Rain rarely falls during the summer months, although fog in late spring and early summer produces some precipitation.

Figure 4. Portion of 1929 oblique aerial photograph looking north along the blufftop at Loyola Marymount Campus conservation activities and agricultural activities near Lincoln Boulevard. (Courtesy of the Benjamin and Gladys Thomas Air Photo Archives, Spence Collection, UCLA Department of Geography; Negative No. E-2450.)

The coastal climate is primarily influenced by the strong high-pressure system known as the Pacific High, located in the ocean west of California, and the marine influence of the ocean itself (Altschul et al. 1992:17). During the summer months, the Pacific High is typically located between 30° and 40° north latitude, where it effectively blocks cool, moist breezes originating in the northern Pacific Ocean from moving onshore. The Pacific High weakens and moves south as winter approaches, allowing weather systems to reach land. The high-pressure system occasionally forms inland during early spring and fall, causing a reversal of the prevailing northwesterly winds. These winds come from the Great Basin to the northeast, bringing strong, hot and dry winds that often lead to the rapid spread of wildfires in the fall.

The Pacific Ocean creates a moderating effect on the local climate that results in little seasonal and daily variation in temperature along the coast of southern California. Onshore flow of marine air also keeps the relative humidity moderately high year-round, generally at about 65 percent (Altschul et al. 1992:19). Temperatures rarely exceed 100°F (37.8°C) or drop below freezing in the Los Angeles area. The mean annual temperature at Los Angeles International Airport (LAX), located about 4 km southeast of the project area, is 19.6°C (61.7°F); the record high temperature of 43°C (110°F) occurred in September 1963, and the record low temperature of -5°C (23°F) occurred in January 1937 (Altschul et al. 1992:19). Coastal areas, however, average less than 5 days a year with mean maximum temperatures above 32.2°C (90°F) and none at all below 0°C (32° F) (Fay et al. 1987).

Sunshine prevails, on average, 73 percent of the year, with only 34 days of rainfall, on average, annually (Caughman and Ginsberg 1981:31). LAX received an average of 29.4 cm (11.57 inches) of rainfall annually between 1951 and 1980 (Fay et al. 1987:123). The greatest monthly precipitation recorded at LAX during that same period was 28.1 cm (11.07 inches), in February 1962, and the greatest daily precipitation was 15.7 cm (6.19 inches), in January 1956 (Fay et al. 1987:123). An important property of the precipitation pattern of the region is its overall unpredictability from year to year. It is not uncommon for rainfall to greatly exceed the annual average from year to year, often resulting in destructive flooding and landslides. Conversely, other years receive only a small fraction of the annual average, resulting in disastrous droughts and destructive wildfires (Shaw and Homburg 1992).

Geology

Southern California along with the entire west coast of North America, is extremely active geologically. California's landscape has been shaped by small-scale geologic processes, such as earthquakes and volcanic events, and broad-scale tectonic events that have caused uplift and subsidence of large land masses. These processes, combined with alluvial and aeolian deposition and erosion and sea-level fluctuations caused by glacial advance and retreat, are responsible for the modern appearance of the landscape. Approximately 150 million years ago (mya), during the Jurassic period, the California coast was situated much farther east, in the area now occupied by the Sierra Nevada (Caughman and Ginsberg 1981), and the current coastline location is where the Pacific Coast Geosyncline was positioned (Dunbar and Waagé 1969). As the North American Plate shifted to the west, it overrode the Pacific Plate, extending the coastline 100 m farther west and creating the Coast Ranges from sedimentary rock scraped from the Pacific Plate as it slid underneath the North American Plate. The San Andreas fault zone marks the boundary between the two plates. The present configuration of the coast was essentially reached by about 6000–7000 B.P., a time corresponding with a rapid decline in sea-level rise (Bickel 1978:6; Orme 1990:46).

The PVAHP is situated within the West Basin of the Los Angeles Coastal Plain (see Figure 1). This basin occurs within the Peninsular Ranges Province, a large geomorphic province extending from the Los Angeles Basin southward to Baja California. The Peninsular Province consists of northwest-southeast-trending mountains composed mainly of Mesozoic igneous and metamorphic rocks and Cenozoic sedimentary rocks. Younger materials in the Peninsular Province are primarily marine and terrestrial sedimentary rocks ranging in age from the Cretaceous period (80 mya) to the Pleistocene Epoch (less than 2 mya) of the Quaternary period (Sharp 1972).

Several hundred years ago, before the Ballona was altered by historical-period and modern developments, the lowlands were a tidal marsh marked by narrow channels of fresh to brackish water meandering toward the beach. Before that, the area was dominated by the Ballona Lagoon, an expanse of shallow, open water. One can imagine this coastal lagoon fringed by dense stands of sedges and reeds and alive with the calls of nesting shore birds. Fingers of sandy alluvium that reached out from the base of the bluffs made inviting places for prehistoric people to rest and camp. The bluffs overlooking the wetlands also were an important area for prehistoric settlement. Known as the Westchester Bluffs, they occupy the northernmost edge of the Del Rey Hills (also referred to as the El Segundo Sand Hills), which range in height between 85 and 185 feet AMSL and are capped by a Holocene sand-dune field that extends about 20 km south along the coast and ranges in width between 5 and 10 km inland (Page 1950). The Del Rey Hills are interpreted as ancient sand bars that have been reworked by wind and water. Grant and Shephard (1939:321) argued that the escarpment at their northern edge was formed by erosion when an ancestral, western-flowing Los Angeles River channel abutted the San Pedro formation exposed in the lower portion of the Del Rey Hills. In contrast, Poland et al. (1959:74) attributed the formation of the escarpment to a possible fault line forming where a relict channel of Centinela Creek occurs. Aerial photographs and older topographic maps show that, prior to the development of the City of Westchester, these hills formed a region of small knolls separated by a network of erosional sinks and drainages. At times, the bluff tops were dotted with vernal pools, small hardpan-floored depressions that filled with water during the winter (Barbour and Major 1988). The bluff faces are incised by several erosion gullies, all of which would have provided access to the lowlands. An important topographic feature adjacent to the east of the project area is the natural inset of the escarpment now occupied by Lincoln Boulevard. As erosion cut into the bluffs, a sandy ramp was created, representing a natural access route for the prehistoric inhabitants of the bluff tops to the resources of the lagoon below and an area slightly elevated above the marsh lands that served as a residential area for thousands of years. To the south of the bluffs was the Los Angeles coastal prairie, which contained numerous terrestrial resources for prehistoric inhabitants of the region.

Geomorphology

Previous investigations have identified three primary landforms in the Ballona: hillslope, alluvial-fan, and alluvial-plain facies. In the highest landscape position is the hillslope facies, which is divided into two slope elements, the back slope and the foot slope (after Ruhe 1975). In at least two locations, ravines have cut through the hillslope, causing alluvial fans (alluvial-fan facies) to form below where there is a dramatic change to a lower slope gradient. Most of the archaeological deposits investigated were associated with the alluvial-fan facies. In the lowest landscape position, the alluvial-plain facies merges and interdigitates with the floodplain deposits of Centinela and Ballona Creeks. These facies vary in their archaeological significance and potential for buried cultural deposits. Archaeological deposits are strongly associated with the alluvial-fan deposits and the foot-slope deposits of the hillslope facies. Scattered cultural remains are associated with the alluvial-plain deposits.

Deposition is the dominant process in all three facies, except on the back-slope portions of the hillslope facies, where erosion and sediment transport are the dominant geomorphic processes. A complicating factor is the extensive human modification of the landscape during the last century. Extensive mechanical excavation and redeposition of fill have altered all of the archaeological sites investigated along the base of the bluff. These modifications are so widespread in some cases that it is very difficult to distinguish historical-period and modern deposits from natural deposits.

Hillslope Facies

The hillslope facies marks the northern edge of the Westchester Bluffs and occupies the highest position in the landscape on the Playa Vista property. In the area of LAN-211, the northern edge of these hills forms a steep, east-west-trending bluff. In elevation, the base of the bluff rises from 4.5–6 m to more than 45 m AMSL on the summit, over a horizontal distance of about 30–40 m. The back-slope position of the hillslope facies rises at an approximately 40° angle. The steep back slope makes the bluff susceptible to mass wasting caused by soil creep, sheetwash erosion, and gullying. Catastrophic slope failures can result from landslides and debris flows, especially in the winter rainy season. Tectonism and loss of vegetation caused by grassfires or long-term drought can help to initiate or accelerate natural erosion processes. Abundant evidence of slope failure and slumping is visible along much of the bluff face. Steep slopes and geomorphic instability would have made the back slope of the hillslope facies an unsuitable setting for human occupation. The foot slope at the base of the bluff is the gentle slope below the back slope. The foot slope has undergone some erosion, as indicated by occasional rills and gullies that have been filled in and the erosion lag deposits, but the dominant geomorphic process has been deposition.

The lower back slope along the entire length of the bluff was modified when a sewer line and the overlying access road were constructed in the 1920s (Figure 5). Construction of this sewer line involved building an artificial bench and excavating a long trench on the back slope of the bluff. Cabora Road (formerly Sewer Line Road) was built before or during 1929 to provide access to the sewer line and was in use between 1929 and 1945. To stabilize the sewer and the road, earthen fill was placed to form an artificial berm that covers the back slope below the sewer and, in some places, where the sewer and the road cross alluvial fans. Soil material from the construction might have been the source of some strata found in archaeological sites at the base of the bluff.

Alluvial-Fan Facies

At several natural breaks in the bluff, ravines and gullies have formed where there has been headward erosion on the shoulder slope and back slope. Alluvial fans composed of sediment eroded from the bluff have accumulated at the bases of these ravines and gullies. Sediments in the alluvial-fan facies are typically brown, pale brown, or yellowish brown and dominated by sand. The color and texture of these sediments clearly show that they are redeposited from the Pleistocene dunes and sheets of sand that cap the bluff to the south. Examination of historical-period aerial photographs of the project area showed that periods of heavy rainfall caused deposition of fan alluvium below the ravines and gullies.

In the project area, prehistoric and early-historical-period archaeological sites are concentrated in and on these alluvial fans. From west to east, LAN-62, LAN-211, LAN-193, and part of LAN-2768 are all associated with this fan alluvium. A major reason that human occupations favored these locations is the elevated position of these fans and better drainage than nearby lowlands to the north. The fans that merge with

Figure 5. 11929 oblique aerial photograph, looking south at the Westchester Bluff, showing Loyola-Marymount University and historical-period structures and sewer line cut near LAN-211. (Courtesy of the Benjamin and Gladys Thomas Air Photo Archives, Spence Collection, UCLA Department of Geography; Negative No. H-702.)

the river alluvium below are characterized by higher silt and clay contents and poor drainage, as indicated by the greenish and grayish colors that resulted from gleying, caused by significant waterlogging for parts of the year. Saturation has resulted in anaerobic conditions (in which oxygen is lacking), which have caused iron in the soil to be reduced. By contrast, alluvial-fan soils have much better drainage, so reddish, brownish, and yellowish colors result from oxidizing conditions that are dominant here. Darker brown colors mark soils with high organic-matter contents, and these colors can mask the pigmenting effects of iron oxidation and reduction.

Lincoln Boulevard ascends the bluff through a large, amphitheaterlike ravine in the project area, known locally as the Lincoln Gap. Natural sedimentary infilling of the Ballona covered the lower portion of this fan with alluvium deposited by the Ballona Creek/Los Angeles River and Centinela Creek systems (see Appendix A). Bucket-auger data indicate that this fan may extend another 400 m north, buried below the historical-period surface, where the fan alluvium interfingers with river alluvium on the floodplain. The fan surface was altered extensively by farming activities in the last century, including leveling and plowing. Agricultural modifications are visible in historical-period photographs. The fan at LAN-62 was large enough that flooding never completely covered it, so deposition of sediments was limited to low-lying parts of the fan. By contrast, smaller fans were typically covered by fresh deposits during major storms and flood events.

The alluvial fan east of LAN-211 is located at the base of an unnamed ravine. This ravine once extended at least 400 m south of the face of the hillslope, but LMU filled the ravine to make it nearly flush with the bluff face. In 1938, an alluvial fan extended nearly 200 m north of the ravine and about 120 m to the east and west, forming the classic-fan-shaped landform.

In the 1950s, Hughes Aircraft Company excavated the northern two-thirds of the alluvial fan to construct several buildings, roads, and a parking lot. This excavation left the southern part of the alluvial fan as a benchlike remnant that initially gave researchers the impression of being artificial, like the fill placed in the ravine farther upslope. Subsequent excavations and examination of the stratigraphy revealed that this bench represented an intact part of the fan (Altschul et al. 2003). This interpretation is supported by a combination of historical-period photographs and maps, preserved archaeological deposits, and, most important, the presence of at least one moderately developed soil within the fan deposits.

Alluvial-Plain Facies

Prior to extensive modification of the hydrology in the Ballona during the early 1930s, two streams flowed through the area, as discussed below. The larger of the two streams, Ballona Creek, now discharges directly into the ocean, because the channel of Ballona Creek is lined with concrete, which keeps it from flowing into the Ballona Lagoon as it did before historical-period modifications. Before the creek was fully channelized in 1935, it drained into the Ballona Lagoon to the north of its current channel. The channel of the smaller stream, Centinela Creek, is also now lined with concrete up to where it empties into Ballona Creek, east of Lincoln Boulevard. Historical maps show that prior to channelization, Centinela Creek flowed across the southern part of the PVAHP area, near the base of the bluff but skirting the north side of the fans, and then discharged into Ballona Lagoon near the existing Lincoln Boulevard–Bluff Creek Drive intersection. Both streams were prone to flooding, which at times was so extensive that the entire Ballona below the bluffs was covered with water. The alluvial-plain facies consists of sediments associated with this extensive floodplain.

The low-lying alluvial-plain facies has a surface that ranges from relatively flat to gently sloping. Deposition is the dominant process, although localized erosion has occurred in places. The most dramatic form of deposition occurred as overbank-flood deposits carried by major storm surges, which are now largely controlled by channelization. Massive deposits of sand and fine gravel are found in the overbank deposits near the streams, and finer-grained sediments, mainly silt and clay, characterize deposits farther from the channels.

The floodplain has aggraded because of both major and minor flooding. In areas where the alluvial-plain facies is undisturbed (that is, not modified by historical-period or modern earthmoving activities), there is typically a weakly developed soil about 1 m thick that consists of an A horizon that is black to dark brown and usually sandy loam in texture. When moist, this soil appears massive, but when dry, a weakly developed subangular blocky structure is visible. In places, this soil also contains chunks of charcoal, roots, and root casts; it apparently formed beneath marsh vegetation. Underlying the A horizon is a greenish gray to pale-green, silty deposit that is usually several meters thick. This silt is a distinct depositional unit and has an upper contact that is usually abrupt. Small numbers of artifacts are scattered in these deposits. For example, the northern edge of LAN-62 Locus G, is located in the interfingering of the marsh and alluvial-fan deposits. Features identified during data recovery in this area indicate that the edge of the marsh was occupied by the prehistoric inhabitants of Ballona (Vargas and Douglass 2009).

The alluvial floodplain was available for human use throughout much of the year. Seasonal winter rains and muddy surfaces would have made it more difficult to traverse, but it was dry most of the time, and the abundant plant resources made it very attractive to humans for resource exploitation.

Hydrology

Historically, the main freshwater sources for the Ballona were the Ballona Creek/Los Angeles River and Centinela Creek systems. The combination of freshwater from these drainages and tidal flow from the Pacific Ocean are what mark the Ballona as an estuarine lagoon. Episodic flooding changed the course of Ballona Creek, the larger of the two drainages, and drastically altered the biotic communities of the Ballona at various times. Johnston (1962:78) provided a telling description of the area: "During the winter rains the swampy delta became a vast inland sea from the higher ground of Culver City to the ocean. The Gabrielinos/Tongvas called this by their general name for any bay, *pwinukipar*, meaning 'it is full of water,' but in summer, they identified this area as a place where 'the water has departed.'"

Ballona Creek, occupying a remnant channel of the Los Angeles River, drains about 230 km^2 (90 square miles) of the Los Angeles Basin (U.S. Geological Survey 2002). Independent of periodic contributions from the Los Angeles River, the Ballona Creek watershed draws from the series of canyons draining the south side of the Santa Monica Mountains, now channelized into the Sawtelle-Westwood and Benedict Canyon runoff-capture systems (Gumprecht 1999:229), as well as the northern and western slopes of the Baldwin Hills, the southern slopes of the Beverly Hills, and the La Brea Plain to the northeast (Figure 6). Prior to modern channelization, Ballona Creek flowed into the lagoon in the approximate location of the intersection of Lincoln and Culver Boulevards. Despite intermittent periods of heavy flow, Ballona Creek was rarely able to flush out sediment from this large drainage area. Consequently, a protected lagoon was created as sand was deposited along the beach by ocean currents (Dillon et al. 1988:6). This sand deposit resulted in the formation of a barrier feature or sand spit that has since been reworked by wind to form sand dunes. When the U.S. Coast Survey map was created in 1861 (Figure 7), the Ballona had become a complex estuarine environment containing an intricate network of tidal outlets, tidal flats and mudflats, slightly elevated sandy islands, and freshwater marshes. Ballona Creek was improved in stages, and its course and banks were kept in a natural state until the 1920s. A concrete lining to channelize the entire length of Ballona Creek was completed in 1935 (Altschul et al. 1991:76). Tectonic activity through the gap forced underground water to the surface, thereby creating marshy areas that attracted prehistoric settlement (Poland et al. 1959:12).

For an undetermined period of time prior to 1825, the Los Angeles River flowed westward along the channel of Ballona Creek before it emptied into the Ballona wetlands. When the Spanish settled in the Los Angeles basin in the late eighteenth century, they noted that the Los Angeles River flowed along this course (Johnston 1962). Historical records are corroborated by offshore bathymetry, which revealed the existence of a large, submarine delta fan that could only have been produced over a long period of time by a drainage much larger than Ballona Creek. During a major flood episode in 1825, however, the river shifted to a southerly route toward San Pedro Bay via the Dominguez Gap (Poland et al. 1959:21). Floods in 1862 and 1884 temporarily returned the Los Angeles River to its western course, but since 1884, it has discharged southward into San Pedro Bay, a route that has been maintained artificially by concrete flood-control levees constructed in the 1930s (Altschul et al. 1992:13).

An important characteristic of Ballona Creek and the Los Angeles River is their unpredictability as water sources. Both are seasonal, intermittent drainages that flow heavily only during floods accompanying major winter storms. Between 1811 and 1891, 13 major floods were recorded on the Los Angeles and San Gabriel Rivers (Poland et al. 1959:21), many of which resulted in channel shifts (Gumprecht 1999; Newmark 1984). The destruction caused by flooding is illustrated in the following description of the 1884 flood that followed the Ballona channel (Reagan 1915:42).

> In those days the Los Angeles River practically had no banks below Seventy St. and very low ones above that point. . . . The people did not realize how much the water would rise and, therefore, built their homes all over the flats, then when the water did come it did great damage and caused much suffering. . . . The floods poured westward along the then Washington Road and Jefferson Street, towards the southeast in Ballona Creek and into the Ballona Bay. All through the southwest, clear to the sea, was a solid sheet of water. All of the country called Cienega was a great Slough . . . and all of the country back of Venice was a sea of water.

The greatest discharge recorded for the Los Angeles River occurred in March 1938, when it reached 1,897 m^3 (67,000 cubic feet) per second upstream of the Main Street Bridge in downtown Los Angeles (Troxell 1942:12). A 1938 aerial photograph also shows extensive flooding in the Ballona as a result of the meteorological event that caused this flood (Figure 8), even though the Los Angeles River followed the southerly route to San Pedro at that time. Highly variable channel configurations also characterized this environmentally dynamic region, and prolonged periods of little or no discharge were also common for both Ballona Creek and the Los Angeles River. Coping with catastrophic conditions, such as those caused by floods and droughts, must have been a vital aspect of local cultural adaptation.

Although draining a much smaller area, Centinela Creek was a much more reliable source of freshwater for prehistoric and early-historical-period inhabitants of the Ballona than the typically unpredictable flows of the Ballona Creek/Los Angeles River system. The numerous archaeological sites that dot its historical course are a clear indicator of the importance of this drainage to both prehistoric and early-historical-period inhabitants (Hoover and Kyle 1990:160). Centinela Creek is a spring-fed stream that drains the southern slopes of the Baldwin Hills. It flows in a northwestern direction into the Ballona from a spring in what is today the City of Inglewood. Upon entry into the Ballona, Centinela Creek turns abruptly southwestward and flows near

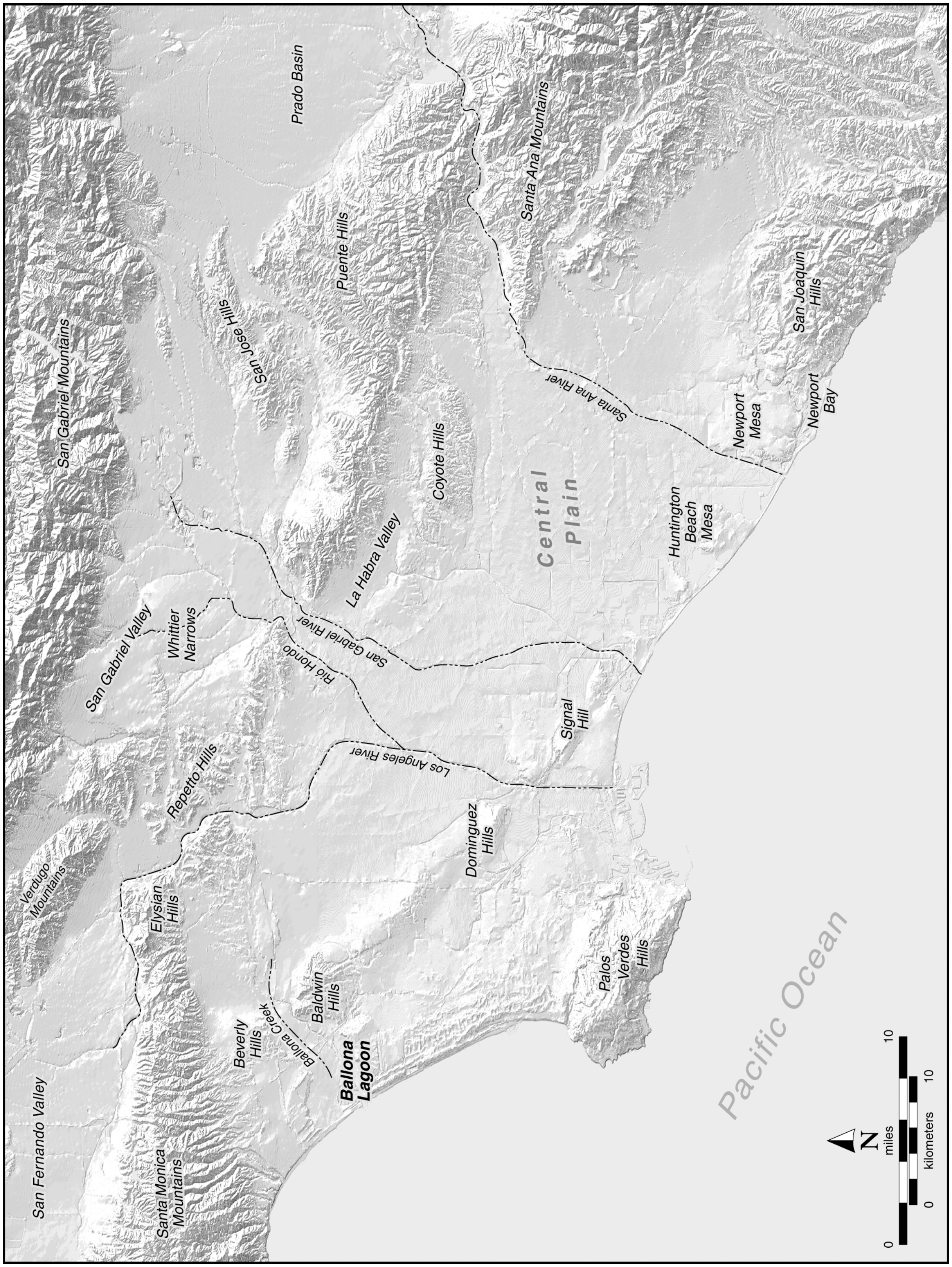

Figure 6. Physiographic map of the Los Angeles Basin and surrounding mountains.

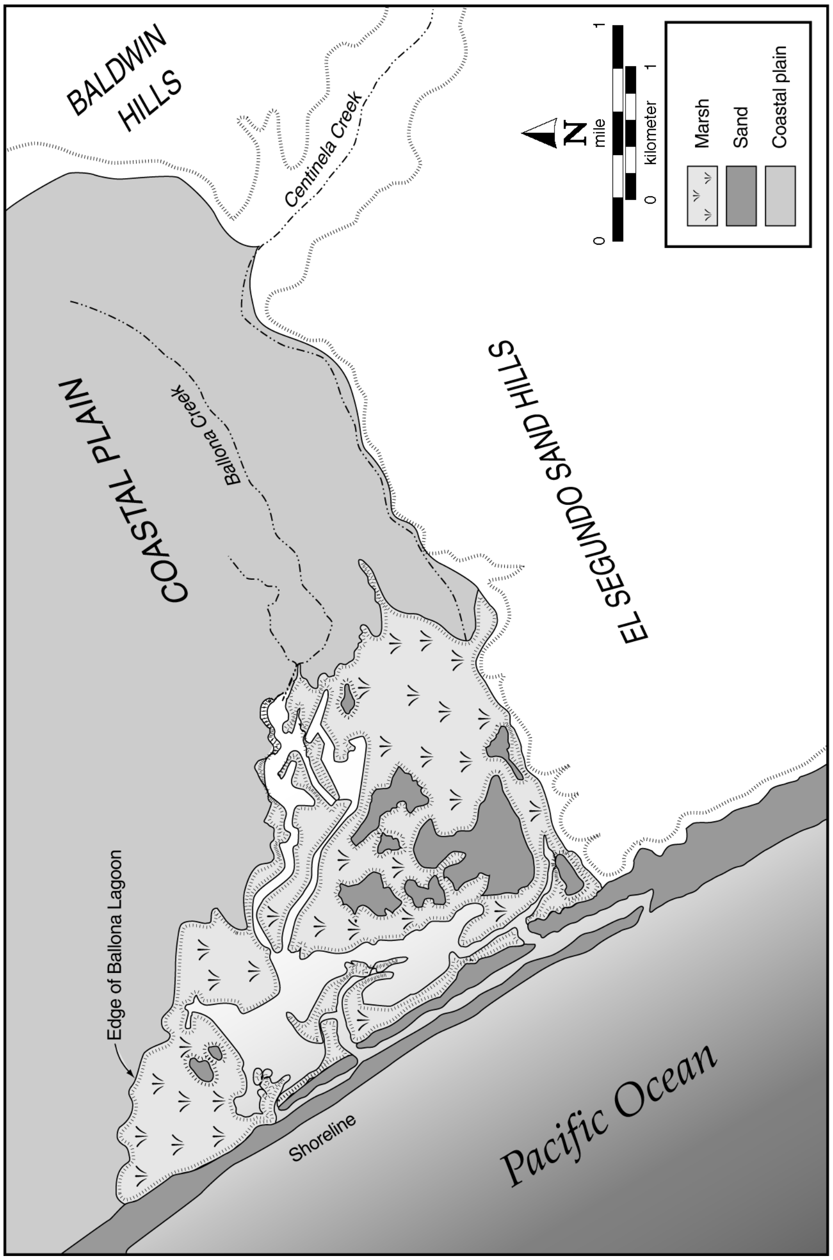

Figure 7. 1861 U.S. Coast Survey map showing the extent of the Ballona Lagoon (adapted from Chase 1861).

Figure 8. 1938 oblique aerial photograph, view to the east, toward the central portion of the PVAHP, inundated in the 1938 flood, overhead, with the locations of LAN-62 and LAN-211 (courtesy of the Benjamin and Gladys Thomas Air Photo Archives, Spence Collection, Department of Geography, UCLA.)

the base of the Westchester Bluffs in a course that parallels Ballona Creek before it drains into the freshwater marsh. Prior to historical-period channelization, it was a perennial drainage that flowed into the Ballona along the base of the Westchester Bluffs. Although large stretches of Centinela Creek are channelized or underground today, Kew (1923:157) noted that it was once possible to row a boat up to the spring from Playa del Rey.

Within the Ballona, both Centinela and Ballona Creeks were subject to "lateral stream migration" during their histories (see Appendix A). Comparison of historical topographic maps and aerial photographs showed how the channels migrated over the last century. Similar channel migrations undoubtedly occurred throughout prehistory, as well. For example, the 1893 survey of the area showed that Centinela Creek ran near the base of the Westchester Bluffs (Figure 9), whereas later photos showed that it had meandered northward to near where Howard Hughes later built the runway for his aircraft plant.

Biota

The Ballona is an estuary—that is, "a semienclosed coastal body of water with an open sea connection, where: (1) seawater is measurably diluted by the river drainage; (2) fluvial and marine sediments co-occur; and (3) marine and continental . . . fauna and flora co-exist" (Palacios-Fest, Appendix D, this volume). During times of low flow, the Ballona would have been a complex of brackish tidal outlets, freshwater runoffs, marshy pools, mudflats, and sandy islands bordering an area of open water partially enclosed by a double-barrier sand spit. The 1893 map (see Figure 9) shows how this area appeared during a late stage of its evolution, prior to historical-period modifications over the last century. Detailed lists of indigenous flora and fauna of the Ballona are presented in Altschul et al. (1992:Tables 1–6), and an in-depth discussion of the local habitats and their floral and faunal associations is presented in Chapters 10, 12, and 14 in Volume 3 of this series.

Figure 9. 1893 U.S. Coast Survey map overlain with the project area boundaries and showing Centinela Creek near the base of the Westchester Bluffs.

Vegetation

Lush marshland communities in the Ballona would have provided a wide variety of plant and animal resources to aboriginal inhabitants. Farming and industrial, residential, and commercial development related to the construction of buildings, parking lots, roads, oil-well pads, and railroad tracks are responsible for removing most of the native vegetation that once existed in the Ballona. Despite these modifications, the Ballona still supports diverse species of marine and terrestrial mammals, invertebrates, and avian fauna as well as several floral communities. An intensive survey of vegetation in the Ballona region conducted in 1981 identified 235 plant species from 50 taxonomic families, including 105 indigenous and 130 introduced species (Gustafson 1981; see also Altschul et al. 1992:20–23). These plants were distributed in three habitats and six plant communities that were representative of those that would have existed prehistorically. Pickleweed-salt-marsh, mudflat, and salt-flat plant communities of the estuary contrast sharply with the freshwater willow and marsh habitat and the coastal-dune and coastal-sage plant communities that dominate adjacent terrestrial landscapes (Altschul et al. 1992:24–26). All of these plant communities would have been present prior to the development of the Ballona, although the boundaries between plant communities would have shifted in response to increasing sedimentation in the wetlands as well as extended periods of flooding and drought.

Most of the indigenous plant species were used by the aboriginal inhabitants of the Ballona (McCawley 1996), but traces of these plants can be difficult to detect archaeologically. Another problem has been the failure of a number of large archaeological studies in the general project area to conduct paleoethnobotanical analyses (e.g., of pollen, phytoliths, and carbonized macrobotanical remains).

Invertebrates

The Ballona continues to host a variety of invertebrate mollusk species. During a modern study of mollusks in the Ballona, Ramirez (1981) identified 13 species of Pelecypoda and 6 species of Gastropoda. The most abundant species were bent-nose clam (*Macoma nasuta*), California jackknife clam (*Tagelus californianus*), littleneck clam (*Protothaca staminea*), small acteocina (*Acteocina inculata*), California assiminea (*Assimenea californica*), California horn snail (*Cerithidea californica*), and salt marsh snail (*Melampus olivaceua*). Although all of these species were found in the same proportions at all sampling locales, only the bent-nose and littleneck clams are known to have been used by the aboriginal people of the region.

Aboriginal conditions were undoubtedly favorable to many more than the 19 species documented by Ramirez. The number and types of indigenous species prior to historical-period developments, however, are unknown. Moreover, the composition of mollusk populations certainly changed in response to long-term, natural environmental processes during the Holocene as well as shorter-term floods and droughts. The most important process, however, was the formation of the coastal sand barrier that formed the lagoon, limited tidal flow, and increased sedimentation. These conditions would have favored mollusk species that could tolerate greater temperature fluctuations, less salinity, and soft substrates.

Mollusks served as some of the most important resources for the aboriginal inhabitants of the coast. Shellfish were an important source of food, and the shells provided raw materials for the production of beads and other ornaments as well as some tools. No systematic studies have been undertaken to reconstruct molluscan paleoecology in the Ballona prior to the study reported in this volume. Although shifts in shellfish availability have been suggested using archaeological data, these interpretations must be considered preliminary in the absence of independent, corroborating data. Nevertheless, an important shift in terms of available food resources is strongly supported by the apparent displacement of native Pacific oyster (*Ostrea lurida*), a species that generally inhabits open bodies of water with hard substrates, by Venus clams (*Chione* sp.), which thrive in shallower water (Altschul et al. 1992; DiGregorio 1987a). Stratigraphic data from several archaeological sites suggest that this shift occurred prior to about 1000 cal B.P. and probably reflects the expansion of mudflats at the expense of open lagoon water in the Ballona estuary.

Fishes

Despite its diminished size, the Ballona still supports a variety of fish species. Swift and Frantz (1981) recorded 23 species of fish, only 3 of which are introduced. Although topsmelt (*Atherinops affinis*), arrow goby (*Clevandia ios*), mudsucker (*Gillichthys mirabilis*), mosquitofish (*Gambusia affinis*), and diamond turbot (*Hypsopsetta guttulata*) were the only species found in abundance, species diversity was undoubtedly much greater before late-historical-period and modern development drained much of the wetlands. Soule and Oguri (1980) suggested that, given the historical size of the estuary, about 50 different species once existed in the lagoon.

Of the 23 species documented in the Ballona, seven species—topsmelt, jacksmelt (*Atherinopsis californiensis*), California halibut (*Paralichthys californicus*), black perch (*Embiotoca jacksoni*), striped mullet (*Mugil cephalus*), diamond turbot, and grunion (*Leuresthes tenuis*)—were probably the most important as food resources. These species, as well as many others, were most abundant in late winter and spring, when most of them began spawning, and relatively uncommon in fall (Swift and Frantz 1981), suggesting that late winter and spring were probably the times when fishing was most commonly practiced by the aboriginal populations of the Ballona (Altschul et al. 1992:31).

Previous archaeological studies in the Ballona have revealed that a much more diverse array of fish species was exploited by the area's aboriginal inhabitants. Fifty-two different species of fish were identified at the Admiralty site in Marina del Rey, at the northwestern edge of the former lagoon (Sandefur and Colby 1992). This collection included grunion and cartilaginous fish, most commonly the shovel-nosed guitarfish (*Rhinobatus productus*), which would have been available in late winter, spring, and summer, and pile surfperch (*Damalichthyes vacca*), which were probably most common in fall in nearshore and tidal waters, as they would have been in the Ballona. Cartilaginous fish, like the guitarfish, angel shark (*Squatina californica*), and bat rays (*Myliobatis californica*), were abundant in archaeological collections from sites on the bluff tops, along with bony fish, such as surfperch (Embiotocidae), croakers (Sciaenidae), flatfish, sardines (Clupeidae), and mackerel (*Scomber japonicus*), which could have been obtained from bay estuary environments such as the Ballona (Maxwell 2003). The availability of these various fish species suggests that, unlike today, fishing was possible almost year-round in the Ballona.

Amphibians and Reptiles

Although vital components of estuarine environments, amphibians and reptiles were much less important as resources to the aboriginal inhabitants of the Ballona than were other animals. Only 11 species of reptiles and amphibians have been documented in the Ballona in modern times (Hayes and Guyer 1981). The expansion of agricultural land and the introduction of nonnative plants and animals to the area have reduced both the species diversity and the overall biomass of herpetofauna inhabiting the region. As with fish, a greater variety of herpetofauna have been recovered from archaeological sites than currently exist in the Ballona (Maxwell 2003; Sandefur and Colby 1992). Although many may be intrusive to these sites, having burrowed into the archaeological deposits, some, such as turtles, were probably used for food and other purposes.

Birds

The Ballona has long been known for avian fauna and was rich with waterfowl for hunting in the early nineteenth century. Because it is one of the few remaining wetlands in the Los Angeles area, the Ballona still serves as an important refuge for birds, especially waterfowl and other migratory species. Dock and Schrieber (1981) have documented 129 species in a $2^{1}/_{2}$-year period in the Ballona, although they have witnessed dramatic seasonal fluctuations, especially in waterfowl populations. Most of the species and the largest populations of birds visit the Ballona during January and February, a time coinciding with peak rainfall. The lowest numbers of species and smallest populations occur in late spring and early summer, a pattern common throughout the coastal regions of southern California (Garret and Dunn 1981; Robbins et al. 1966). Migratory birds, especially waterfowl, abandon the Ballona as the mudflats begin drying up in spring. Most of the species found during the summer are permanent residents, although relatively few bird species breed in the Ballona.

Most of the bird species identified by Dock and Schreiber probably inhabited the area during prehistoric times. Anseriformes (ducks and geese) dominate archaeological collections from the Ballona, although other waterfowl such as rails, loons, grebes, gulls, albatross, and great blue herons were also present in some collections (Maxwell 2003). Maxwell (2003:165) noted, however, that shorebirds were relatively rare, suggesting a focus on exploiting wetland resources rather than nearby beaches. Falcons, harriers, and eagles are also found in archaeological collections from the Ballona. These various birds were undoubtedly relied upon most heavily during the winter, when they were most abundant. Ducks and geese provided an important and predictable food resource for the aboriginal inhabitants of the Ballona, although Brown (1989) argued that birds in the Ballona were acquired primarily for their plumage and that their use as a food resource was only secondary. The basis of this argument is the disproportionate number of coracoids, scapulae, and wing elements found in archaeological collections from three bluff-top sites and the abundant ethnographic evidence for the importance of bird plumage in aboriginal California cultures. Fenenga (1990), however, argued that Brown misused ethnographic analogy and that the disproportionate representation of breast and wing elements may in fact represent the meatiest portions of the birds, thus reflecting their use as a food resource.

Mammals

Estuarine environments such as the Ballona require certain specialized adaptations for mammals. Although some mammals can drink saltwater or brackish water, most species have not evolved this capability. Marine mammals such as sea otters (*Enhydra lutris*), northern fur seals (*Callorhinus ursinus*), California sea lions (*Zalophus californianus*), harbor seals (*Phoca vitulina*), and northern elephant seals (*Mirounga angustirostris*) are known to visit the Ballona for brief periods, but the freshwater and brackish water of the Ballona probably did not provide habitats for these animals (Friesen et al. 1981). Thirteen indigenous mammal species have been documented in the Ballona, and an additional 20 species are known or suspected to have visited the area prior to historical-period modifications (Friesen et al. 1981). Although some of these species resided in the Ballona wetlands, most probably traveled from surrounding areas to seek food. Mule deer (*Odocoileus hemionus*), rabbits (*Sylvilagus audubonii* and *S. bachmani*), black-tailed jackrabbits (*Lepus californicus*), and squirrels (*Spermophilus beecheyi* and *Sciurus* sp.) were probably among the most important species for aboriginal populations.

These species are commonly found in archaeological collections from the Ballona (Altschul et al. 1992; Maxwell 2003), although these collections are dominated by smaller rodents, some of which have burrowed into archaeological sediments and others of which show evidence of human processing. A variety of carnivores also are found in low frequencies in archaeological collections, including dog or coyote (*Canis* sp.), bobcat (*Lynx rufus*), river otter (*Lontra canadensis*), fisher (*Martes* cf. *pennanti*, a medium-sized mammal), badger (*Taxidea taxus*), skunk (cf. *Mephitis mephitis*), and raccoon (*Procyon lotor*). One of the most unusual discoveries in the archaeological collections was pronghorn (*Antilocarpa americana*) bones in the collections from test excavations at LAN-211 (Maxwell 2003) and two other sites (Cairns 1994; King 1967). Although rare, pronghorn were known in the Los Angeles basin and Antelope Valley until 1933 (Jameson and Peeters 1988:225). Nevertheless, they have never been reported in the Ballona area, neither during the historical period nor in modern times. The presence of killer whales (*Orcinus orca*) and different species of dolphins at other Ballona archaeological sites, however, suggests that aboriginal inhabitants may have ranged outside the wetlands to collect mammals. The pronghorn remains may also have been brought into the Ballona by prehistoric hunters.

Cultural Setting

John G. Douglass, Richard Ciolek-Torello, Mark Q. Sutton, Jeffrey H. Altschul, Patrick B. Stanton, Anne Q. Stoll, Benjamin R. Vargas, Christopher P. Garraty, and Donn R. Grenda

To understand the cultures of an area, it is crucial to understand their histories and broad patterns of change in their historical contexts. The goal of this chapter is twofold: to broadly examine the culture history and cultural chronology of the Southern California Bight and to detail the same within the Ballona area, including the project area. By doing this, we can better understand not only what occurred in the Ballona but how such events reflect or conflict with patterns along Santa Monica Bay and places farther removed. Through the 8,000 years of human occupation in the Ballona, there were a number of important trends. In the Ballona, these included the emergence of Takic groups in the area; dramatic changes in settlement patterns and site structure during the Intermediate, Late, and early Historical periods; and the establishment of a dispersed community during the Intermediate period. These and many other trends are discussed in this chapter. This culture history is tied to the research questions in Chapter 5 of this volume and the paleoenvironmental reconstruction of the Ballona in Chapters 6–8 of this volume.

The cultural chronology of the Southern California Bight is broadly defined in this section to accom.modate various uncertainties and competing models. Figure 10 presents a current summary of the various models, based on the results of excavations at major sites in the southern California coastal region over the last 7 decades. Over the course of the PVAHP, we have developed a working chronology for the Ballona that divides the prehistory and history of the region into six periods: the Paleocoastal period, the Millingstone period, the Intermediate period, the Late period, the Protohistoric/early Historical period, and the Historical period. We also subdivide the Millingstone and Intermediate periods into early and late components based upon our work in the area. The early and late Millingstone is divided in the Ballona by a distinct hiatus in occupation between 5000 and 6000 cal B.P., a span of time from which there is not a single radiocarbon assay among literally hundreds of samples run by both SRI and Archaeological Associates from archaeological sites throughout the Ballona. Although some reanalyzed obsidian-hydration dates appeared to fall within the margins of that 1,000-year hiatus, we have placed greater emphasis on the more reliable radiocarbon dates to define our working chronology. The early and late Intermediate periods also correspond to peaks and valleys in radiocarbon dates from Ballona area sites (see Volume 2 of this series for details).

This chapter is organized by major time periods recorded in southern California. A general discussion of each time period includes information on a few selected sites that illustrate the attributes of that particular time period and represent its trends and patterns. One site in particular, Malaga Cove (LAN-138), spans the entire range of human occupation in its nearly 20-foot-thick midden deposit and is thus extremely important to the understanding of prehistory in southern California. This site is therefore discussed throughout the chapter, across chronological periods. After each general discussion of a particular time period, we present a specific discussion of sites and trends in the Ballona for that time period. For the early Historical period, we provide a combination of historical and archaeological information on the Ballona.

The Ballona area is generally divided into two sections, based on Ballona Creek. The upper Ballona Creek area includes the Baldwin Hills, where early archaeological and geological excavations in the 1920s uncovered what was thought to be remains of "Early Man." The project area lies within the lower Ballona Creek area, the prehistory of which is much better known. In our discussion of the Ballona, we refer specifically to upper or lower Ballona Creek, as well as more generally to the Ballona Lagoon area without referring to specific locations.

The Development of a Cultural Chronology for Coastal Southern California

Over the last decade, a much clearer picture of the prehistory of coastal southern California has begun to emerge. Recent excavations at a number of sites, including those in the Ballona

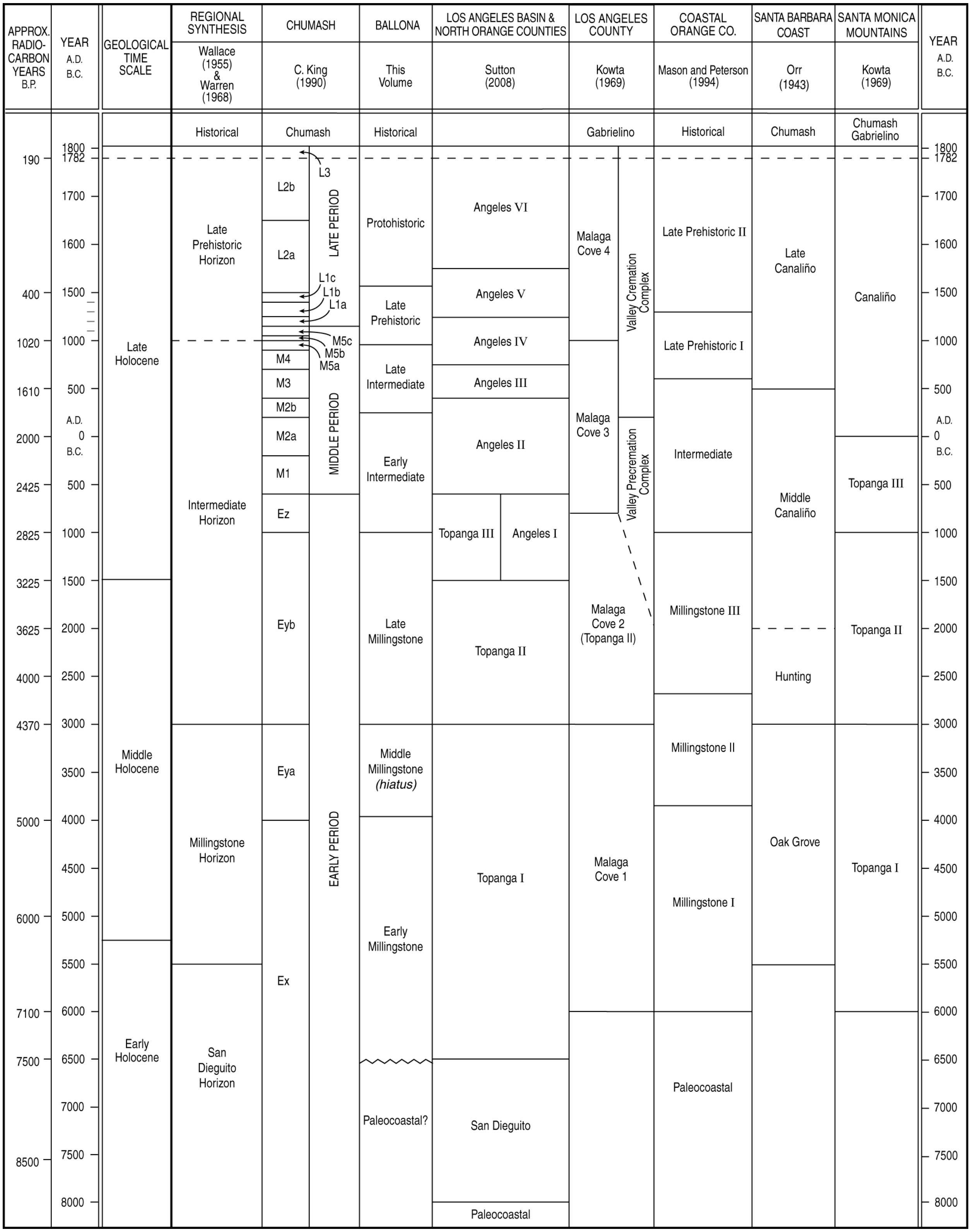

Figure 10. Chronological chart comparing cultural history for the Ballona region (Douglass et al. 2005, above) and reconstructions for other areas of southern California.

(Altschul et al. 2003; Douglass et al. 2005) and Landing Hill (Cleland et al. 2007), plus recent synthetic treatments of southern California prehistory (e.g., Byrd and Raab 2007; Sutton 2009; Sutton and Koerper 2009; Warren et al. 2008) have combined to better elucidate southern California prehistory.

The initial attempts (see Moratto 1984:120–126) to develop a cultural sequence for southern California were undertaken in the 1920s by D. Rogers (1929) for the Santa Barbara area and by M. Rogers (1929, 1939, 1945) for the San Diego area. Further work in southern California was done by the WPA in the 1930s (e.g., Winterbourne 1967) and by Walker (e.g., 1937, 1951) at a number of sites, including Malaga Cove; in the 1940s and 1950s by the University of California at sites such as Topanga (e.g., Heizer and Lemert 1947); and in the 1950s by Wallace (e.g., 1954).

In 1955, Wallace (1955) produced the first general synthesis of southern California prehistory. Four cultural "horizons" were proposed: Horizon I (Early Man), Horizon II (Millingstone period), Horizon III (Intermediate period), and Horizon IV (Late period). Horizon I was mostly speculative, because few data were then available. Horizon II was designated "Milling Stone Assemblages" (Wallace 1955:219), based on materials that had been excavated all along the southern California coast. Horizon III, Intermediate Cultures, was so designated to account for the poorly known time between the Millingstone and Late period assemblages (Wallace 1955:221). Horizon IV, Late Prehistoric Cultures, represents the archaeological record of the known ethnographic groups in the region. The Wallace chronology is still employed by some researchers and served as the foundation for the working chronology we have developed for the Ballona.

In 1968, Wallace's "Horizon II: Milling Stone" was subsumed under the Encinitas tradition (Warren 1968) (see Figure 10), a designation reflecting the Willey and Phillips (1958) definitions of "horizon" and "tradition." Warren (1968:6) defined the ecological adaptation of the Encinitas tradition as reflecting a well-developed plant-collecting economy in which projectile points and faunal remains (indicating hunting) were rare. In the Santa Barbara region, the Encinitas tradition (Oak Grove) ended about 5000 cal B.P. and was replaced by the Campbell tradition (or Hunting Culture), a complex with mortars, pestles, and an increase in the use of maritime resources (fish and sea mammals) and the hunting of terrestrial mammals. Elsewhere in southern California, the Encinitas tradition persisted later in time (see below).

Subsequently, the term Encinitas tradition was increasingly employed to include all southern California (coastal and inland) sites of similar age with somewhat similar cultural materials. Many researchers abandoned the use of Millingstone phase names in favor of the more general terms "Millingstone horizon" or "Encinitas tradition" (without reference to regional specificity) or simply referred to more general time frames, such as the early, middle, and late Holocene.

Kowta (1969) presented an outline of southern California prehistory that built on, and elaborated, the work of Wallace and his predecessors (apparently completed prior to the publication of the Warren paper). Kowta (1969:Figure 5) proposed sequences for three subregions (the San Fernando Valley, Santa Monica Mountains, and Santa Monica Bay) along the coastal region of Los Angeles. The adoption of the Encinitas tradition and subsequent elimination of Millingstone phase names (Warren 1968) resulted in a general disregard of the coastal portion of the Kowta classification.

Based on their work at Newport Bay in Orange County, Mason and Peterson (1994) proposed another chronology (see Figure 10) for coastal southern California. The "periods" defined by Mason and Peterson (1994) were divisions based on clusters of radiocarbon dates. For example, Mason and Peterson (1994:57–59) defined three temporal periods of the Millingstone—MS1 (8000–5800 cal B.P.), MS2 (5800–4650 cal B.P.), and MS3 (4640–3000 cal B.P.)—but noted that there was "little difference in the cultural content" between them. Nevertheless, some researchers have continued to employ this chronology (e.g., Stoll et al. 2003:Figure 3; Cleland et al. 2007:Figures 2–6).

The extensive work undertaken in the Ballona area over the last 3 decades (e.g., Altschul et al. 1991; Altschul et al. 2003; Douglass et al. 2005; Grenda et al. 1994; Van Horn 1987a; Van Horn and Murray 1984, 1985; Van Horn and White 1983) resulted in a refinement of existing chronologies (Stoll et al. 2003) (see Figure 10). As a part of this work, over 200 radiocarbon dates have been assayed. There is an absence of radiocarbon dates between about 6000 and 5000 cal B.P. (see Hull and Douglass 2005), indicating the possibility that the Ballona area was not occupied during that time. Van Horn was the first to identify this hiatus in the Ballona, although his initial identification was a nearly 2,000-year hiatus; SRI's research, with hundreds of additional radiocarbon dates, suggests a 1,000-year hiatus. Determining the nature of such a hiatus is an important research goal.

Paleocoastal Period

The first people in southern California appear to have arrived along the coast as early as 12,000 B.P. (see Erlandson et al. 2007a). These maritime-adapted people apparently migrated down the coast from the north, as shown by the discoveries on the northern Channel Islands and the mainland coast of Central California. These early people are generally known as Paleoindians. Coastal Paleoindians are part of the Paleocoastal tradition, and the inland Paleoindians are known as Clovis. The Paleocoastal people were maritime adapted and have been documented along the coast of central California and on the northern Channel Islands (see Erlandson et al. 2007a). Clovis was a terrestrial and lacustrine adaptation (with a different technology) and generally dates to the same time as the Paleocoastal materials. Major Clovis localities are known at Lake Tulare (Riddell and Olsen 1969) and Lake China (Davis 1975), among other locations in central and southern California, including the Mojave Desert and the coast.

It seems plausible that the first Americans could have migrated along the coast of the Pacific Rim, even quite early, to colonize the Americas. Sea levels would have been as much as 400 feet lower before 12,000 B.P., exposing a coastal plain along which people may have traversed (Erlandson 2002). In addition, the islands would have been larger and closer to the mainland. It may be that the coastline of northwestern North America was not glaciated after about 13,500 B.P., allowing people to move south along a continental shelf exposed by lower sea levels (Fedje and Christensen 1999; Fedje and Josenhans 2000; Josenhans et al. 1997). Such a route may have been sufficiently productive to support human populations moving south. Most recently, it has been suggested that the extensive kelp beds that extend from Japan to California may have provided the resource base necessary for a movement of people along the coast in the late Pleistocene (Erlandson et al. 2007b). As sea levels rose at the end of the Pleistocene, sites containing evidence of an early coastal migration or maritime adaptation would have been flooded. Very little evidence exists to support a coastal-migration model, largely because most such sites are now underwater and very difficult to locate. The earliest sites in coastal California are, however, located on the Channel Islands (Erlandson et al. 2007a; Johnson et al. 2002).

Many dozens of sites dating between 12,000 and 7000 cal B.P. are known along coastal California, but only one is located north of Monterey Bay (Erlandson et al. 2007a; also see Erlandson 1997:5; Erlandson and Colten 1991:3; Jones et al. 2002, 2008). The other early sites are distributed in three primary clusters. One cluster extends from San Luis Obispo south to the Santa Barbara coast (including the northern Channel Islands). The second cluster is concentrated on the southern Channel Islands, and the third is around the ancient lagoons of San Diego County. Only two or three are known along the coast in the Los Angeles area. One important site in Orange County dating to this period is ORA-64.

Evidence of maritime adaptation—including the use of shellfish, fish, and marine mammals—has been found at a number of early coastal southern California sites. These sites include Daisy Cave (Erlandson et al. 1996; Erlandson et al. 2007a; Rick et al. 2001), Arlington Springs (SRI-173) (Johnson et al. 2002), Cross Creek (Jones et al. 2002), Diablo Canyon (Jones et al. 2008), and Arlington Point (Erlandson et al. 1999). Further, it has been argued that there is evidence of boat technology dating from ca. 8000 cal B.P. from the Eel Point site (SCLI-43) on the southern Channel Island of San Clemente (Cassidy et al. 2004) and possibly earlier elsewhere (Erlandson and Moss 1996:295), including Daisy Cave (Rick et al. 2001).

As Paleocoastal groups moved south along the coast north of the Los Angeles Basin, they would have occupied the general area now occupied by the Chumash. The Chumash language, originally classified in the Hokan linguistic family, is now considered a separate linguistic family, Chumashan, and is thought to have been in place for a considerable amount of time (Golla 2007). Based on the presence of lexical data, Klar (2008) has suggested that an unknown (but not Chumashan) language was spoken on the northern Channel Islands before the entry of the Chumash and could represent the initial migrants into the region. In the interior, it is probable that Clovis was Hokan (Moratto 1984:543–544; but see Lathrap and Troike 1988). This would imply that at least two groups of linguistically unrelated Paleoindians were moving south in California at the same time, followed by Chumashan groups later in time.

Paleocoastal Evidence in the Southern California Bight

The period of occupation in the Southern California Bight prior to 8500 cal B.P., known as the Paleocoastal period, is only vaguely understood. The California Bight is a geologic term defining the indentation where the north-south-trending California coastline changes to a more east-west orientation, roughly from Point Conception to San Diego. Sites from this time period are characterized by an abundance of ground stone artifacts, stone ornaments, large projectile points, and charmstones. The Paleoindian occupants of the bight frequently settled in grassland and sagebrush communities on elevated landforms somewhat distant from the modern shoreline (Vellanoweth and Altschul 2002:100). Solid evidence for Paleocoastal sites in the intervening areas of Ventura, Los Angeles, and Orange Counties is scant and inconclusive. Breschini et al. (1992) listed five sites in Los Angeles County that were investigated in the early twentieth century and have produced radiocarbon dates older than 7000 cal B.P.—specifically, the Malaga Cove site (LAN-138), the La Brea Tar Pits site (LAN-159), the Haverty or Angeles Mesa site (LAN-171), the Los Angeles Man site (LAN-172), and LAN-271—although the dates obtained from these sites are suspect; for example, the early Holocene age of LAN-271 is based on marine shell now thought to have been contaminated by fossil shell (Erlandson 1994:222). A short review of these sites explains the circumstances that have fostered this uncertainty.

Reports of evidence of "Early Man" in Los Angeles were heralded as a major discovery in 1914, when human remains were found in the Rancho La Brea Tar Pits (LAN-159) in association with the bones of extinct animals (Merriam 1914). Assumed to be contemporaneous with Pleistocene Rancholabrean fauna, this find spawned the sensational notion that human occupation of southern California extended back as far as 34,000 years B.P., clouding serious investigation for years to come. Radiocarbon dates from archaeological materials have brought the range into the more reasonable span of 9000–4450 cal B.P.; nevertheless, problems inherent in dating bone-collagen extract and decontaminating samples taken from a tar seep suggest that these newer dates also should be regarded with caution. Contamination of the skeletal material from oil impregnation cannot be ruled out (Erlandson 1994:222).

The discovery of deeply buried human-skeletal remains by construction workers for the Haverty Company in 1924 at Angeles Mesa (LAN-171) in Baldwin Hills (Stock 1924) provided more fuel for the debate. These remains were identified and excavated during the construction of the North Outfall sewer line for the City of Los Angeles. During the month of March 1924, there was a series of articles in the *Los Angeles Times* documenting the daily finds of these deeply buried human remains. Skeletal remains of at least eight individuals—three males, three females, and two subadults of indeterminate sex—were uncovered in close association, at depths of 5.8–7 m below surface (b/s) (Brooks et al. 1990). Bone-awl fragments, a quartzite core tool, and some freshwater gastropods were found in association with the skeletal remains in the marshy area at the base of Baldwin Hills. The depth of the finds and the partial mineralization of some of the bones suggested to Stock (1924) that the remains might date to what we, today, call the Paleocoastal period; an amino-acid-racemization (AAR) age of more than 50,000 years taken roughly 60 years ago seemed to confirm this conclusion (Taylor et al. 1985:137). More recently, however, most of these remains have been dated to within the Holocene (see Taylor et al. 1985:Table 1).

In 1936, a third discovery of a so-called Early Man was made. A single skeleton, dubbed "Los Angeles Man," was uncovered at LAN-172, 2 miles west of the Angeles Mesa site, in a similar stratigraphic context to that of mammoth bones (Lopatin 1940). Initial testing suggested that the human and mammoth bones were "approximately the same age" (Heizer and Cook 1952:298), and later AAR dating (Bada and Helfman 1975:Table 7) suggested an age of ca. 26,000 B.P. Subsequent radiocarbon dating, however, showed the skeleton to be about 3,500 years old (Taylor et al. 1985).

These early finds thrust the topic of Early Man in the Los Angeles Basin into an era of controversy from which it has only recently begun to emerge, as more reliable radiocarbon dates have become available. Conducting the first comprehensive, multidisciplinary review of the Angeles Mesa remains, Sheilagh Brooks and her colleagues (Brooks et al. 1990) subjected the bones to new, conventional dating methods (decay counting ^{14}C) and accelerator mass spectrometry from noncollagen organic-bone (osteocalcin) components.

The wide range of dates and disparate results depended on the techniques used and indicate that dating issues for these sites remain unresolved. Haverty Man No. 4, for example, has been assigned dates ranging from 3,870 ± 350 to 15,900 ± 250 years old, a span that exceeds an acceptable margin of error for radiocarbon dates. As to their significance, Brooks et al. (1990:80) felt that "the assumption that all of the Haverty skeletons are of similar age also may need to be reassessed," to which Erlandson countered, "It is hard to imagine that the burials are not temporally related" (Erlandson 1994:223). In the absence of additional data about their original context (unlikely to be obtained at this late date) or a new series of more reliable dates, the meaning of the Haverty skeletons, as well as others thought to be from this period, remains problematic.

Although there is currently nothing to suggest that inland (Clovis) peoples occupied the Los Angeles Basin, there are hints of visits by inland Clovis people to the region. There is one isolated Clovis point from Malibu (LAN-451) (Stickel 2006), although the context is unclear. Nevertheless, the presence of olivella-shell beads dating to about 11,000 B.P. in the Mojave Desert (Fitzgerald et al. 2005) also supports the idea of some sort of contact with the interior during this time period.

The Malaga Cove site (LAN-138) figures importantly in the discussion of early Holocene adaptations in the Los Angeles coastal area, but its inclusion on the list of Paleocoastal sites is questionable. Malaga Cove is a multicomponent site located atop a bluff overlooking the Santa Monica Bay just north of the Palos Verdes Peninsula. Two loci at Malaga Cove were systematically excavated by Richard Van Valkenburgh in 1931–1932 as part of the Van Bergen–Los Angeles County Museum Expedition, but Van Valkenburgh never published the results of his work. As Wallace has pointed out, "It is a great pity that Van Valkenburgh never got around to reporting the results of his investigations, for he found some unique materials, and his field notes indicate that he had some good insights into local prehistory" (Wallace 1984:1).

Several years later, in 1936–1937, Edwin F. Walker of the Southwest Museum excavated a portion of the Malaga Cove site (Walker 1937, 1951). Walker identified four discrete occupational strata in the 28-foot- (8.5-m-) deep sequence; the stratum pertinent to the Paleocoastal occupation was the lowest of the four, roughly 1 m (3 feet) in thickness, and he labeled it Level I. Walker called the Level I occupants of the site "the Scraper People," believing them to belong to what is now referred to as the Paleocoastal period (Walker 1937); Wallace (1984) later endorsed this belief by equating them with the San Dieguito culture. Both scholars hinged their conclusions on an analysis of the artifacts recovered from Level I, specifically, a number of small chert drills (that Walker referred to as "microliths"), worked-shell pieces, flaked and core tools, "rude scrapers," and two leaf-shaped bifaces. Bone and shell artifacts were relatively abundant in Level I, as were shell beads (primarily spire-removed olivella) and bone beads, but milling stones were entirely absent (Walker 1952).

Subsequent radiocarbon dates from Malaga Cove range from 215 ± 80 B.P. (UCLA-1008A), in a disturbed area of the site, to 7130 B.P. (UCR-1196), on a shell bivalve (Breschini et al. 1992:14). The latter date was obtained from shell removed from the sea cliff in an unknown stratigraphic context, which obfuscates its accuracy (Erlandson 1994:224). It is plausible, though, that the strata that Walker referred to as Level I at Malaga were not part of a discrete deposit. Careful examination of photographs taken during Walker's excavation (Braun Library, Southwest Museum, Walker Papers, Nitrate Box 17) indicated significant rodent disturbance in Level II at the interface with Level I. Hence, the Level II materials may have moved downward within the subsurface matrix as a result of bioturbation. In the absence of radiocarbon dates from secure stratigraphic contexts, the integrity and antiquity of the materials recovered from Level I at Malaga Cove remain in doubt.

Paleocoastal Evidence in the Ballona

In the Ballona area, evidence of a Paleocoastal occupation is scant; only two sites showed any evidence of occupation during this time period: LAN-61, located on the bluff top, just east of the Lincoln Gap, and LAN-63, located immediately to the west of LAN-61, just west of the Lincoln Gap (Figure 11). Although there are no radiocarbon dates from LAN-61 for this period (Lambert 1983:8; Van Horn and Murray 1985), a crescent and several stemmed points were identified by Van Horn and Murray during their large-scale data recovery investigations at this site in the 1980s. Crescents generally date prior to approximately 7000 cal B.P. A few stemmed points also were recovered from the surface of LAN-63 in the 1980s (Hull and Douglass 2005; Lambert 1983:8; Van Horn 1987a). Subsequent data recovery at LAN-63, however, including dozens of radiocarbon dates, failed to reveal any evidence of a Paleocoastal component (Douglass et al. 2005).

There are several sites in the greater Ballona region whose temporal association cannot be ascertained, either because they have been largely destroyed by historical period and modern buildings or because they do not provide adequate temporal data. Such sites include LAN-65, LAN-1716, and LAN-1118 (see Figure 11). LAN-65 is located in close proximity to LAN-64 and these two sites may be related or contemporary (Pence 1979). LAN-65 has been heavily impacted by buildings, and only a small portion was tested by Pence (1979), who recovered chert and quartzite debitage, and shell. LAN-1716 consisted of artifact concentrations at two loci (A and B) along a dune covered ridge south of Ballona Creek and east of Dockweiler State Beach in Playa del Rey (Singer 1990). Locus A consisted of two weathered flakes, Locus B of shell fragments. Both loci were in the front yards of single-family homes. LAN-1118 consists of a 250-by-100-m “shell midden with isolated lithic debitage” discovered in 1981 by Gary Stickel and Steve Appier at the west end of La Tijera Boulevard, along St Bernard Street near the Los Angeles International Airport. (Stickel and Appier 1981). The site was heavily disturbed by grading activity.

Millingstone Period

The Millingstone period—sometimes referred to as the Early period—is a roughly 5,500-year span beginning around 8500 cal B.P. and ending with the first dramatic increase in regional human population, around 3000 cal B.P. We previously argued (Stoll et al. 2003) that the Millingstone period in the Ballona began around 6500 cal B.P., beginning with the stabilization of sea levels, but more recent work in the Ballona (Douglass et al. 2005) has shown that this Millingstone occupation goes back to approximately 8200 cal B.P., based on radiocarbon dates on the bluff tops at LAN-64. The Millingstone period (called a “horizon” in some chronological schemes) is definitive of a time period when milling implements (especially manos and metates), scraper planes, choppers, and core tools were abundant and when there was a dearth of projectile points (in this case, dart points and spears) and faunal remains. Inherent in the definition of the Millingstone period is a heavy dependence on seeds and a relative lack of dependence on hunting (hence the abundance of milling implements and the near absence of hunting equipment and faunal remains).

Level 2 from the Malaga Cove site clearly indicated a Millingstone period occupation. A second radiocarbon date of 6510 ± 200 B.P. (Hubbs et al. 1960:201) obtained from a shell sample (*Chione* sp.) placed the lowest levels at the Malaga Cove site at the beginning of the Millingstone period. In addition, Millingstone period implements from Malaga Cove’s Level 2 included large numbers of ground stone artifacts; cobble hammers; choppers; a few mortars and pestles; large, coarsely flaked projectile points; and knife blades (Walker 1952:51–60).

The Tank site (LAN-1) was excavated in the late 1940s in the Topanga Canyon area (Heizer and Lemert 1947; Treganza and Bierman 1958; Treganza and Malamud 1950). Two cultural strata were identified, both dating to the Millingstone period, but were poorly dated. The collection from the site (estimated at approximately 10 percent of the site contents) (Treganza and Bierman 1958:73) included large numbers of metates and manos, scrapers, hammerstones, and core tools as well as cogged stones, discoidals, crescents, and other tools. Many features were also uncovered, including caches of milling tools, some of which contained fragmented human bone. Nineteen primary and secondary inhumations also were found at the site. Subsistence remains were quite limited (Treganza and Bierman 1958:68). Treganza and Malamud (1950:151; also see Gamble and King 1997) suggested that the Tank site was an early village (partly based on the presence of the inhumations), but Hale (2001:77–78) suggested that it represented a less sedentary settlement. In July 1910, the *Los Angeles Times* reported that a large number of burials were excavated from the mouths of Topanga and Temescal Canyons by geology students from Stanford University. It is unclear what sites were actually excavated. In addition, in January 1923, the *Los Angeles Times* also reported that at the mouth of Topanga Canyon, the construction of Topanga Road cut through a prehistoric burial area. Again, it is unclear at which specific archaeological site this burial area may be documented.

Several other sites with early Millingstone period components are known along the coast in the Malibu area. These include the Sweetwater Mesa site (LAN-267) (see King 1967; also see Gamble and King 1997:64), the Shobhan Paul site (LAN-958) (Porcasi 1995; Porcasi and Porcasi 2002; Salls 1995), and the

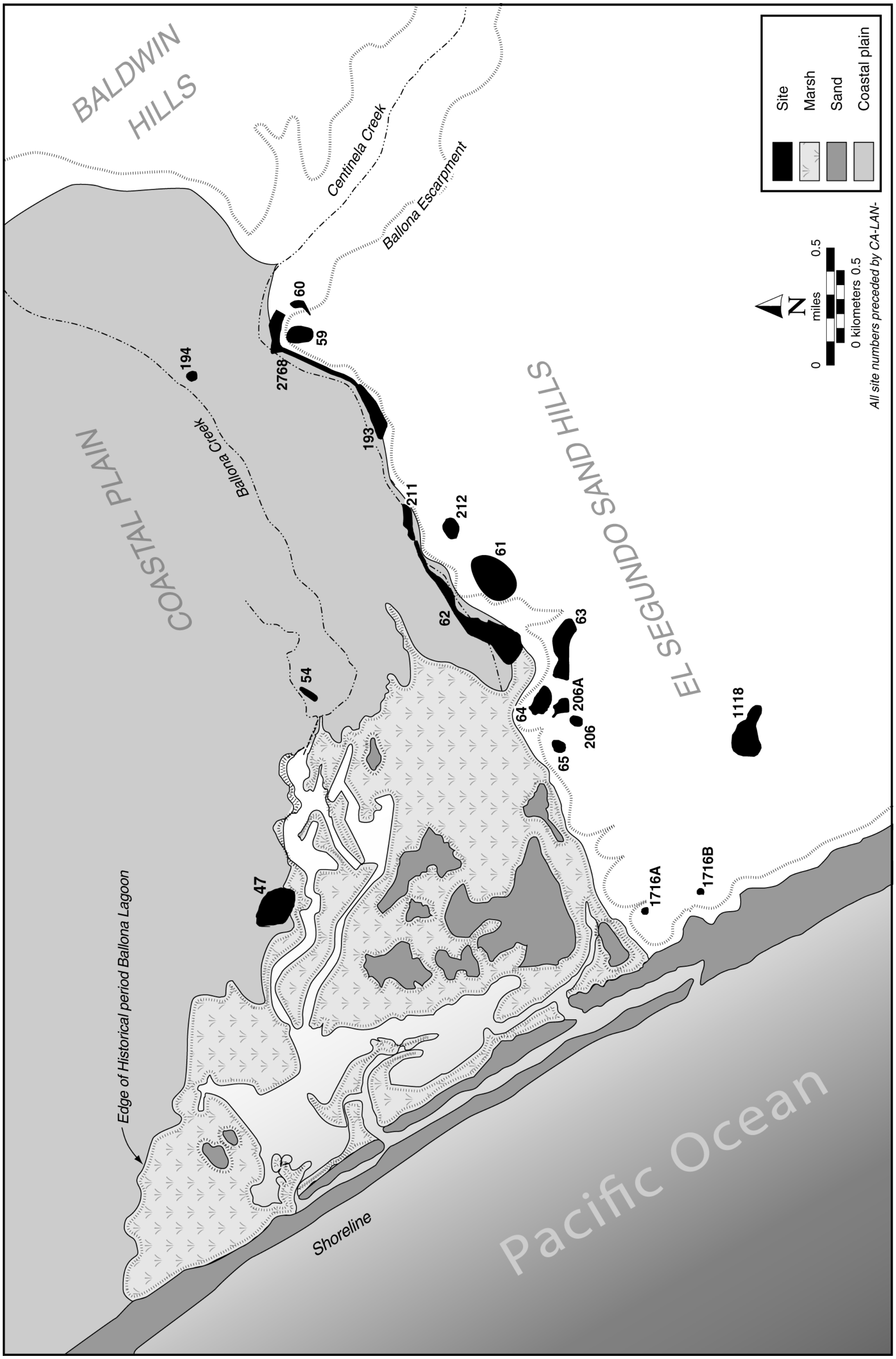

Figure 11. Archaeological sites in the Ballona region.

Parker Mesa site (LAN-215) (King 1962). No inhumations were reported from any of these sites. The Shobhan Paul site contained many manos and metates, large side-notched and lanceolate points, some obsidian specimens, and other artifact types. Based on the artifact collection, Porcasi (1995:60) has argued that the site dates to the early Millingstone period. More recently, radiocarbon assays on shell placed the Shobhan Paul site between 8200 and 5100 cal B.P. (Porcasi and Porcasi 2002:24). A few other early Millingstone period sites are known in the Santa Monica Mountains area, although they are not thought to have been occupied to any great extent prior to ca. 7500 B.P. (King et al. 1968:99).

Farther down the coast, in Orange County, several early Millingstone sites have been identified. The best known of these is Bolsa Chica (ORA-83), or the "Cogged Stone Site" (Herring 1961, 1968), so named for the hundreds of cogged stones discovered at the site. The site is located on Bolsa Chica Mesa in Huntington Beach and is radiocarbon dated to at least 9000 cal B.P. (Couch et al. 2009:148). Excavations by Herring (1968) produced more than 200 cogged stones. Later excavations by Muñoz (1975) produced a wide variety of artifacts, including manos, metates, cogged stones, a discoidal, and a perforated "spindle-shaped" charmstone as well as numerous scrapers and a variety (but small quantity) of manufactured tools (e.g., cores, hammerstones, and blades). More recently, five caches containing 4 or more cogged stones and one cache containing 17 cogged stones have been discovered (Couch et al. 2007). Some have suggested that the large number of cogged stones (i.e., greater than 500, some collected by amateurs) found at Bolsa Chica is evidence that during the early Millingstone period, the site was likely a major manufacturing center for cogged stones. It is uncertain whether this is the case, and the primary function of the site remains unclear.

Continuing south, the multicomponent Irvine site (ORA-64) (Drover et al. 1983) contained an early Millingstone component located on a bluff above Newport Bay in Orange County. Drover et al. (1983:Table 1) reported 22 uncorrected radiocarbon dates on marine shell, ranging between 8445 ± 280 and 4900 ± 80 B.P. More recently, Erlandson et al. (2005:Table 1; also see Macko 1998:Table 2) reported 14 adjusted radiocarbon dates on olivella-shell beads that ranged between 8950 ± 50 and 7620 ± 60 B.P. (calendar-age range between 9420 and 7780 cal B.P.) (also see Macko et al. 2005:93).

The early Millingstone component at ORA-64 contained numerous manos and metates, charmstones, 2 cogged stones, 982 discoidals (Macko 1998:Table 22), ceramic effigies (Drover 1971, 1975), and a few projectile points (Drover et al. 1983:53; Macko 1998:102–103). The large number of discoidals may suggest that they were manufactured at the site or nearby, although this is unclear, because reports have not been published regarding stone-tool analysis. Mortuary patterns included cairn burials (Drover et al. 1983) and inhumations (as many as 600, many of which were flexed, although the exact number has never been published). One flexed inhumation was dated to 6435 B.P., and a crescent was also discovered in association (Drover and Spain 1972:43; also see Drover et al. 1983:18–19), making it the earliest flexed burial known in the Los Angeles/Orange County area. The early Millingstone period component of the Irvine site also contained obsidian from several sources, including northeastern California, demonstrating wide-ranging trade during the early Holocene (Erlandson et al. 2005; Fitzgerald et al. 2005; Macko et al. 2005; Sutton and Koerper 2009). The faunal remains from the site led Drover et al. (1983:47) to argue that there was "a breadth of animal use which has not generally been considered a feature of the Millingstone horizon."

Late Millingstone occupation in the Los Angeles Basin was first identified at the Tank site (LAN-1) in the stratum above the early Millingstone period component (Treganza and Bierman 1958; Treganza and Malamud 1950). Late Millingstone occupation is differentiated from the early Millingstone component by a reduction in the percentage of manos/metates and scraper planes, the addition of mortars/pestles and flexed inhumations with no specific orientation, a reduction in the size of projectile points, fewer core tools, the presence of stone features (some associated with human remains), the appearance of shaped and incised stones, and late discoidals (the designation "late" is per Underbrink and Koerper [2006:117]) (Johnson 1966:19; Moratto 1984:127). Shellfish, and presumably acorns, became more important. Johnson (1966:16) proposed that the exploitation of yucca was an important element of late Millingstone economies.

Along the Los Angeles coast, a number of other sites can be assigned to the late Millingstone period. Zuma Creek (LAN-174) (Peck 1955) is a late Millingstone site located on a mesa northwest of Point Dume, along northern Santa Monica Bay. At that site, manos, metates, possible mortars, scrapers, projectile points, core tools, cogged stones, discoidals, stone balls, and possible charmstones, among other artifacts, were recovered. By far, the most common artifacts (excluding debitage) at the site were manos; projectile points made up only a small fraction of the collection. The site also contained flexed inhumations, extended inhumations, and reburials under cairns (King 1967; Littlewood 1960). A radiocarbon date of 4950 ± 200 B.P. (King 1967:62) placed the main occupation of the site within the late Millingstone period. The Zuma Mesa site (LAN-40) (Ruby 1961) is similar to the nearby Zuma Creek site, although it contained more scrapers. Zuma Mesa was dated by comparing it to other sites with similar assemblages that were radiocarbon dated to the late Millingstone period (Ruby 1961:202).

The artifacts recovered from Paradise Cove (LAN-222) (Gamble and King 1997:64; King 1967:61), a site located at the edge of the Santa Monica Mountains on the northeast side of Point Dume, included manos, metates, scrapers, and core tools, as well as a few leaf-shaped, stemmed, and side-notched projectile points. There were also inhumations at the site, most of which were extended (more typical of the early Millingstone period), although some were flexed. In the excavation area, the site was "literally paved with millingstones," under which were the inhumations (King 1967:61).

One of the extended inhumations was radiocarbon dated to 4300 ± 80 B.P. (King 1967:61).

Late Millingstone period sites are also known along coastal Orange County and are sometimes considered to be part of "an expansion of settlement to take advantage of new habitats [kelp beds and estuaries] and resources [shellfish and fish] that became available as sea levels stabilized between about six and five thousand years ago" (Mason et al. 1997:58; also see Masters and Aiello 2007). The Banning-Norris site (ORA-58) is a large, stratified site along the lower Santa Ana River that was initially excavated in the 1930s by Winterbourne (1968) and, later, Dixon (1968, 1970). The lower component of the site dated to about 3700 B.P. (Dixon 1970:63), and an upper late component is also present. The site contained manos, metates, shell beads and ornaments, cogged stones (including one cache of three) (Dixon 1968), discoidals, plummet-shaped charmstones, stone balls (four associated with inhumations and three in a cache), a "killer whale" effigy, a variety of other unusual artifacts, at least two cremations, and numerous inhumations (Anonymous 1938; Koerper et al. 1996; Macko et al. 2005).

At Landing Hill in Seal Beach (Cleland et al. 2007), four of the five sites that were excavated produced numerous radiocarbon dates and cultural materials indicating major occupations between about 5500 and 3000 cal B.P. (Cleland et al. 2007:329), generally within the late Millingstone period. Other sites in the area have produced similar radiocarbon dates (see Whitney-Desautels 1997; York and Underwood 2002). The artifact collections from these sites included numerous manos and metates, fewer mortars and pestles, hammerstones, cores, bifaces, and charmstones. A few cremations and numerous inhumations (mostly tightly flexed but a few loosely flexed or extended) were also documented. The varied faunal remains from these sites were regarded as reflecting "generalized use of estuary, nearshore, and local terrestrial habitats" (Cleland et al. 2007:329).

Sutton (2009) has argued that from the end of the Millingstone period, ca. 3500 cal B.P., through the early Intermediate period (ending ca. 1500 cal B.P.), there was an initial entry of Takic groups (proto Gabrielino/Cupan branch) into the region. These Takic groups replaced the existing late Millingstone groups along the coast. The archaeological record reflects this major change. First, the entering Takic groups were biologically distinct from the preceding populations—as reflected in both osteometric and aDNA data (the data set is admittedly small; see Sutton [2009] for a full discussion)—suggesting that a migration took place. Second, significant increases in site numbers were noted in some areas, such as the Ballona (Altschul et al. 2005:291, 295; 2007:35; Grenda and Altschul 2002:128), suggesting the arrival of incoming groups during the early Intermediate rather than the late Intermediate, (ca. A.D. 500), as has been traditionally thought. Also, larger sites with a greater diversity of artifacts appeared at about this time but seem to have been occupied on a seasonal basis. Third, economies changed from a heavy emphasis on marine resources (especially shellfish) to more of an emphasis on terrestrial resources. At the same time, freshwater fishing became more important during the transition from the late Millingstone period to the subsequent early Intermediate period. Lastly, there were some changes in mortuary patterns on the coast. Flexed burials under cairns disappeared on the coast but continued inland; cremation was uncommon and was not, contrary to common belief, a Takic marker (see Sutton 2009). Large mourning features with cremated human bone appeared about 2600 cal B.P. (during the early Intermediate period). These features apparently represent a diffusion of ideas from Yuman groups in the deserts to the east and could mark the inauguration of some sort of ritual complex in the region.

The first Takic groups, who arrived in the region at some time between the end of the late Millingstone period and the early Intermediate period, would have used atlatls and darts, such as Elko and/or Gypsum series points, which generally date between 4000 and 1800 cal B.P. in the Mojave Desert (Sutton et al. 2007:241). These projectile points, (e.g., Elko Contracting-stem or Vandenberg Contracting Stem) are known from coastal southern California (Cleland et al. 2007:191, 193; Koerper and Drover 1983:10, 12; Koerper et al. 1994:Table 3; Lambert 1983:Figure 3; Macko 1998:103) but do not appear to have been confined to Takic times (see Harrison 1964; Moratto 1984:137–138; also see Koerper and Drover 1983:14). Thus, the use of projectile points of any kind as markers of the initial Takic entry into southern California appears problematic. Note that although it may not have been extensive, the trade of olivella grooved-rectangle beads from the southern Channel Islands to the Orange County mainland and into the Great Basin is consistently dated at 5,000 years ago (Bennonoweth 1995, 2001), and these provide strong evidence of contact between the coastal and desert groups.

Other traits that might mark the arrival of the Takic include certain textiles (Bleitz 1991; Lauter 1982:87–88; Rozaire 1967:330; Titus 1987:23); single-piece, circular *Haliotis* fishhooks (Koerper et al. 1995, 2002:68; Raab et al. 1995:14); bone harpoon points (Kowta 1969:48); and stone beads of Sierra Pelona schist (see Altschul et al. 2007:35; also see King 1990:133). Lastly, it is commonly believed that cremation marked the entry of Takic groups, but this has been shown not to be true (Allen 1994; Sutton 2009). By about 3200 cal B.P., Takic groups reached the southern Channel Islands and replaced the populations there (see Sutton 2009). It was about that same time that the extensive trade in steatite and shell beads between the islands and the mainland began.

Millingstone Period Occupation in the Ballona

Millingstone period sites have also been discovered in the Ballona, on the bluff tops above the PVAHP area (in the lower Ballona) and to the east, near the Baldwin Hills (in the upper Ballona), where ephemeral camps were located near an inland swamp later known as Las Cienegas. Early archaeological surveys of this area in the upper Ballona identified a series of about 15 sites with artifact collections that included cogged stones, large projectile points, and large numbers of ground stone artifacts (Farmer 1934, 1936; Rozaire and Belous 1950). The Angeles Mesa site (LAN-171) is among this group of sites.

Evidence of occupation in the lower Ballona Creek area (including the project area) during the Millingstone period has been scant in the past. Even as recently as 2003, for example, only two sites (LAN-61 and LAN-206) were known to have early Millingstone components (Stoll et al. 2003). Recent reinterpretation of some sites, in addition to data recovery efforts at others, has yielded much stronger evidence of a Millingstone component in the Ballona area.

Van Horn and White (1997a) argued that the occupants of the Millingstone period component (Component A) at the Berger Street site (LAN-206) fished and collected shellfish in the nearby Ballona estuary. The paucity of tools and faunal remains in the midden was consistent with a short-lived campsite; presumably, individual occupations did not last more than a few days or weeks. The picture that emerges is one of brief forays to the lagoon from campsites on the bluff tops overlooking the bay. In small, mobile groups, Millingstone period residents of the Ballona exploited nearshore and lagoonal fish and shellfish. As evidenced by a common material culture found at sites along the coast, a distinct cultural system became widespread over the region during the Millingstone period.

Below the bluff, Millingstone period dates have been identified at two sites: LAN-54 and LAN-62 (see Volume 2 of this series for details) (Altschul et al. 2003; Vargas and Altschul 2001; Vargas et al. 2005) (see Figure 11). LAN-62 appears to date to at least 6000 cal B.P., whereas LAN-54 generally dates to the late Millingstone, ca. 4000 cal B.P. Four sites on the bluff tops, LAN-61, LAN-63, LAN-64, and LAN-206 (including LAN-206A), have yielded radiocarbon dates or other diagnostic artifacts that fall within the Millingstone period (Douglass et al. 2005; Van Horn 1987a; Van Horn and Murray 1985). Radiocarbon assays from LAN-64 (Hull and Douglass 2005) have yielded a cluster of dates between 7000 and 8200 cal B.P., making it, by far, the oldest occupied site in the Ballona area (and one of the oldest sites along the Southern California Bight, as well). LAN-64 also yielded cogged stones and discoidals during data recovery efforts, but their context in the upper (Intermediate period) component of the site argued that they were likely curated and used during later occupations of the site. This cluster of early Millingstone radiocarbon dates was from a series of shell-dump features identified at the base of the cultural deposit, dug into the underlying C horizon at the site. Beyond *Chione* and scallop shells and a small amount of debitage in these features, little is known about the Millingstone occupation at this site, except that it may have been used as a temporary camp for collection of nearby lagoon resources (Douglass et al 2005). It is likely, however, that these prehistoric inhabitants of the Ballona utilized a number of locations along the bluff-top mesa and selected locations along the edge of the lagoon for short periods of time. At LAN-206, a single uncorrected radiocarbon date of 6750 ± 80 B.P. on a shell valve (*Chione* sp.) recovered from 50–60 cm b/s also argued for a Millingstone period occupation of this neighboring site (Van Horn and White 1997a:19). A component of this site, LAN-206A, located on the west end of the West Bluffs property, yielded no datable organic material but did contain cogged stones and discoidals (Douglass et al. 2005). LAN-63, located immediately to the east of LAN-64 and LAN-206A, also contained cogged stones and discoidals (as well as stemmed points), but radiocarbon assays failed to yield dates older than the Intermediate period. Furthermore, these diagnostic artifacts were not found in feature contexts; so, it is unclear whether they, like those at LAN-64, were curated artifacts. Finally, an uncorrected shell date of 4710 ± 80 B.P. from the Marymount site (LAN-61A) falls within the late Millingstone period (Van Horn and Murray 1985). Cogged stones and discoidals were also recovered during data recovery efforts at the site by Van Horn and Murray. Overall, then, there is strong evidence of Millingstone occupation in the Ballona, both on top of and below the bluffs.

Many questions remain about the Millingstone period in the Ballona, however. The dating of cultural materials from this period continues to pose methodological and interpretive challenges. Shell was used for radiocarbon assays at LAN-61 (Van Horn and Murray 1985), and although the species was not identified, it likely was obtained from *Chione* sp. Shell has also been used to date Millingstone deposits at LAN-62 (*Chione*), LAN-64 (*Chione* and *Argopectin*), and LAN-206 (*Chione*) (Douglass et al. 2005; Van Horn and White 1997a; Vargas et al. 2005). Most archaeologists in southern California use *Chione* for radiocarbon dating, because the large size of the shell allows a sample to be obtained from a single specimen, as opposed to combining shell pieces found in one or more proveniences. Using this species to identify Millingstone period sites may be problematic, however, because current studies of mollusks from our coring program indicated that *Chione* and estuarine species were not well established in the Ballona Lagoon prior to 6500 cal B.P. (see Chapters 6–8 of this volume). The radiocarbon dates from LAN-64, which date as far back as 8200 cal B.P., suggest that either the lagoon was established earlier than the coring program indicates or the shell was brought to the site from along nearby Santa Monica Bay.

In addition, currently, subsistence and settlement patterns during the Millingstone period are not well understood in the Ballona. As discussed in the beginning of this section, one of the hallmarks of the Millingstone period is the dearth of faunal remains because of a focus on seed collection. Because of the age of deposits, preservation of pollen and macrobotanical remains from Millingstone period middens (especially those dating to the early Millingstone period) is varied but generally poor. At LAN-64, the oldest example of a Millingstone component in the Ballona, there was a complete absence of vertebrate remains and only a small amount of invertebrate remains (identified as *Chione* and *Argopectin*). The large-scale data recovery excavations at LAN-61 in the 1980s (Van Horn and Murray 1984, 1985) revealed a Millingstone period component, but much of the faunal remains dated to the Intermediate period, the primary site occupation. The data revealed from current PVAHP data recovery excavations at LAN-54, LAN-62, and LAN-211 are the most informative for revealing Millingstone period subsistence remains (see Volume 3 of this series for details on vertebrate, invertebrate, macrobotanical, and microbotanical analyses and interpretations).

Intermediate Period

The Intermediate period, dating from 3000 to 1000 cal B.P., is marked by changes in settlement patterns, economic activities, mortuary practices, and technology. The latter portion of the Intermediate period, ca. 1500–1000 cal B.P., is marked by the spread of the bow and arrow to the coast from the north and east. Sometime toward the end of the Intermediate period, the trade in Coso obsidian decreased dramatically (Sutton et al. 2007:244), and Obsidian Butte obsidian increased in importance. Yuman ceramics, plus some local wares, are present. Major settlements continued to be occupied on a seasonal basis. Flexed burials continued, and cremation remained uncommon. As discussed above, Sutton (2009) argued that a major process beginning in the late Intermediate period was the diffusion of a Takic language, the mother of the Cupan languages, into Yuman-speaking areas immediately to the south of the Los Angeles Basin.

Common traits of Intermediate period sites along the Southern California Bight include a relative dearth of manos, metates, and core tools; an increase in the number of mortars and pestles; a greater number and wider variety of projectile point types; flexed inhumations (some beneath rock cairns); and the introduction of stone-lined, earthen ovens (Johnson 1966:19). As Johnson (1966:19) pointed out, however, there was generally little change in the morphology of core tools and grinding implements between the Millingstone and Intermediate periods. Johnson (1966:4) suggested that the ovens were used to bake yucca and/or agave. Similar features containing carbonized yucca (as well as other botanical resources) have also been found in the central Transverse Ranges, most occurring between about 2300 and 800 cal B.P. (Milburn et al. 2008:6, 20). Van Horn has identified examples of these types of features on the bluff tops in the Ballona, at LAN-61 (Van Horn and Murray 1984, 1985) and LAN-63 (Van Horn 1987a). SRI identified similar types of archaeological remains during subsequent work at LAN-63 (Douglass et al. 2005) and argued that these represented either communal ceremonial features or large roasting pits, depending on the contents of the features. In addition, a pit house reused as a large roasting pit was identified by SRI at LAN-2768 (see Volume 2 of this series). As discussed below in this section, there appears to have been new variation in burial patterns, including the introduction of cremations.

The Intermediate period at Malaga Cove (LAN-138) is marked by the presence of fishing and sea-mammal-hunting gear in the upper portion of Level 3. Intermediate period occupation at Malaga Cove, thought to date to around 1450 B.P., is characterized by big stone mortars and pestles, abalone-shell fishhooks, bone harpoon barbs, chert knives and scrapers, steatite vessels, and shell ornaments. These artifacts mark the beginnings of maritime exploitation (Walker 1952; Wallace 1984).

Johnson (1966) identified an Intermediate period component at LAN-2 that contained rock-lined ovens and seven flexed inhumations (also see discussion of this site in Hale [2001:79–90]). LAN-2 also contained abundant metates, manos, scraper planes, and hammerstones, as well as a few choppers, small and large points, pestles, a crescent, and a few mortars. Radiocarbon dates for LAN-2 ranged between 2700 and 2440 B.P. (Johnson 1966:15). Based on these dates, Johnson (1966:20) proposed that Topanga III (what we call the Intermediate period today) began about 3,000 years ago.

Intermediate Period Occupation in the Ballona

The Intermediate period is the best-documented portion of the prehistoric occupation in the Ballona. Ten Intermediate period sites have been identified through radiocarbon dating. Four sites (LAN-60, LAN-62, LAN-193, and LAN-2768) are located at the base of the bluff, along the banks of Centinela Creek (see Figure 11). LAN-54, which has both late Millingstone and early Intermediate period components, is located in the middle of the Ballona Lagoon, alongside Ballona Creek; this site is unique among Intermediate period sites in the Ballona in its location away from the bluffs. Five large midden sites (LAN-59, LAN-61, LAN-63, LAN-64, and LAN-206) occupy almost every elevated knoll along the edge of the Westchester Bluffs overlooking the Ballona. These sites contain relatively dense artifact and feature deposits that have yielded radiocarbon dates from the Intermediate period (Altschul et al. 2007; Douglass et al. 2005; Van Horn and Murray 1985). Many of these sites appear to be multicomponent, with minor Millingstone and Late period components.

Two basic questions concerning Intermediate period occupation in the Ballona have guided SRI's research in the PVAHP area. First, what accounts for the increase in settlement during this period? And second, what is the nature of the relationship between the bluff-top and lowland sites? In pursuit of an answer to the first question, previous researchers have hypothesized that some Intermediate period cultural traits indicate the arrival of people from the desert (Van Horn 1987a). These traits include tanged projectile points, cremation of the dead, the introduction of stone beads, and a lack of shell artifacts. The preference of stone over shell as a raw material for making beads suggests the presence of people without a well-developed, preexisting maritime tradition. At some sites, such as ORA-263, this period is marked by massive amounts of stone beads and a small number of shell beads found in burial contexts; at LAN-63 and LAN-64, although in much smaller quantities, stone beads far outnumbered shell beads in burials (Hull and Douglass 2005).

Recent investigations have examined the microlith industry and the presence of desert-style projectile point types during the Intermediate period as expressions of a cultural tradition unique to the Ballona (Van Horn and Murray 1985). Artifacts referred to as microliths are scarce at large sites with Intermediate period components, such as ORA-83 in Bolsa Chica (Whitney-Desautels 1986) and ORA-64 in Newport Bay (Macko 1998); however, numerous microblades were identified from primarily Intermediate deposits at LAN-61 (Van Horn and Murray 1985). The question of desert migrations during the Intermediate period has been discussed by several authors (Altschul and Grenda 2002; Koerper 1979; Kowta 1961; Kroeber 1925; Moratto 1984; True 1966; Van Horn 1987a, 1990). Most have suggested that an arrival date of approximately 1500 cal B.P. is consistent with the data; however, some authors have argued for a much earlier migration (ca. 3500 cal B.P., near the Millingstone/Intermediate period transition), such as Sutton (2009), as discussed above for the Millingstone period. Both arguments may be correct, because it is possible that multiple migrations took place over hundreds, if not thousands, of years.

Three archaeological sites, LAN-63, LAN-64, and LAN-206A, immediately to the west of the Lincoln Gap on the bluff top, provide our best data on Intermediate period settlement. Analysis of the midden materials supports a highly diverse set of activities, strongly suggestive of a more permanent occupation. These sites overlook two large, natural depressions. The eastern depression was used as a community trash dump and was surrounded by hundreds of thermal features. On the western flank of this depression were three features consisting of large numbers of milling implements, many of which had been intentionally broken and smeared with ochre. Interspersed among the milling stones was cremated human bone. Inhumations also were found in several locations throughout the community. Often, these burials were found in small clusters, suggesting the presence of burial grounds for specific social groups. The western depression, which held water for various lengths of time, was used primarily as a plant-resource-procurement area, and processing took place on the higher ground, where hearths abound. In short, space at these bluff-top sites was highly structured and segregated into communal refuse areas, resource-procurement and -processing areas, ritual space, and burial areas.

These features at LAN-63—the easternmost of the three sites–with purposefully broken artifacts, and some with cremated human remains, are similar to features found at Landing Hill (including ORA-263). Burial Feature 29 at ORA-263 contained large amounts of fragmentary, cremated human bone and broken ground stone fragments. This feature, approximately 23 m^2, contained ground stone that had been purposefully broken and left in place (in situ) by the prehistoric inhabitants of the site. In total, 135 pieces of ground stone were recovered, nearly all within a roughly 3-by-5-m area. The majority of the bowls and mortars recovered appeared to have been intentionally broken or "killed," similar to what was seen at LAN-63 in the Ballona area. This main concentration of cremated human bone also contained an exceptionally dense concentration of beads (primarily stone beads, although some shell beads were also present) and ornaments. This deposit represents an Intermediate period (ca. 1900–2300 cal B.P. cluster) cremation feature intrusive into a Millingstone period deposit. It appeared that the cremation feature was used for a few hundred to perhaps 1,500 years (ca. 2300–800 cal B.P.), based on radiocarbon dating of teeth. Based on similarities with ethnographic and ethnohistoric documents, Cleland et al. (2007:114–115) argued that the cremation feature at ORA-263 may represent a mourning feature. Hull et al. (2006, 2013) came to a similar conclusion.

Similar types of mourning features have also been identified at other sites within the western Los Angeles Basin. Cairns of purposefully broken milling stones, for example, have been documented at the Little Sycamore site (VEN-1) (Wallace 1954), the Stone Bowl site at Big Tujunga Wash (Walker 1952), and the Cairn Site in Chatsworth (LAN-21) (Walker 1952; see also Tartaglia 1980). Hull et al. (2006, 2013) have argued, similarly to Cleland et al. (2007), that the features at LAN-63 and ORA-263 are likely communal features related to mourning of departed community members. During the early Historical period, mourning ceremonies were documented by various ethnographers in the southern California area, including Benedict (1924), Strong (1929), and Kroeber (1925). These features, as Hull et al. (2006, 2013) argued, contained elements of artifacts that reveal an organized deposition through a sequence of actions, including burning, breakage, pigmentation, and placement. Based in part on the fact that many of the ground stone implements were related to traditional women's work within Gabrielino/Tongva culture, Hull et al. (2006, 2013) argued that women within the community may have been mourned through these communal events. These features, and associated communal activities, are very important, because they appeared to date to the late Intermediate period (ca. 2000 cal. cal B.P.) and have not been identified archaeologically in earlier contexts in the Southern California Bight. They may reflect additional evidence of an increased sedentary nature in Intermediate settlement patterns; certainly, they reflect site structure not seen before.

Van Horn (1987a, 1987b) has argued that Intermediate period sites on the bluff tops (such as LAN-61, LAN-63, and LAN-64) were created by periodic, short-term visits by one or two domestic units. For the occupation prior to 3000 cal B.P., we concur. After this date, however, these settlements underwent a fundamental change, and multiple social groups lived there on extended bases for short periods of time. More than 20 radiocarbon dates, primarily from features at LAN-63 and LAN-64, are clustered within a 300-year period around 2000 cal B.P. (Hull and Douglass 2005).

This occupation corresponds with a brief period of unusually high precipitation documented by Wigand (2005), roughly between 2100 and 1900 cal B.P. Sites located on the bluff tops were ideally situated for the procurement of resources from two distinct environments: the Ballona Wetlands to the north and the vernal pools of the coastal prairie to the south. Macrobotanical evidence from these sites suggests that their inhabitants took advantage of this ecotone, collecting seeds from plants growing around vernal pools and marsh plants from the lagoon. Because of the dramatic increase in rainfall during this brief period, resources in both the wetlands and the coastal prairie would have been at their peak, making the area especially attractive to settlement.

Although there have been competing hypothesizes related to the functional variation of bluff-top sites and those located below the bluff during the Intermediate period (see Stoll et al. 2003 for a review; see also Altschul et al. 2007), current views of the greater Ballona settlement system suggest that all sites were roughly contemporaneous. Although some sites may have been specialized food-collecting and -processing sites, the occupants of all Intermediate period sites performed similar types of activities. Data from LAN-63 suggest that this site may have been unique in the Ballona during this period, with more site structure and more evidence of ritual activity than any other contemporary site, although this pattern may simply be a reflection of better preservation of the site and the larger-scaled data recovery efforts, which resulted in its complete exposure as part of planned development of the area.

Late Period

The Late period, beginning around 1000 cal B.P. and ending with European contact in A.D. 1542, witnessed extensive population growth along much of the southern California coast. There are more sites and a greater variety of sites with greater internal differentiation than from any other time in prehistory. Villages with complex site layouts and burial grounds with highly variable mortuary treatments appeared, suggesting the development of social differentiation. The Late period component at Malaga Cove (LAN-138), Level IV, consisted of a midden measuring more than 4.5 m (15 feet) in thickness and containing large quantities of small, leaf-shaped projectile points, steatite bowls, mortars, pestles, bone tools, shell fishhooks, and ornaments of bone and shell (Walker 1952). Late period sites elsewhere in the Bight include fully developed villages with complex site features, suggesting a corresponding differentiation within the social system. During this period, as we discuss below, there appears to be a more formal placement and differentiation of burials than seen previously along the Southern California Bight, possibly further suggesting greater social-status markers.

One example of a Late period site is the Sheldon Reservoir site, LAN-26, on the east side of Arroyo Seco in Pasadena. This burial-ground site was first excavated in 1938 by Edwin Francis Walker. An obsidian-hydration rim measurement from unsourced obsidian suggested a date of A.D. 916 for the site. Based on the artifacts recovered at the site, King et al. (1974) dated occupation of the site to between A.D. 1000 and 1769.

Two levels excavated at this site yielded 2 cremations and 53 flexed inhumations (Walker 1952:73). Near these burials in the upper level were a variety of large, broken stone tools—metates, mortars, and pestles—indicating that the aboriginal custom of "killing" artifacts as part of the funeral rites was practiced by this group (Walker 1952:73). The 2 cremations were deposited in such a manner that 1 of the cremations was completely surrounded by a circle of five small boulders and the second was bounded by a crescent of seven boulders on its western side (Walker 1952:73). A few of these burials were interred with Late period projectile points beside or above them (Walker 1952:73, 79).

Located approximately 10 feet north of the burial area were approximately 10 cairns composed of 35–200 stones and broken stone artifacts (e.g., metates, pestles, bowls, scrapers, and projectile points), many of which were fire affected (Walker 1952:79). These cairns were possibly associated with the mourning ceremony, according to Walker (1951:79).

Another Late period site is LAN-246, the Mulholland site. Located in the Santa Monica Mountains, LAN-246 was a large habitation site first excavated by Alex Apostolides in 1963 (Galdikas-Brindamour 1970). Radiocarbon dates obtained from charcoal and human bone indicated that the site was occupied between A.D. 1240 and 1440. Galdikas-Brindamour (1970) argued that the inhabitants were a subgroup of either the Gabrielino/Tongva or the Chumash, in light of the proximity of this site to the cultural boundary separating these two groups. She also argued that the artifact assemblage, soil, midden, and inferred social complexity were indicative of a "multiactivity, sedentary village" with a year-round resident population, although no distinct house floors or house remains were identified (Galdikas-Brindamour 1970:157). Modern looting at this site was a significant problem and very likely affected the artifact and burial recovery.

Excavation at LAN-246 by Apostolides resulted in the discovery of 23 human burials (Galdikas-Brindamour 1970:Table1). The majority of the burials were interred in tightly flexed positions; a few individuals were interred in a loosely flexed positions. Some burials were found with numerous artifacts, whereas artifacts were completely absent from other burials. Galdikas-Brindamour (1970) saw this as indicative of rank within the social organization of the resident group at this site.

In addition to these burials, many artifacts were recovered from nonburial contexts at LAN-246. Ground stone artifacts included manos and metates, pestles and pestle fragments, slate pendants, and numerous shaped slate blanks (Galdikas-Brindamour 1970:140). There were 30 steatite *comales* and vessel fragments recovered, as well as mortars and basket-hopper mortars (Galdikas-Brindamour 1970:137). One of the mortars had been "killed," and a steatite olla fragment was in the process of being reworked as a *comal* at the time of deposition (Galdikas-Brindamour 1970:137). Flaked stone artifacts included choppers and cores. There were approximately 100 projectile points collected, including large stemmed, large triangular, small convex-based, and concave-based examples (Galdikas-Brindamour 1970:139).

Worked-shell artifacts recovered from LAN-246 included more than 800 shell beads, which were mostly made from olivella shells, although some were made from clam and California mussel. Worked-bone artifacts recovered included 20 bone awls and worked-bone artifacts, including the distal end of a cougar humerus with a circumferential groove around the proximal end. Faunal remains of more than 25 vertebrate species were recovered, as well as shellfish remains.

Another important site dating to the Late period is LAN-1575, thought to be the site of Ya'angna, located in downtown Los Angeles near Union Station (Goldberg 1999:1–2). Various absolute- and relative-dating methods were used to establish the site chronology. Overall, radiocarbon dating indicated that LAN-1575 was in use between A.D. 950 and 1800 (Goldberg 1999:120). Some 14 primary inhumations, 3 cremations, 2 possible cremations, and 2 clusters of scattered human remains were recovered from this site (Goldberg 1999:Table 4.1). All ages except adolescents (13–20 years of age) were represented by the burials; the sexes were found to be relatively evenly represented—4 males and 5 females (Goldberg 1999:Tables 5.5 and 5.6). Unlike some other burial areas from the Late period, only a few of the burials at LAN-1575 had associated artifacts.

A number of artifacts were recovered from nonburial contexts at LAN-1575. Ground stone artifacts included one pestle half, one ground stone fragment, a bowl-mortar fragment, and stone beads. Other lithic artifacts included a metate fragment reused as a hammerstone, red and yellow ochre, a stone pipe fragment, a flat pebble, and fire-affected rock (FAR). Worked-shell artifacts included two fragments of shell-bead detritus, one scallop pendant, five modified abalone fragments, one modified clam fragment, and a variety of shell beads made from olivella, California mussel, and abalone. Three sherds of Tizon brown ware were also recovered. Asphaltum was noted on beads, and its application was apparently used to help provide definition for the incised grooves on some of the beads.

Finally, the Encino Village site, LAN-43, is located on the floor of the San Fernando Valley at the northern base of the Santa Monica Mountains, near the boundary of the Fernandeño and Chumash territories (Mason 1986:9; Wheeler 2004:81). The site was first excavated in 1984 by Scientific Resource Surveys, Inc. (SRS), under the supervision of Nancy Whitney-Desautels and Roger D. Mason (Mason 1986:9). The Encino Village site had two distinct burial areas; one contained 21 inhumations, and the second contained approximately 13 cremations (Mason 1986:13; Wheeler 2004:81). Additionally, 11 canid inhumations, 1 canid cremation, and 1 red-tailed hawk inhumation were recovered from this site (Langenwalter 1986:63; Mason 1986:13). Based on radiocarbon dating of features and human bone, this site appeared to date primarily between the Late through Mission periods; a few radiocarbon dates were from the Millingstone and Intermediate periods. The direct radiocarbon dating of human bone dated the burials to three time periods: the late Intermediate/early Late period transition; the Protohistoric period; and the Mission period (Taylor et al. 1985).

Although detailed information regarding the artifacts recovered from the 1984 excavations at the Encino Village site are not available, Mason (1986:13) did state that excavations resulted in the collection of a large number of artifacts. These included more than 9,000 flaked stone tools, of which about 2,700 were bifaces and 900 were projectile points; approximately 300,000 pieces of lithic debitage; 700,000 pieces of bone; and more than 5,000 shell artifacts, mostly beads, as well as ground stone artifacts, bone artifacts, ceramics, shell, floral samples, and historical-period artifacts.

Late Period Occupation in the Ballona

Whereas population and site density increased in other areas of the Southern California Bight, in the Ballona, it was quite different. Rather than increasing, the number of sites occupied appears to have decreased dramatically compared to the previous Intermediate period. Three sites in the Ballona—all along the edge of the Ballona wetlands—have good evidence of occupation during the Late period: LAN-47, LAN-62, and LAN-211. The two sites on the south side of the wetlands—LAN-62 and LAN-211—appear to have functioned as a single community stretching along the base of the bluffs for approximately 1.5 km. In addition, as discussed below, two additional sites—LAN-61 and LAN-63, both located on the adjacent bluff tops—appeared to have some evidence of Late period use.

LAN-47 was investigated in the late 1980s by SRI (Altschul et al. 1992). Although only a small fraction of the site was investigated, the information return was high. The site was found to have been occupied for a relatively short period of time, between approximately A.D. 1050 and 1150. By the time the site was occupied, the Ballona wetlands were in their final stages of sedimentation, and an estuarine lagoon environment prevailed. The prehistoric inhabitants of the site subsisted on plants and animals found in the marsh, particularly shellfish, waterfowl, fish, small mammals, and various seeds and berries. Surprisingly, little evidence of pelagic exploitation was found. In addition, there was also a lack of evidence for permanent occupation of the site. It appeared that LAN-47 represented a series of temporary camps established along the northern edge of the Ballona wetlands at various times throughout the year when resources were available. Four flaked stone technologies were identified at the site, ranging from finely controlled bifacial and microlith industries to the manufacture of expedient flake tools. The variation in lithic technology was mirrored in the range of lithic raw materials used. Although there were bone tips identified in the collection, there was little evidence of technology related to the manufacture of other goods, including fishhooks and shell beads.

Late period occupation of LAN-62 and LAN-211, both located across the Ballona wetlands from LAN-47, is evident but has been disturbed in many places by subsequent occupation. That said, one of the most important events in the Ballona area during prehistory occurred at LAN-62 during the Late period: the apparent establishment of a formal burial area. During previous periods of occupation at the site, deceased members of the community were interred in the site midden in an unorganized fashion. During the Late period, it appeared that people began to be buried in a centralized portion of the site, within what is now known as Locus A. During the subsequent Protohistoric and early Historical periods, people continued to be buried more and more densely in this small, restricted and confined space. Although there did not appear to be a large number of burials in this area dating to the Late period, they were present and appeared to be the founding burials for this important three-dimensional burial space at LAN-62.

LAN-61 and LAN-63—which overlook LAN-47, LAN-62, and LAN-211 from the bluff tops—also appear to have been used during the Late period. Van Horn (1987a) and Van Horn and Murray (1985) focused their work on the Intermediate period components of these sites and downplayed occupation during subsequent periods. Analyses by Hull and Douglass (2005) at LAN-63 and by Douglass et al. (2005) at LAN-61 suggest that there was Late period use of these sites, based on the presence of triangular and tear-shaped (or Canaliño) Cottonwood arrow-point types. Although Van Horn (1987a) and Van Horn and Murray (1985) have argued that use of these arrow-point types ended around A.D. 1000, SRI's work at LAN-62 and LAN-211 suggests that they were used from the late Intermediate period (ca. A.D. 500) through the early nineteenth century. Therefore, although there are no Late period radiocarbon dates from these sites, these arrow-point types suggest that the sites were used during the Late, Protohistoric, and/or Mission periods.

Wigand's (2005) climatic reconstruction provided a clue as to why settlement changed so drastically between 2000 and 1000 cal B.P. He suggested that there was a return to drier conditions by 1000 cal B.P., with less annual precipitation and cyclical episodes of wet climate alternating with extreme drought. The Los Angeles River may also have shifted its course away from the Ballona. These drier, less predictable conditions would have severely impacted vernal pools and reduced associated freshwater and terrestrial resources but would have left salt marshes relatively unaffected. With reduced freshwater inputs, salt marshes may have even expanded during this period. Deteriorating terrestrial conditions may be one of the reasons for the shift from dispersed villages at the ecotone between the Ballona Wetlands and the coastal prairie to aggregated settlement at the lagoon edge. As the coastal prairie dried up, people may have shifted to the more reliable salt-marsh resources.

Preliminary findings from recent excavations at Late period lagoon-edge sites partially support this scenario (Reddy 2009). There is evidence for increased use of salt-marsh plants and, perhaps more important, shellfish, such as Pismo clam from sandy-beach habitats and abalone from more distant, rocky-shore habitats as the lagoon continued to fill with silt. Fishing, especially for bony fish from sandy-beach and offshore habitats, also experienced resurgence. It is possible that this resurgence in fishing may have been related to the use of the *tomol*, or plank canoe, although no direct evidence of the use of the *tomol* in the Ballona has been found. It was not until the Protohistoric or early Historical period that the residents of the Ballona appeared to experience the demographic, social, and economic changes that characterized other areas of the southern California coast during the Late period.

Protohistoric and Early Historical Periods

The line between the Late and Protohistoric periods is admittedly arbitrary. The Protohistoric period in the Los Angeles Basin begins with the initial European contact in A.D. 1542 and ends with the establishment of the Mission San Gabriel in 1771, after which direct and recurrent contact between the Gabrielino/Tongva and Spanish settlers in the Los Angeles Basin was established (King 1978:46). The early Historical period (also known as the Mission period) runs from 1771 until the beginning of the era of secularization in 1834.

The Protohistoric period is possibly the least-well-documented period in the southern California occupational sequence. A distinct time bias against remains from this period is evident in the work of some early archaeologists, such as Edwin Walker, who excavated in pursuit of Early Man and disregarded later components. Walker summarized the Protohistoric and early Historical period evidence he found at Malaga Cove in a single sentence: "Level 4 reached the historic stage as shown by the presence, at its very top, of a few small glass trade beads of the type introduced by Spaniards at the beginning of the nineteenth century" (Walker 1952:68). In addition, if sites were multicomponent and were occupied during the Protohistoric period, as well as either the Late or Mission periods, it is possible that the Protohistoric period component may be difficult to identify and distinguish from components of other time periods.

There are, however, a few well-known examples of sites from this period. The ARCO site, LAN-2682, is located at the ARCO refinery in Carson, adjacent to the Wilmington–San Pedro wetlands. This site was first discovered in September 1998 during replacement of underground utilities at the refinery. Prior to the identification of human remains by construction workers, approximately 300 cubic yards of soil had been removed and stockpiled at another area of the refinery. At that point, archaeologists were contracted to excavate any human remains (Bonner 2000:154).

Despite natural historical-period and modern disturbances to the ARCO site, two distinct components were identified. An upper component, generally 80 cm thick, contained the remains of at least 10 adult males, 4 adult females, 1 infant, 1 subadult, and 4 adults of indeterminate age and appeared to date to the Protohistoric through Mission periods (ca. A.D. 1680–1810). The lower component was separated from the upper by approximately 20 cm and was approximately 55 cm thick. It apparently dated to the Late period (ca. A.D. 1420–1620) and contained at least 5 adult males, 1 child, and 1 adult of undetermined sex. In addition to 27 burials identified in situ, over 32,000 human-bone fragments were recovered from the mechanically excavated soils removed prior to archaeological involvement. Hundreds of loose adult teeth were found in that soil, as well as a representative sample of other elements of the human body. W. Bonner (2000:157) made clear that at least some of the intact burials were represented in the screened, mechanically excavated soils, because 16 of the burials were impacted by trenching. All of the 32,000 recovered bone fragments appeared to be associated with the upper component of the site, dating to the Mission period.

The condition of the remains was surprisingly free of disease. Bonner (2000:157) stated that teeth were generally free of caries and dental or gum disease, although ground down and extensively worn. There was some evidence of tuberculosis and of interpersonal violence. Of note regarding the burials was the presence of trauma. Two burials were identified as having their extremities severed, and a third cremated skull appeared to have been burned in place (Luhnow 2000:166). The skull was recovered with ash, charcoal, and a burned steatite bowl fragment. One of the individuals, whose hands were missing, had suffered an antemortem fracture to the mandible and was also missing the sternum (Bonner 2000:157).

Compared to other burial areas dating to the Late through Mission periods in coastal southern California, the ARCO deposit was relatively sparse in terms of artifacts (Luhnow 2000:162). Single examples of ground stone and fishing implements were recovered, and shell ornaments (including shell beads) were few. Lower-component burials contained a total of 279 artifacts, including shell beads (many covered in asphaltum), lithic debitage and formed stone tools, ochre, a glass bead, 3 complete abalone shells, and 1 bone tool (a deer-tibia wand). Luhnow (2000:163–166) argued that there were 11 artifacts that were ritualistic in nature, including a deer-tibia wand, a steatite eccentric resembling a sewing bobbin placed in an unburned basket, a large stemmed obsidian dart point, an incised soapstone block, shell beads, red ochre, and a ground *Columella*-shell ornament. Upper-component burials exhibited a different pattern from that of lower-component burials. Lower-component burials, both human remains and artifacts, were placed with care, whereas upper-component burials had fewer artifacts and were less formally placed (Luhnow 2000:166). In total, 608 artifacts were recovered from the upper component; shell beads, lithic debitage, and formed tools predominated. Very few historical-period artifacts were recovered from the upper component: 2 leather disks and 13 glass trade beads, some of which were recovered from trench backdirt. The glass beads were all of a drawn variety, half translucent and half opaque. Colors of the beads were blue, white opaque, and colorless. Overall, Luhnow (2000:167) argued that few items in the burial area were related to shamanism or ritual, including an incised soapstone tablet fragment, a soapstone eccentric, the deer-tibia wand, and a soapstone pipe.

The Medea Creek site, LAN-243, consisted of an inland Chumash burial area located approximately 300 m north of an associated village (L. King 1982:1, 44). This site was located in the Santa Monica Mountains, along the west bank of Medea Creek, a tributary of Malibu Creek (L. King 1982:37–38; Martz 1984:301). According to analysis by Linda King (1982:197), this burial area served the local region as well as the nearby village and was probably under the influence of the larger village at Malibu (Humaliwo) (Martz 1984:381). Linda King (1982:35) indicated that the burial area may have been founded by A.D. 1450 and used until approximately A.D. 1800.

The burial area at Medea Creek consisted of an estimated 397 primary and secondary interments clustered in an oval area 20.1 m (east-west) by 9.5 m (north-south) in dimension (King 1982:36). Clusters of burials may indicate family plots. Furthermore, King (1982:64) felt that the burial area associated with this site conformed to descriptions of historical-period burial areas on the Channel Islands. The tightly confined burials and the discrete boundaries of the burial area indicated some form of fence or enclosure. Preserved redwood in the burial area was suggestive of pole markers, and whalebone planks painted red found in some surface features might have been used as grave markers (L. King 1982:64).

Burials at Medea Creek were, in general, poorly preserved, partly because of the disturbance mentioned above, and consisted of primary interments, reburials, and cremations (Martz 1984:309). Martz indicated that 68 percent of the burial-ground population consisted of primary interments, 29 percent were reburials, and 10 percent appeared to have been "defleshed" prior to burial; at least 3 percent (or 13 burials) showed evidence of burning, 8 burials appeared to have been cremated and redeposited, and 3 burials exhibited evidence of trauma in the form of burning and mutilation (L. King 1982:147; Martz 1984:309). Most of the cremated individuals were only partially cremated (Martz 1984:375). Linda King (1982:53–54) indicated that "most reburials were found in areas of dense use and were probably originally from primary burials which had been cut through and then redeposited around and/or over a primary burial." Some reburials, however, were found on sterile sediment or in locations where there were no apparent sources of disturbance (L. King 1982:53–54). Linda King (1982:55) identified four possible mortuary behaviors involving burning: (1) cremations, (2) partial charring of articulated burials or grave pits (preinterment grave-pit burning), (3) burning of the cut-up bodies of victims of violence, and (4) generalized burning of wood, seeds, and artifacts, perhaps originally on the surface of the burial area or in the grave. Burned floral material and the occasional thermally affected artifact associated with several burials and throughout the matrix potentially indicated that ceremonial fires, both in the burial pit and on the surface, were common occurrences in this burial area (King 1982:57).

Linda King (1982:66–67) made several astute observations regarding the status of the individuals recovered from the burial ground at Medea Creek. Similar to the early Historical period burial area at Humaliwo (see below), there appeared to be marked differences in burial treatment between individuals; some burials (including children) contained significantly more burial items than others. The few artifacts of shamanistic/ceremonial importance were recovered with male individuals, whereas basket impressions in asphaltum were common in female burials (L. King 1982:70). As at Humaliwo, as well, some burials associated with higher-status grave goods were buried more deeply than others. Linda King (1982:93) observed that children tended to be more differentiated than adults and that males tended to be buried deeper than females (L. King 1982:96). At Medea Creek, then, the overall pattern suggested status differentiation based on ascribed status, according to Linda King (1982:99).

Of the more than 28,000 artifacts collected from Medea Creek, only a few were Hispanic in origin. Artifacts were recovered with 60 percent of the burial-ground population (Martz 1984:323). Fewer than 500 historical-period glass beads were recovered; 80 percent of the beads were associated with only 2 individuals, and the remainder were distributed among 15 individuals (Martz 1984:323–324). Martz suggested that the paucity of historical-period artifacts may represent only a small number of trade interactions with Hispanic people (Martz 1984:322).

Finally, the Chumash site of Humaliwo (Malibu) (LAN-264), a site occupied for thousands of years, contains an early Historical period burial area. This site, located within Malibu State Park, is within the city limits of the town of Malibu, which takes its name from the Chumash name for the site. Original work in the 1960s and 1970s (Gibson 1975; Glassow 1965), partly in coordination with the University of California, Los Angeles (UCLA), archaeological field school, identified five major areas of the site: Area 1, an early Historical period burial area; Area 2, a Late period midden deposit; Area 3, a Middle period midden deposit; Area 4, an Early and Middle period midden deposit; and Area 5 (designated as such by Gamble et al. [1996]), a Middle period burial area with a possible midden component. The temporal dates were assigned based on radiocarbon dates, shell-bead types, other diagnostic artifacts, and obsidian-hydration dates (Gamble et al. 1996:3–4).

Although isolated burials were recovered, the vast majority of burials at the site were concentrated in two areas: Area 1, the early Historical period burial area, and Area 5, the Middle period burial area. These two burial areas are spatially and temporally distinct from one another. Area 5 contained 114 burials and was not completely excavated. The early Historical period burial area was excavated in 1972 and contained 137 burials and 59 nonburial features. Excavators reported that the entire burial area was examined and all burials excavated. Although these burials were poorly preserved, in-field osteological analysis was conducted. In addition, Phillip Walker and several of his students analyzed the remains in a laboratory setting in the mid-1990s. Based on historical-period artifacts as well as shell beads, it appeared that this burial area was used for a very short period of time, between A.D. 1785 and 1805 (Gamble et al. 1996; King 1996).

The health of the early Historical period burial population was mixed. Walker et al. (1996) noted that the population's long bones were large compared to the Middle period population's, perhaps suggesting unfavorable living conditions. Differences in habitual activity patterns, Walker et al. (1996:35–36) argued, may have led to alterations in the size and shape of long bones. Although certain pathologies, such as venereal disease, may cause such differences, this was thought not to be the cause. Overall, body size during the historical period appears to have reduced, based on the concordance between temporal differences in long-bone dimensions and tooth size. Walker et al. (1996:37) suggested that this was also due to unfavorable environmental stress on the early Historical period population at Humaliwo. Poor nutrition, for example, can stunt growth. The presence of inflammatory lesions in the early Historical period collection argues for syphilis and other venereal diseases in the population, introduced by the Spanish. Compared to the Middle period burial population at Humaliwo, however, the early Historical period population had less overall evidence of strenuous physical activity and traumatic injury. Cranial fractures were nearly absent from the more recent population.

Analyses of historic documents and the collection from the early Historical period burial area suggested that there was interaction among the native inhabitants of the site, both ranches in the area, and the Mission San Fernando Rey. Gamble (2008:108) stated that 118 inhabitants of Humaliwo were baptized at Mission San Fernando Rey, the second-largest number of neophytes recruited in the area, second only to Muwu. As discussed in Chapter 5 of this volume, the chief of Humaliwo was documented in Mission records as originally from Catalina Island, within Gabrielino/Tongva territory. King (1994) argued that this area of Santa Monica Bay, near the historical-period Gabrielino/Tongva and Chumash ethnic boundary, was politically consolidated and ruled by Humaliwo.

The early Historical period burial area at Humaliwo offers an important opportunity to understand sociopolitical organization. Gamble (2008; see also Gamble et al. 1996, 2001) argued that the archaeological data from Humaliwo reflects the ethnographic and ethnohistoric accounts of Chumash sociopological organization and a disparity of wealth between elites and commoners (Gamble 2008:202). Glass beads, shell beads, and other historical-period artifacts were disproportionately distributed in the burial area. Whereas nearly half of the burial-area population had fewer than 20 shell beads associated with each, roughly 10 percent had more than 1,000 shell beads each. These burials, varied in individual age and sex, were concentrated in one particular portion of the burial area, suggesting that highly ranked, ascribed-status individuals were clustered together. In addition, these burials with more highly ranked shell beads were placed deeper in the ground than other burials, which is likely a reflection of the ability of family members to pay grave diggers more. Some of these presumed-high-status burials also contained redwood planks, associated with the *tomol*, or plank canoe, which some have argued was associated with high-status individuals (Arnold 2004; Gamble et al. 2001).

In addition to status, Gamble (2008; Gamble et al. 1996, 2001) argued that historical-period artifacts in the early Historical period burial area suggested that some inhabitants of Humaliwo were working as cattlemen at nearby ranchos. For example, a number of burials contained spurs, saddle adornments, bridle or pants adornments, and other rancho-related items. Additional items reflected the possible status of some in the burial ground as neophytes, such as a St. Francis de Sales medal. Finally, several Hispanic-originated weapons, including portions of a sword, knives, and a pistol, were discovered in the burial area. Interestingly, the pistol was partially covered in asphaltum and was used as a sort of receptacle (Bickford 1982), illustrating the novel indigenous uses of Hispanic goods during the Mission period (see Chapter 5 of this volume). Gamble (2008:206) suggested that the large number of glass beads in the burial area may have originated from interactions between residents of Humaliwo and residents of nearby ranchos; Native Americans were routinely paid for their services with glass beads. It is also possible that glass beads were accessible to the residents of Humaliwo via the Pueblo of Los Angeles and the Mission San Fernando Rey.

Protohistoric and Early Historical Period Occupation in the Ballona

In 2003, when Test Excavation Report 4 of the Playa Vista Monograph Series, *At the Base of the Bluff* (Altschul et al. 2003), was published, there appeared to be little evidence from the Protohistoric and early Historical periods in the Ballona. A few glass beads had been recovered from LAN-61 (Van Horn and Murray 1985), LAN-63 (Van Horn 1987a), and LAN-211 (Altschul et al. 2003). In addition, glass beads had been identified at two redeposited runway sites, LAN-1932 and LAN-2676 (Altschul et al. 2003); these materials likely originated at LAN-211 and LAN-62, respectively.

Subsequent data recovery at LAN-62 and LAN-211, below the bluffs, as well as reevaluation of the materials from LAN-61 and LAN-63, on top of the bluffs, now offer strong evidence of Protohistoric and early Historical period occupations in the Ballona (see Figure 11). As discussed in detail in Volume 2 of this series, the most telling evidence is a burial area dating from some time between the Late and Mission periods discovered at LAN-62 during data recovery efforts in 2003 and 2004 (Vargas et al. 2005). As discussed for the Late period occupation of the Ballona earlier in this chapter, this burial area was established during the Late period and continued to be used through the early nineteenth century. Although hundreds of burials were present, only a portion of them could be dated to any specific time period. Of those that could be dated, the majority appeared to date to the Mission period, because they were buried with diagnostic artifacts, such as glass and/or shell beads and other historical-period items. The Mission-period burial area itself is tightly confined three-dimensionally and was marked by whalebone. As discussed in Stoll et al. (2003) (see also Stoll et al. 2009), a Mission period *ranchería* called Guaspet or Guasna was likely located somewhere in the Ballona area and may have been connected to the burial area at LAN-62. The tightly bounded space used for the burial area and the general patterns of grave goods are similar to those found at LAN-264, the Chumash site of Malibu/Humaliwo (Gamble et al. 2001; Gamble and Russell 2002) and Medea Creek (Martz 1984) (see Volumes 2–5 of this series for details). There has been speculation in the past that there may have been a Mission period village in the Ballona called Sa'angna, but recent research suggests that Sa'angna was likely a regional or place name rather than a village (see Stoll et al. [2003:19–26] for details).

Data recovery at LAN-211 in 2005 (Van Galder et al. 2006) (see Volume 2 of this series) revealed a multicomponent site dating from some time between the Intermediate and Mission periods (and possibly earlier—the base of the deposit was not exposed) with strong Protohistoric and Mission period occupations, based on the excavation of Feature Block 1. Although the nature of the deposit is still debated, it is clear that this feature block contained nearly a dozen features (including pits, hearths, and rock clusters) and an extremely dense lithic and faunal collection, many times more dense than what was found at other sites within the PVAHP. This deposit contained numerous projectile points (primarily various types of Cottonwood varieties) and the entire range of lithic production and usage. The deposit revealed that subsistence by the occupants of this area during the Mission period included a mixture of native foods as well as nonlocal resources (domesticated cow and sheep/goat, domesticated barley, wheat, and corn) (Reddy 2009) (see Volume 3 of this series for details).

In addition, there are some data that suggest use of blufftop sites during the Protohistoric and early Historical periods. The best evidence, though scant, is from LAN-61 (Van Horn and Murray 1985). In their report, Van Horn and Murray (1985) argued that there was little evidence of a Mission period occupation at the site beyond the presence of 10 glass trade beads. However, recent reinterpretation of their report by SRI (Douglass et al. 2005) has identified a number of lines of evidence that may further strengthen the argument for a Mission period presence at the site. Several features at LAN-61 contained *comales* (flat steatite vessels used for cooking), which are diagnostic to the Mission period (Lynn Gamble, personal communication 2009; Hudson and Blackburn 1981:196–197). The presence of *comales* in feature contexts, rather than simply in the midden, is clear evidence that they were used on-site in domestic activities. In addition, the presence of both Cottonwood and Canaliño projectile points indicates the possibility of use of the site through the Mission period. Van Horn and Murray (1985) argued that these points were not used after 1000 A.D., but their abundance in Mission period contexts at LAN-62 and LAN-211 puts this argument in doubt. The same is true for LAN-63, where Freeman and Van Horn (1987) identified a cluster of Canaliño, Marymount, and Cottonwood projectile points in the central-northern section of the site (Hull and Douglass 2005). Although these projectile points generally date to the Late period, they were used through the Mission period and may be indicative of use during that period. Several glass trade beads dating to the Mission period were also discovered by Van Horn at LAN-63. Overall, the evidence clearly indicates intensive occupation of at least two sites below the bluffs and more limited use of sites on top of the bluffs (it is important to add that LAN-61 is located directly above the burial area at LAN-62) during the Protohistoric and early Historical periods.

The broad sequence of events for the Historical period (A.D. 1771–1941) in the Ballona has become well established in published sources. (We use the term "Hispanic" in this section to refer to the Spanish-born missionaries, the ethnically mixed soldiers and immigrants who came from what is now Mexico to settle in the pueblo, and the European-influenced culture introduced by these eighteenth-century arrivals to southern California.)

The founding of Mission San Gabriel in A.D. 1771 ushered in a wave of European immigration and social change that overwhelmed the long-established territories of the indigenous people in the Los Angeles Basin. Shortly thereafter, the indigenous people reached a point of no return in sustaining their traditional lifeways. The Spanish government supported the establishment of missions in Alta California as the preliminary step toward the subjugation and ultimate colonization of the land and its indigenous inhabitants. The Gabrielino/Tongva were welcoming at first, then resistant, but neither stance changed the eventual outcome. The success of the padres is reflected in the more than 7,000 baptisms recorded at the Mission San Gabriel between 1771 and 1820. The mission fathers worked tirelessly to both entice and compel all Native Americans to relocate onto mission lands in San Gabriel, where they were baptized and put to work as field hands and domestic workers.

With the rise of the Hispanic mission and rancho systems, many Gabrielino/Tongva people abandoned their camps and village sites. Disease and cultural upheaval forced the native population into steep decline, and the survivors merged with other displaced populations. Between 1781 and 1831, the mean death rate was 95 per 1,000 individuals, compared to a mean birth rate of 44 per 1,000 in prehistoric times (McCawley 1996). Mean life expectancy at birth was only 6.4 years (McCawley 1996:197). Hugo Reid, a Scotsman married to a Gabrielino/Tongva woman, wrote in 1852 that the result of this period of turmoil was a massive migration of the remaining Gabrielino/Tongva away from their traditional homeland, many resettling as far north as Monterey (Reid 1968). Many written sources have suggested that, except for the well-known pockets of aboriginal settlement around a few large ranchos and the expanding pueblo, the Los Angeles Basin was essentially empty of native peoples by the late 1850s, although this supposition is likely overstated.

As native Californian lifeways became increasingly ephemeral, the future became the domain of Hispanic settlers newly arrived from Mexico. A scant 10 years after the founding of the Mission San Gabriel, the settlement named Pueblo de Nuestra Señora la Reina de Los Angeles was founded on the plain near the Los Angeles River. Eleven families arrived in 1781 from Sonora and Sinaloa to begin the community. Sixteen years later, José Manuel Machado, a soldier-guard stationed at Santa Barbara and patriarch of the Machado family, moved his large family to the burgeoning pueblo. They were followed shortly thereafter by the Talamantes family. Over the course of the next century, the Talamantes and Machado families and their descendents became important landowners in the Ballona.

Rancho Los Quintos and the *Ranchería* of Guaspet

Mission period records suggested that the Ballona area was occupied by the Gabrielino/Tongva in at least one village (*ranchería*) called Guaspet or Guasna. A total of 92 Gabrielino/Tongva from the village of Guaspet were recruited to the Missions San Gabriel and San Fernando Rey between the years 1788 and 1815 (Stoll et al. 2009; see also Volume 5 of this series) (Figure 12). Newly identified archival documents revealed that there was a significant Spanish occupation in the Ballona, as well. In 1787, there were reports of the butchering by Native Americans of cattle that were grazing in the vicinity of the Ballona (Mason 2004). In just a few years after the establishment of the Pueblo of Los Angeles, the need for grazing land for the pueblo's growing herds of livestock became acute. Soon, the Ballona was being used as a communal grazing area for the pueblo's herders. Sometime around 1804, the land was granted to the family of Pío Quinto Zuñiga, an ex-soldier, and his wife, Rufina, a Juaneño neophyte from San Juan Capistrano (Mason 2004; Stoll et al. 2009; see also Volume 5 of this series). Members of the pueblo contested the granting of what was called the Rancho Los Quintos to the Quinto Zuñiga family. Although it is unclear how long the Quinto Zuñiga family held the land claim to the Ballona, it is clear that they interacted with the Gabrielino/Tongva residents at Guaspet, which was likely contained within their land grant. Members of the Quinto Zuñiga family were officiates or godparents at several baptisms of neophytes from Guaspet between 1803

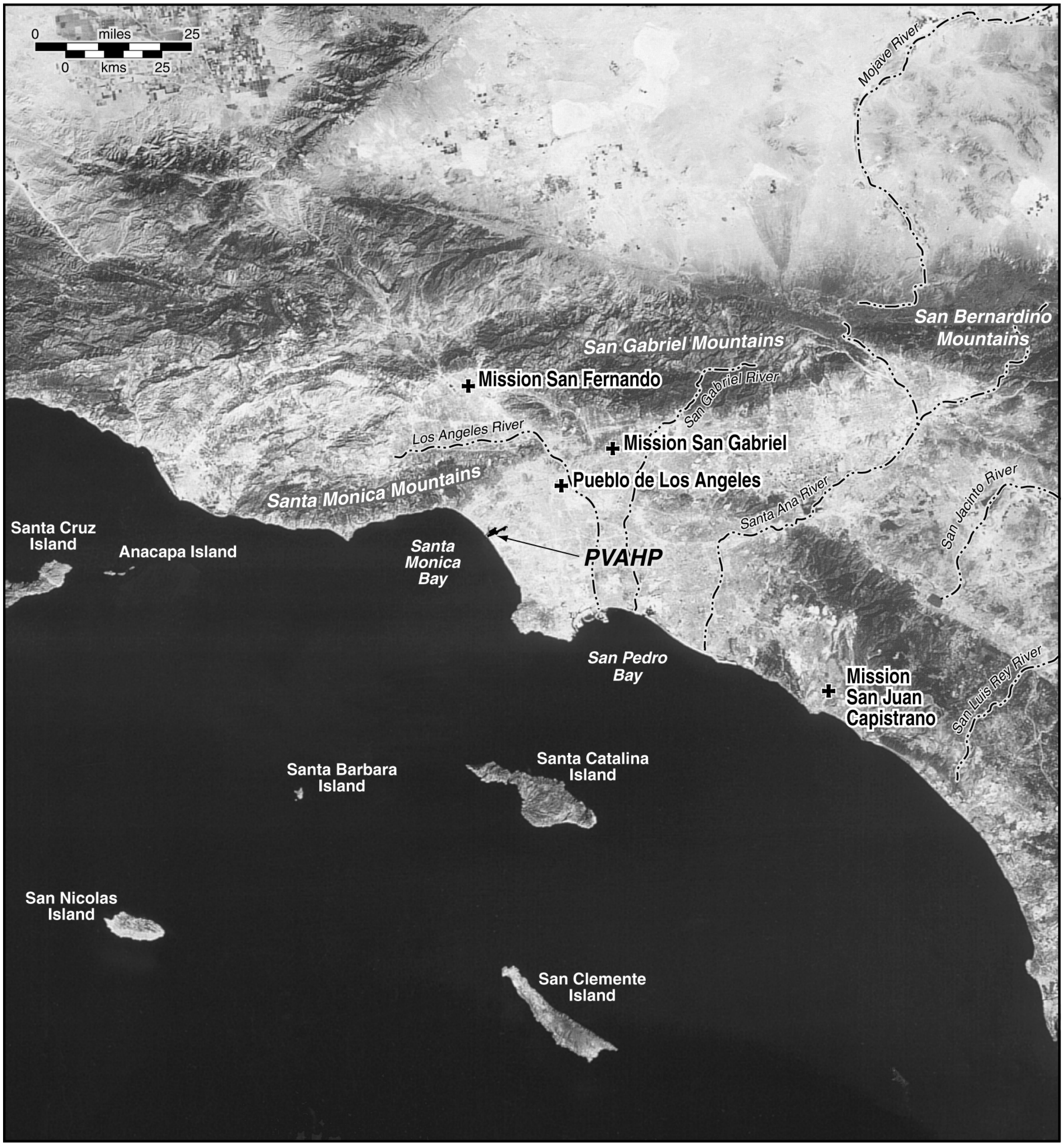

Figure 12. Satellite photograph of a portion of the Southern California Bight, with locations of project area land features, the Pueblo, and Missions.

and 1809 (Stoll et al. 2009). In both 1799 and 1801, Pío Quinto Zuñiga was listed in pueblo records as a producer of cattle and wheat (Mason 2004). It is possible that the domesticated plants and animals found in the midden at LAN-211 may have been obtained from Rancho Los Quintos. Pío Quinto Zuñiga died in 1805, and it appears that by 1808 or 1809, the Quinto Zuñiga family left the Ballona (Mason 2004; Stoll et al. 2009). The Mission San Gabriel continued to recruit members from the *ranchería* of Guaspet until approximately 1815.

Historical Period

Although Native American and Hispanic occupation of the Ballona during the early Historical period has been documented, subsequent use of the Ballona by Native Americans after the mid-1810s is less clear. There is no evidence of recruitment to the Missions San Gabriel and San Fernando Rey from the *ranchería* of Guaspet after 1819. Beginning in 1819, the next wave of Hispanic people in the area referred to it as Rancho la Ballona.

Rancho la Ballona

The next Hispanic inhabitants of the Ballona were the Machado and Talamantes families. They considered the land in the Ballona to be attractive, in part because its distance from San Gabriel had kept it outside the mission's land claims. Beginning about 1819, with Alcalde Joaquin Higuera's blessing and a permit from the military commander, José de la Guerra y Noriega, the Machado and Talamantes brothers moved their stock to the area now known as Culver City. In their petition of September 19, 1839, for the grazing land that became the Rancho La Ballona (Marie 1955:52), the men stated that "we occupied, with our grazing stock, houses and other interests, the place called 'Paso de las Carretas' but more generally known by the name of 'the Ballona.'" Paso de las Carretas (or Wagon Pass) may refer to the low place between the sand hills known as the Ballona Gap. Robinson (1939a:105) showed the road running through Wagon Pass as following the path of today's Washington Boulevard. The common interpretation is that "the *paso* fronted on the sea astride the rancho's northern boundary" (Rolle 1952:147). The term "Ballona" might have been derived from *ballena*—Spanish for "whale." Although whales are not mentioned in the historical record, killer-whale bone has been found in Ballona area archaeological sites, such as at LAN-63 (Colby 1987). Alternatively, "Ballona" may have derived from Bayona, the Spanish birthplace of the Talamantes family.

The statement in the grant petition referring to the Machado and Talamantes occupation of the Ballona has led researchers to assume that because the ranchers were grazing cattle there, the Machado and Talamantes families must have lived in the Ballona in 1819. In these early years, however, only one of the four ranchers, Agustín Machado, actually lived on the rancho, and he was, at most, a part-time resident. Documentary sources stated that Agustín raised his family at his principal residence in the Pueblo of Los Angeles, not in the Ballona. The first adobe that he ordered to be built on the Rancho La Ballona was constructed in about 1821, just northeast of present-day Overland Avenue; it was washed away in a flood about a year after its completion. The second adobe, built later in the 1820s, was located near what is now the intersection of Overland Avenue and Jefferson Boulevard (Wittenburg 1973:19). Its location, entirely outside the PVAHP area, is generally considered the core of the Rancho La Ballona community.

From 1819 through 1839, the Machado and Talamantes families made use of their rancho in the Ballona, stocking it with "large cattle and horses and small cattle" and improving it with "vineyards and houses and sowing grounds" (Robinson 1939a:108). Among the crops planted were grapes, corn, pumpkins, beans, and wheat (Wittenburg 1973). Rancho La Ballona became a legal entity on November 27, 1839, when its 13,920 acres were granted to Agustín and Ygnacio Machado and Felipe and Tomás Talamantes by Governor Alvarado (Cowan 1977:18) (Figure 13). The *diseño* shown in Figure 13 is one of several similar *diseños* depicting Rancho La Ballona. However, in studying the *expediente* (land-trial) folders for Rancho La Ballona (Expediente 87), a second, very different *diseño* was discovered in the California State Archives (Figure 14) and depicts what appears to be a beach, flat land containing a lake or lagoon, and hills or mountains in the background. The legend for this *diseño* was translated by Scott O'Mack as follows:

> Explanation that clarifies this simple plan:
>
> From the number 1 to the number 5, [the latter] being the lake of the [illegible] de Castilla, it is a league and a half [or] a little less. From the number 1 to the number 11, it is less than half a league. From the number 2 to the number 4, the former being the mesa of the Abilas and the latter the [illegible] Grande, it is less than a quarter of a league. From the number 3 to the number 2[?], the former being the pasture of the governor and the latter being the arroyo of the [illegible], it is half a league. The number 2 consists of the marsh, the number 11 is the beach.
>
> Note that the numbers 6 and 7 are lakes that are named of the [illegible]. The number 5, which is the [illegible] de Castilla, has, as distance from number 11, which is the beach, half a league.

It is possible that this is a *diseño* of Rancho la Ballona from a completely different angle and perspective. For example, it is possible that the "lake of the [illegible] de Castilla" refers to the Ballona wetlands, and the "mesa of the Abilas" may be the area above the Westchester bluffs (Avila had title to the Rancho Guaspita, adjacent on the south to the Rancho La Ballona, on the bluff top). In general, however, much of the description and detail does not refute or support the interpretation that this *diseño* is for Rancho la Ballona.

At the time of this grant, only Agustín Machado maintained a residence on the ranch; the Talamantes brothers had established adobes on the nearby Rincon de los Bueyes, and Ygnacio Machado had moved in 1834 to the rancho he later claimed, the Aguajé del Centinela, west of Inglewood's Centinela Springs (Robinson 1939a:109). An adobe built ca. 1833 and known today as La Casa de la Centinela represents the first *Californio* occupation of this rancho (Robinson 1939a). Located on Midfield Avenue in Westchester, it is currently the home of the Centinela Valley Historical Society. Other ranchos near the Ballona were Sausal Redondo (Antonio Ignacio Ávila, claimant), adjacent and to the south of the Ballona, and Ciénega ó Paso de la Tijera (Vicente Sanchez, claimant), 3 miles east of the project area (Cowan 1977). An adobe reputedly built about 1823 and belonging to the latter rancho was used prior to World War II as the Sunset Fields Golf Club clubhouse (Grenier 1978; Parks 1928). The adobe still stands at 3725 Don Felipe Drive, Los Angeles, but has been extensively modified. Since 1973, the adobe has been occupied by the Consolidated Realty Board of Southern California, Inc.

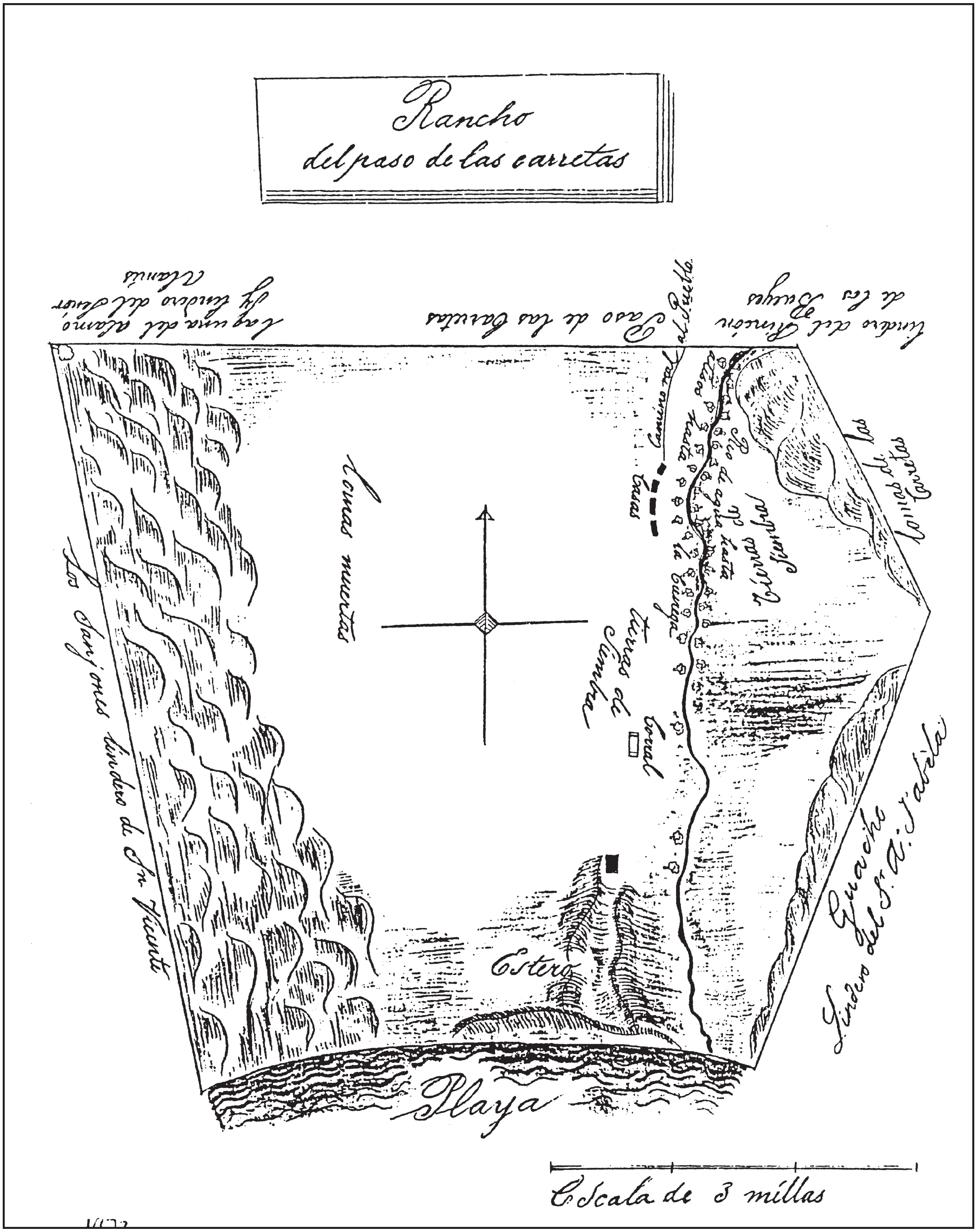

Figure 13. The 1839 diseño for Rancho La Ballona (courtesy of the California State Archives, Sacramento).

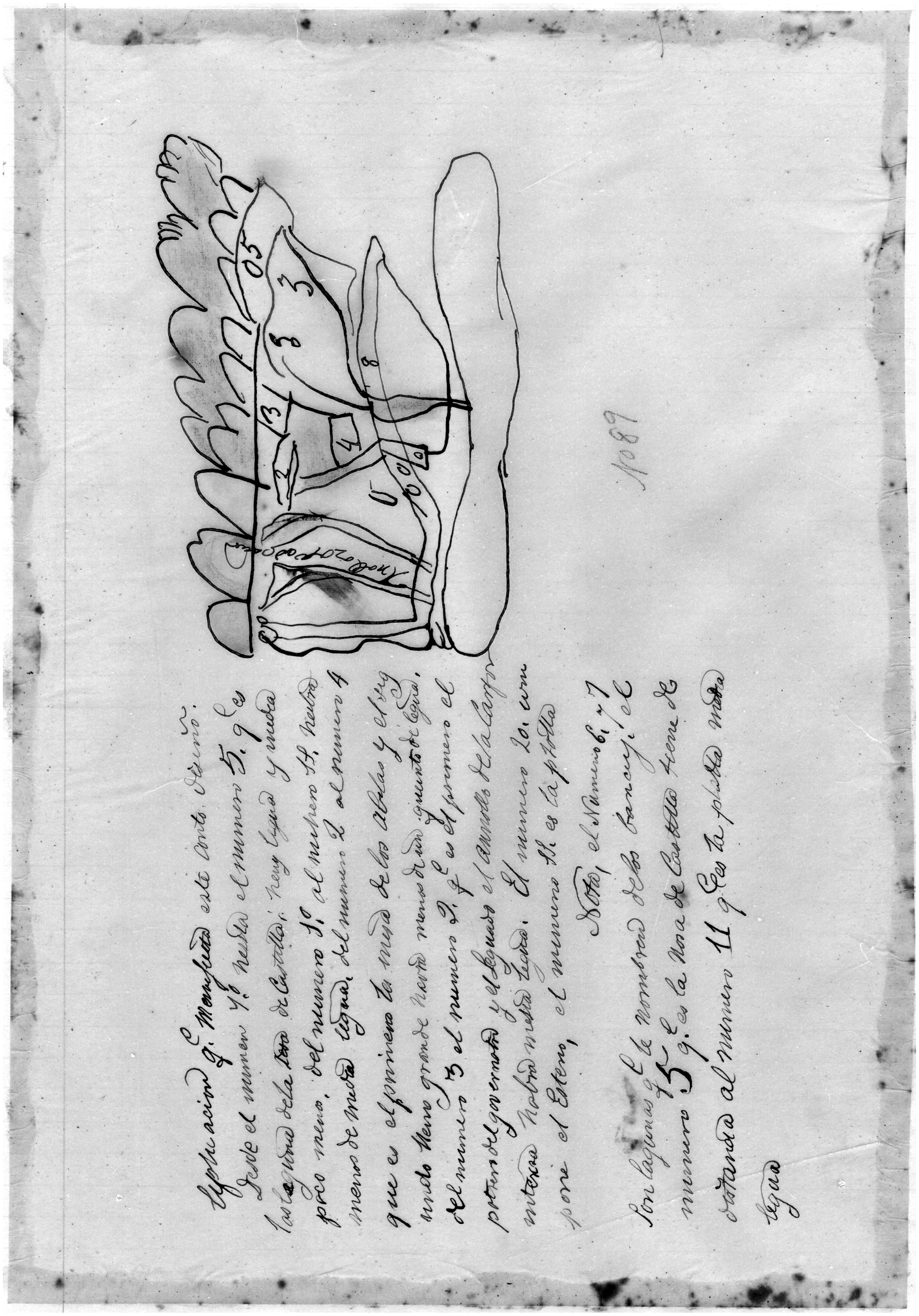

Figure 14. A second possible diseño for Rancho La Ballona (courtesy the California State Archives, Sacramento, file Expediente 87-2).

The identity of the workforce on these Los Angeles ranchos, and particularly on the Rancho La Ballona, is of special interest. The historical record clearly indicates that the Machados and Talamanteses hired workers for the Rancho La Ballona and likely gave positions of authority to relatives or hired retainers. Cristobal Machado, interviewed by Robinson in the 1930s, recalled that “the work of the ranch was done by the local Indians, one group of whom had their huts among the sycamores not far from Agustín’s home, while another group had their village against the hills beneath the present-day Loyola University” (Robinson 1939a:108–109). The latter location would place the settlement not only within the project area but possibly at the site of LAN-211. The 1839 *diseño* of the Rancho La Ballona does not show the locations of these dwellings at the base of the bluff, although other residential structures are shown. Surveyor George Hansen, however, surveyed the base of the bluffs in 1875 and did identify the locations of several structures, including the “brushhouse” of Jose Armiendo (possibly Armiendz), near the northern end of LAN-2768; a residential structure for Luis Valenzuela; and a corral for livestock. The 1875 survey thus documents that at least two, and possibly three, residential structures existed at the base of the bluff prior to 1828. It is unclear, however, who Jose Armiendo and Luis Valenzuela were. Were they Gabrielino/Tongva or Luiseño ranch hands? Were they Hispanic *vaqueros* working for the Machados?

At the conclusion of the U.S.-Mexico War in 1848, Alta California was ceded to the United States, and in October 1852, the Hispanic families owning Rancho La Ballona filed their claims with the U.S. Land Commission for the confirmation of their grant. In 1854, the board upheld the Rancho La Ballona grant, and the U.S. District Court upheld the decision on appeal (Robinson 1939b).

The Talamantes family members did not retain their landholdings in the Ballona long after the 1850s, however. The insolvency of Tomás Talamantes in 1855 and the death of Felipe in 1856 necessitated the division of their shares of the rancho and the dissolution of the Talamantes/Machado partnership. During that same period, Agustín Machado prospered. In addition to owning a large tract of land in the Pueblo of Los Angeles near his town home (Wittenberg 1973:21), Machado increased his landholdings in what is now Riverside County by buying up two large cattle ranches, building adobes, and establishing family members in them. In the summer of 1855, he purchased 3 leagues of the Rancho Santa Rosa on what is today known as the Santa Rosa Plateau and built an adobe there, which is still standing (Nature Conservancy 2002). In 1858, Machado purchased La Laguna Rancho from Abel Stearns, a 13,339-acre property that included Lake Elsinore. At least one of the adobes Machado built on this rancho became a Butterfield Overland Stage Company stop (Gould 1936:46). The ranch operations were managed by his eldest son, Juan Bautista Machado; other family members also participated (Fred Machado, personal communication 2002).

By the time Agustín Machado died in 1865, he had become one of the wealthiest men in Los Angeles. His estate covered thousands of acres and included livestock, orchards, and numerous adobe dwellings. He also controlled a large number of Native American workers on his ranchos. Occasionally, these were mentioned in contemporary documentation; a report from 1861 mentioned native laborers living near La Laguna and “the excellent camp ground near the Machado adobe” (Gould 1936:47). Native workers were described at La Laguna in some detail by Charles Nordhoff in 1873 (Nordhoff 1973:150). At the time of his visit to La Laguna with “Señor M” (Machado), the native residents of the rancho lived in “open shanties” within a few feet of the adobe. The Lake Elsinore and Santa Rosa Plateau areas fall within the traditional territory of the Luiseño, and the Machado family clearly lived in close association with Luiseño people. Recent research in the U.S. Federal Population Census revealed a possible connection between the Machado’s Luiseño ranch workers and Rancho La Ballona (National Archives, Laguna Niguel, California, 1900 Census, T623, Roll 90). In 1900, an Indian Population Census of the “Ballona township” counted a total of three individuals, all of whom were born in Luiseño territory (two in Temecula and one at San Luis Rey). These three were employed in the Ballona township, spoke no English, and could have been brought to the Ballona by the Machados to work on one of their large farms or dairies. It is interesting to note that no Gabrielino/Tongva individuals remained in the Ballona at that time, according to census data.

After the death of Agustín Machado in 1865, property boundaries had yet to be settled (Rolle 1952:154). Numerous heirs were granted small parcels, most of which were sold within a decade. To resolve a dispute over the boundary between Rancho La Ballona and Rancho San Vicente y Santa Monica on the northwest, Machado’s heirs took the matter to court. Fortunately for historical researchers, the resolution of the legal disputes required the heirs to hire professional land surveyors to map the rancho boundaries. The original maps and notes created by Henry Hancock and George Hansen during their surveys and resurveys of Rancho La Ballona have been preserved and are available for study.

The surveyors’ 1868 map of Rancho La Ballona (Huntington Library, San Marino, California, Solano-Reeves Collection, Folder 12) contains useful information about land use at that time, including several structures (see below). The surveyors’ notes indicate that a total of 13,919.46 acres of the rancho was divided among the heirs of Agustín Machado. Eight were named specifically, and each received an allotment. A separate portion, titled simply “allotment of the heirs of Agustín Machado,” consisted of 4,224.16 acres located at the base of the bluff. This portion of the rancho covers most of the PVAHP area, including the site of LAN-211. The surveyors’ notes on that map describe a division of the heirs’ allotment into four types or classes, with total acreage for each class. First- and second-class lands, comprising 446.70 acres and 479.80 acres, respectively, were deemed “irrigable” and adequate for agriculture. The largest portion of the heirs’ allotment, 2,654.04 acres, was designated third-class “pasture land" and included part of the PVAHP area; "land in the bay," the fourth-class land, covered 643.62 acres of the heirs' allotment. At the time of that survey, a large, standing body of water occupied the westernmost portion of the rancho—hence the designation, "land in the bay." The final patent to the Rancho La Ballona, with the partitions as decreed by the U.S. District Court and laid out by George Hansen in 1868, was issued on December 8, 1873. Title to the rancho was confirmed to the heirs of Agustín Machado, long after the death of the four original grantees. A further subdivision of the rancho was accomplished in 1875, after many lawsuits, and the estate of Agustín Machado received the largest allotment (Altschul et al. 1991).

The first settlement on the Rancho La Ballona was represented on the 1868 map by two small structures south of Ballona Creek and well to the east of the PVAHP area, on land allotted to Andrés, José Antonio, Rafael, and Cristobal Machado. This small beginning near Ballona Creek slowly evolved into the community of "Machado," which, by 1880, was occupied by families of cattle herders, sheepherders, and dairy farmers. The Machado brothers operated a dairy of some 200 cows and produced about 150 pounds of cheese per day on the Rancho La Ballona (Wilson 1959:136). As previously pointed out (Altschul et al. 1991), it is likely that Machado had no distinct community center but, rather, encompassed a scattering of residences along both sides of Ballona Creek beginning about 1 1/2 miles northeast of the project area. The location of Machado on later maps shifted with the arrival of the California Central Railroad in 1887, which used the name for one of its rail-line stops (Adler 1969).

Previous Research

John G. Douglass, Richard Ciolek-Torello, Sarah Van Galder, and Donn R. Grenda

History of Archaeological Research in the Ballona

In the previous chapter, we presented the culture history and chronology of the Southern California Bight and how the Ballona Lagoon and the PVAHP area fit into that cultural chronology. In this chapter, we focus specifically on the Ballona Lagoon, which includes the lower Ballona Creek area. Such a focus is important to understanding the connection between the development and decline of the lagoon and wetlands and the prehistoric settlement of the area. This chapter summarizes previous work in the Ballona Lagoon area and the history of what has been previously discovered. This history of research—by both early avocational archaeologists and professional archaeological firms, such as SRI and Archaeological Associates—provides, in turn, a context for Chapter 5 of this volume, the revised and updated research design for the PVAHP.

As discussed in Chapter 3 of this volume, several terms are used to describe the Ballona area. The upper Ballona Creek area is north and east of the project area and includes archaeological sites in the Baldwin Hills. Several of these sites were some of the first investigated in the area and were originally thought to hold "Early Man" remains, which were later discovered to be much more recent than originally thought. The lower Ballona Creek area, which is generally referred to in this volume as "the Ballona area," includes the project area. The lower Ballona Creek area has been much more extensively recorded and investigated over the decades, including extensive excavations by either SRI or Archaeological Associates, both above and below the Westchester Bluffs. Most of the sites, with a few exceptions, are located either along the edge of the bluffs or just below the bluffs, along the edge of the former Ballona Lagoon and wetlands.

Early Archaeological Investigations in the Ballona

F. M. Palmer (1906), a Redondo Beach dentist, was the first investigator to explore the numerous prehistoric sites in the region and write about his discoveries (Wallace 1984). In his "Report on Researches," published after he excavated in the Redondo Beach area, Palmer noted "a number of lesser villages that were situated at points of vantage, for about 7 miles, along the coast line of this part of the Southern California mainland" (Palmer 1906:24). From this, it appears that he might have been aware of sites in the Ballona.

Six years later, Nels Nelson (1912) conducted the first professional archaeological overview of sites in the Ballona during a brief visit to southern California. Funded by the American Museum of Natural History's Department of Anthropology, Nelson surveyed prehistoric "campsites" and "refuse heaps" from Topanga Canyon to the southern limits of San Diego Bay. Reaching the Ballona, he surveyed at the base of the Westchester Bluffs but did not go as far east as the Lincoln Gap. During his study, Nelson (1912) noted that "Site No. 4" was a refuse heap located at the mouth of a small ravine that opened north of Centinela Creek and 3 miles northeast of Port Ballona. Port Ballona was located at the inlet of Ballona Lagoon, near the modern town of Playa del Rey. Nelson's description of Site No. 4, limited as it was, appeared to correspond with the recorded location of LAN-2768, although there are a number of recorded sites along the base of the bluff in that area. Nelson did not personally observe the site; rather, he based his report on the observations of a hunter living halfway between the archaeological site and Port Ballona. Nelson reported the presence of a large accumulation of material, including human skeletal remains and assorted artifacts. Nelson's 1912 report was the first professionally published reference to archaeological sites in the Ballona.

Although interest in "Early Man" sites brought scientists to the upper Ballona in the 1920s, that decade was relatively quiet for archaeology west of the Baldwin Hills. In 1931, Arthur Woodward of the Natural History Museum of Los Angeles County directed the Van Bergen–Los Angeles County Museum Expedition to explore sites in the Los Angeles area, including the famous Malaga Cove site (LAN-138) (Wallace 1984). Work in the field was done by Richard Van Valkenburgh, an astute archaeologist who was employed by Woodward at the museum between 1930 and 1935, under the sponsorship of the State Emergency Relief Act. Van Valkenburgh also conducted ethnographic work for the museum during that time (King 1992:4). By the mid-1930s, the

Natural History Museum's collections included a number of artifacts from at least three sites in the Playa del Rey–Ballona area, including mortars, manos, shell, projectile points, and worked stone (Woodward 1932).

For many years, and continuing through the 1930s, local doctor F. H. Racer of Lomita made collections from sites along the coast (Wallace 1984:1). He mounted many of the artifacts in his collection and housed them together with items from other parts of the world in a small "museum" behind his residence. He also maintained a catalog describing the artifacts and the sites at which they were found. When Dr. Racer died in 1961, his collection passed to his daughter, who permitted only a single, 2-hour viewing of the material before putting the entire collection up for sale (Bates 1963:47). The subsequent fate of Racer's collection is unknown. An unpublished manuscript by Racer (1939) documented the sites he explored in what he called the Harbor District, which included the Ballona area. Racer glowingly described the richness of the project area and bluff-top sites in the 1930s:

> Several years ago a man from Inglewood trucking black earth for green houses uncovered a great number of whole or broken mortars, pestles, and other artifacts [likely LAN-193 or LAN 2768]. These were given to his neighbors and scattered. On the top of the hill above this find was a settlement of several acres [likely LAN-59]. Quantities of broken shells, arrow heads and knives, manos and burned stones. The owner of this field has found several mortars and others have found other artifacts. Several fragments of steatite [were found]. There are several camp grounds on top of the same bluff west of Loyola University. Several steatite vessels were found when the road department excavated a site just west of Loyola [Racer 1939:5].

The sites "just west of Loyola" have been identified as LAN-61, LAN-63 and LAN-64.

During that period, Malcolm Farmer began making notes on sites in the Ballona area. Farmer, a boy just 16 years old at the time, and his friend Eugene Robinson—who was loosely affiliated with the Southwest Museum—began a survey of sites in Playa del Rey, along the bluff tops, and in the Baldwin Hills area, along Ballona Creek, looking for evidence of Early Man (Farmer 1934). Farmer talked with landowners and surveyed on foot those areas where he expected to find cultural remains. His notes were partially copied and later incorporated into the data used by Charles Rozaire to create the first official site records for the area (Farmer 1936; Rozaire and Belous 1950). During his surveys, Farmer identified LAN-61 and LAN-1018, both located on the bluff tops. Farmer did not believe that the latter was an archaeological site but, rather, a bed of fossil shells and recorded it as such. Test excavations at LAN-1018 led to a similar conclusion (Peak and Associates, Inc., 1990), although prehistoric artifacts were identified during testing. It is unclear whether this site still exists.

Farmer collected artifacts during his 1936 survey, which he turned over to the Southwest Museum for curation. Among the items recorded from the Baldwin Hills area were pestle and metate fragments, manos, soapstone and granitic bowl fragments, cogged stones, flaked stone scrapers, smoothing stones coated with asphaltum, hammerstones, stone knives, and shell fragments. Tracings and sketches of some of these items were included with his notes. Unfortunately, collections made by others at that time were not so well documented.

In addition to Farmer's materials, the Southwest Museum houses several additional small collections of artifacts from the Ballona area. Very little information is associated with these finds, and the larger ground stone artifacts were commingled with other unlabeled artifacts in a basement storage area at the museum known as the Stone Room. At some point during the 1930s or early 1940s, Mr. F. R. Johnson conducted an excavation of "a camp in the Baldwin Hills near Playa del Rey" and collected several stone artifacts that he donated to the museum in 1944 (Collection Card 948-G-110, Southwest Museum files).

William Deane was another avid collector who amassed a large collection from the project area during the 1940s. His artifact collection was documented and photographed by Marlys Thiel (1953), who interviewed him at his Torrance home in 1953. Deane told Thiel that although the bulk of his collecting near the Hughes Aircraft plant was done in 1947, he had continued to add a few objects each year after that. He gave a rough provenience for the artifacts in his collection. Items from Site No. 6, "above Lincoln, near Loyola University," included cogged stones, metates, mortars, and pestles. The current disposition of Deane's collection is unknown.

The South Central Coastal Information Center (SCCIC) at California State University, Fullerton, lists several site numbers that may correspond with Deane's Site No. 6, including LAN-54, LAN-57, LAN-59, LAN-60, LAN-61, LAN-65, and LAN-206. In May of 1953, Deane sent Thiel a letter in which he marked the site locations on a map more precisely. The map referred to, however, was no longer in the report file, and the location of Site No. 6 is unknown; it may be related to LAN-1018 or LAN-212, in addition to the sites listed above. Information from Deane was used by Hal Eberhart at the UCLA Archaeological Information Center in the 1950s to plot several of the sites he described. For some sites in the area, including LAN-212, Deane's information provided the only locations available. Eberhart mapped LAN-212 in the northern area of the LMU campus, including parts of the Sacred Heart Chapel and the sunken gardens.

In a 1964 undergraduate paper, George Schofield described artifacts he and some associates collected in the 1960s (Schofield 1964). Although the locational information was somewhat contradictory, his collection appeared to have been taken from several sites on top of the bluffs, possibly including LAN-61, LAN-63, LAN-64, LAN-65, LAN-206, and LAN-212. Artifacts found included manos, metates, projectile points, flaked stone tools (especially scrapers), tarring pebbles, worked shell, and some steatite objects. The collection remains in private hands.

Archaeological work in this general time period was performed by UCLA at LAN-47. In 1961, Keith Johnson excavated a portion of the site and identified a midden containing four burials in formal pits, ground stone tools, flaked stone tools and debitage, faunal remains, bone tools, and other finds related to prehistoric occupation in the area. This site and its excavation history is discussed in more detail below.

Finally, in 1950, two graduate students at UCLA, Charles Rozaire and Russell Belous, visited the Ballona area to obtain information for a term paper on Ballona Creek archaeology. Rozaire and Belous formally recorded many archaeological sites in the Ballona. From the site forms they prepared as part of their projects, they showed their familiarity with work done by Malcolm Farmer and F. H. Racer, because they attempted to relocate many of their sites. Rozaire and Belous produced the first site records for many sites in the region, including LAN-59, LAN-60, LAN-61, LAN-63, LAN-64, and LAN-65.

Recent Archaeological Investigations on the Bluff Tops

Professional archaeologists returned to the Ballona area in 1979, conducting a series of quick surveys with negative results (Dillon 1982, 1982; Dillon et al. 1983; King and Singer 1983) and larger inventory and evaluation projects (Pence 1979). These were followed by projects headed by David M. Van Horn and his associates, which took place primarily in the 1980s in the areas above and below the bluff (Archaeological Associates 1988; Freeman 1991; Freeman et al. 1987; Van Horn 1984, 1987a, 1990; Van Horn and Murray 1984, 1985; Van Horn and White 1997a, 1997b, 1997a; Van Horn and White 1983).

The bluff-top sites are situated on the northern edge of the Westchester bluffs, a large mesa that, according to Wigand (2005), prehistorically included a wide variety of resources, including seasonally water-filled depressions and the coastal prairie, an expansive area containing a host of wild plants. These sites overlook the prehistoric Ballona Lagoon and wetlands, which also offered choice resources enjoyed by these sites' inhabitants.

LAN-59: The Hughes Site

The Hughes Site, or LAN-59, is located at the eastern end of the bluffs, overlooking current-day Sepulveda Boulevard (see Figure 11). It was discovered by Malcolm Farmer in 1936 and later recorded by Charles Rozaire and Russell Belous in 1950. The site was also known to private collectors in the area, who removed many artifacts over the years. In addition, the site was badly damaged by mechanical grading prior to 1950. Apparently, soils from the site were scraped up and used to fill erosional gullies nearby.

LAN-59 underwent data recovery by Archaeological Associates in 1984 under the direction of David M. Van Horn. Previous testing at the site (Murray and Van Horn 1983) indicated that the site was intact, and data recovery work was conducted ahead of construction of single-family homes within the site boundary. LAN-59, based on three radiocarbon dates, was estimated to have been occupied during the late Intermediate period (ca. A.D. 400–1000) (Van Horn 1984:47). However, three complete crescent-shaped objects were also identified during data recovery work, suggesting a much earlier (e.g., early Millingstone, ca. 5000 B.C.) component to the site. In addition, Lake Mojave and Gypsum Cave dart points also suggested a much earlier component to the site than the late Intermediate period. During data recovery work, nine features were identified, six of which were "rock features" consisting of concentrations of fragments of FAR (some of which were reused ground stone fragments) and other artifacts; the other three were a stone bowl fragment associated with faunal bone and two caches of abalone-shell bowls.

Lithics indicated a full range of production and processing activities at LAN-59. Not unexpectedly, the vast majority of the lithic finds at the site consisted of simple flakes bearing no clear signs of retouch or reuse (Van Horn 1984:15). The majority of the lithics were produced from locally available materials, although jasper, fused shale, and obsidian were recovered in small numbers. The identification of 265 tarring pebbles indicated that waterproofing baskets was an important activity by inhabitants. Nearly 80 lithic specimens were classified as projectile points, of which 14 were identified as dart tips and 23 were identified as arrowheads; the remainder were too fragmentary to classify (Van Horn 1984:22). Dart points were identified as Lake Mojave and Gypsum Cave, and arrow points were Rose Spring series, leaf-shaped Cottonwood points (also referred to as Canaliño), and Desert Side-notched; six arrow-sized points were not identifiable to type. These projectile points, along with the presence of 10 steatite *comal* fragments, suggested that LAN-59 may also have a more recent component dating to the Protohistoric or Mission period. Whereas leaf-shaped Cottonwood and Desert Side-notched points were generally used from the Late period through the Mission period, the use of *comales* was a relatively late phenomenon, likely during the Mission period.

LAN-61: The Loyola Marymount Site

LAN-61 is located on the east side of the Lincoln Gap, on the LMU property. Van Horn's testing and data recovery excavations at LAN-61 (see Figure 11) produced significant results (Van Horn and Murray 1985). Testing at the site revealed three loci and intact, thick deposits. Van Horn and his colleagues argued that the three loci appeared similar, and based on the absence of typical Late period artifacts, such as shell beads or Desert Side-notched projectile points, the site was abandoned prior to A.D. 1000. Obsidian-hydration analysis was conducted at the UCLA Obsidian Hydration Laboratory on a sample of 21 obsidian flakes obtained from these excavations. Using a 220 years/micron index derived from work in nearby Malibu, the results indicated that the obsidian was in use ca. 1429 cal B.P., or ca. A.D. 554, which was consistent with the interpretations based on the projectile point styles. The obsidian, however, was not sourced and was assumed to be from the Coso source, which may lead to issues with interpretation.

Based on these results, Van Horn recommended that data recovery be conducted at LAN-61. These excavations were begun in late 1984 by Archaeological Associates under the direction of Van Horn (Van Horn and Murray 1985) and resulted in the identification of 32 features (13 at LAN-61A, 19 at LAN-61B, and none at LAN-61C). Feature types included hearths, artifact scatters, a burial, artifact caches, earth ovens, and features of unknown use. Many of the features found were associated with subsistence and production activities at the site. Only a single burial (Feature 9 at LAN-61A) was described. In addition to formal burial features, however, there were four distinct "clusters" of human bone at LAN-61A (with a total of 191 human elements) and two distinct "clusters" of human bone at LAN-61B (with a total of 65 human elements). Although the authors suggested that there were two distinct clusters of human bone at LAN-61A, both were located in Trench B, only 0.3 m apart from one another. In both clusters, nearly all the bone consisted of unburned human-cranial fragments. It is likely that the two clusters actually represent a single burial. Unlike at LAN-61A, where almost all the human bone was unburned, at LAN-61B, nearly all human bone was burned. It is likely that the bone clusters from LAN-61B represent individual cremations, which should be considered individual features, although they were not reported as such.

The single reported burial feature, Feature 9, is of interest, in part because it is similar to a mortuary feature found at nearby LAN-63 (Feature 587) (Douglass et al. 2005; Hull et al. 2006, 2013), which dates to roughly the same period as LAN-61. Feature 9 consisted of a concentration of burned objects and a peripheral scatter of artifacts, cobbles, and human bone. The entire feature measured approximately 2.9 by 2 m. Artifacts consisted of a compact, oval pile of ground stone and cobble fragments, all exhibiting fire alteration. Fragments of some ground stone (including a metate and bowl) could be partially refitted, indicating that whole artifacts were broken and tossed into a fire. A similar feature found at LAN-63, though much larger and more diverse than Feature 9, was thought to have functioned in a manner similar to features associated with the historical-period mourning ceremony documented for the Cahuilla, Serrano, Gabrielino/Tongva, Luiseño, and other southern California tribes (see Cleland et al. 2007; Hull et al. 2006, 2013; Walker 1952).

Subsistence analyses at LAN-61 suggested that whereas fish and birds in the lagoon were sought for food, shellfish played a relatively small role in the subsistence practices of the site's occupants. This is in stark contrast to nearby LAN-63, where shellfish played a large role in the prehistoric diet. Shellfish remains were very sparse throughout LAN-61. Fish remains suggested that the site's inhabitants focused on marine life gathered from nearshore and shallow lagoon habitats. The complete absence of artifacts made from marine shell is notable. The focus on nearshore and lagoon resources and the absence of artifacts made from shell are typical of prehistoric sites in the Ballona. It appeared that more-distant habitats were exploited only in the Mission period, when large numbers of shell artifacts were also used (Van Galder et al. 2007). The abundance of ground stone and terrestrial-fauna remains suggested that plants and animals from the nearby coastal prairie contributed an important portion of the diet. Deer and rabbit were prominent in the terrestrial-faunal collection.

Everyday activities on-site, besides subsistence, included the manufacture of tar-lined baskets (based on the presence of hundreds of tarring pebbles and clumps of asphaltum) and numerous bone-point tips. Van Horn and Murray (1985) argued that based upon the lack of site structure and the undeveloped midden, LAN-61 was occupied on a short-term, intermittent basis during the fall and winter months but not year-round. Based on the results at nearby LAN-63, SRI disagrees with this interpretation. The presence of steatite bowls and *comales* found in all portions of the site suggest that trade with Catalina Island was important to the residents of the site. *Comales*, flat steatite cooking implements, likely date to the Mission period (Lynn Gamble, personal communication 2009).

Ten radiocarbon and 19 obsidian-hydration samples were collected and analyzed as part of the data recovery investigations. The corrected (but uncalibrated) radiocarbon dates for LAN-61 ranged from 580 ± 60 B.P. to 4710 ± 80 B.P., and the majority fell into the Intermediate period (ca. 3000–1000 cal B.P). The obsidian-hydration dates fell within a range of 2000–900 cal B.P., and the majority were in the 1400–1300 cal B.P. date range. Generally, the obsidian-hydration results indicated an occupation approximately 1,000 years later than was indicated by the radiocarbon dates. It is unclear whether this discrepancy was because the radiocarbon dates were not calibrated or because of an error in the hydration index used for the obsidian dates. Obviously, this is an important issue for future research at the site.

It is important to note that, whereas most of the data focused on by Van Horn and his colleagues pointed primarily to an Intermediate period occupation for LAN-61, there was some evidence of a Mission period (A.D. 1771–1832) component to the site. In total, 10 glass trade beads were recovered from three different trenches at the site (Van Horn and Murray 1985:147–148). In addition, at least one feature contained examples of *comales*, diagnostic of the Mission period. Finally, a number of Cottonwood projectile points were identified in the collection, and these generally date from a time between the Late and Mission periods.

At the end of the report by Van Horn and Murray (1985), the authors argued that their sample from the site was representative and offered important information on the prehistoric inhabitants and activities at LAN-61. They noted that it was possible that other important finds may be identified during grading of the property. Consequently, archaeological and Native American monitoring was conducted during grading of the property for the construction of dorms, but reportedly little archaeology was identified during that work.

LAN-63 and LAN-64: The Del Rey and Bluff Sites

The Bluff site, designated LAN-64, and the Del Rey site, LAN-63, both sit on the edge of bluffs, just to the west of the Lincoln Gap. Both sites are on the opposite side of the Lincoln Gap from LAN-61 (see Figure 11). The two sites should probably not be viewed as different occupations, because they were used during the same time periods by groups of people who established them as either temporary camps or logistical base camps and who lived there on a periodic basis throughout the year (Altschul 1999; Van Horn 1987a:272). The sites were first excavated by Archaeological Associates (Van Horn 1987a) in anticipation of residential development on the property and later underwent data recovery and intensive monitoring by SRI.

Excavations by Van Horn (1987a) revealed a large material-culture collection that included thousands of pieces of lithic debitage, and formal tools were recovered, including drills, reamers, choppers, scrapers, crescents, knives, and projectile points. The different styles of projectile points—which included Gypsum and Marymount as well as later-dating side-notched, leaf-shaped Cottonwood points (also called Canaliños) and Cottonwood Triangular arrow points—suggested a wide occupation span. In addition to these tools, excavations also recovered large numbers of ground stone tools, digging-stick weights, net weights, hammerstones, tarring pebbles, and stone anvils. The archaeological team also recognized a number of bone tools, such as awls, spatulas, gorges, compound hooks, and atlatl spurs.

The faunal remains from the sites differed somewhat from one another. The Del Rey site contained a large number of bones from fish and terrestrial animals; this was less the case at the Bluff site, even when adjusted for the volume of soil excavated. In addition to bone, a large number of shells were found—apparently, for the most part, dumped away from living and food-processing areas (DiGregorio 1987b:230). The vast majority of identified shellfish was Venus clam; there were also rather small numbers of Pacific oyster, littleneck clam, and scallop. DiGregorio (1987b:229) argued that there was a change, at some point in prehistory, in the vertical and horizontal distribution of shellfish remains along the bluff top and sought an environmental cause for it, namely a rapid change in the Ballona, such as a flood. Whatever the event was, it appeared to have differentially affected shellfish species, causing some to become scarce, although not the Venus clam.

Quite interestingly, the excavations—especially those at the Del Rey site—revealed a degree of site structure, in the form of features. In total, 16 features, classified into four types, were identified at the two sites—15 at the Del Rey site and the other at the Bluff site. Feature types identified were hearths (n = 8), caches of various types (n = 6), a pit hearth, and an earth oven. The caches were identified by clusters of different kinds; shells were one type, and ground stone tools were another. Van Horn (1987a) interpreted most of the features as related to food processing, although 3 apparently had ritual functions. These features were identified in the central portion of the site. Artifact scatters were located around the periphery of these features, at the margins of the site, as were shell heaps, indicating that some activities may have been performed in central portions of the site, whereas refuse and some domestic activity occurred on the site periphery. Thus, there was a pattern to feature locations, artifact scatters, and food-waste dumps, which together provided a schematic picture of a population with structured lifeways.

Van Horn (1987a) submitted six pieces of shell from the two sites—five from the Del Rey site and one from the Bluff site—for radiocarbon dating. All the (uncorrected) dates were fairly close to one another, ranging from 2530 ± 90 to 2020 ± 70 B.P. These radiocarbon dates generally support an Intermediate period occupation at the site. They do not, however, likely show evidence of all occupations at the site, because recovered cogged stones and crescent-shaped chipped stone tools suggested use during the Millingstone period. In addition, several glass trade beads and Cottonwood projectile points suggested use during the Late through Mission periods.

Overall, Van Horn (1987a) argued that the two sites were used much in the same way as LAN-61, on the other side of the Lincoln Gap: as temporary camps for hunting and logistical activities. Although Van Horn saw glimpses of site structure in the way shell and artifact scatters were arranged on the periphery of the site, he generally argued that the sites were dedicated to resource procurement, that they were essentially unstructured, and that all activities were performed around hearths. Furthermore, he argued that trash was distributed homogeneously, rather than collected or redeposited in a formal manner.

Further data recovery was conducted on the sites between 2000 and 2003 by SRI, in preparation for development of the property. The goal of SRI in undertaking the additional data recovery was threefold: (1) to excavate a sample of intact features and activity areas, (2) to identify temporal relationships among the features, and (3) to define distinct activity areas. SRI's research strategy thus focused on the discovery and excavation of features, because the researchers believed there would be little new information gained from further midden excavations. In order to attempt to recover activity areas and other types of features, SRI focused excavations on hearths; the idea was that many activities might be centered on these features. Data recovery occurred in two stages. In 2000, SRI conducted block excavations at both LAN-63 and LAN-64 and recovered 21 features. Subsequently, in 2003, SRI initiated a large-scale, intensive monitoring program in which SRI directed the controlled grading of the project area for development. This work was an extension of data recovery and resulted in the mapping and excavation of hundreds of additional prehistoric features. At LAN-64, for example, traditional data recovery methods used by both SRI and Archaeological Associates did not reveal a single feature. The intensive monitoring and controlled grading of the site revealed 60 features, including burials, complex rock features, and shell dumps. In addition to an Intermediate period component, the shell dumps constituted a component dating from a time between 7000 and 8200 cal B.P., offering information on the earliest recorded prehistoric use of the Ballona. Traditional data recovery by SRI at LAN-63 recorded 21 features; an additional 286 features, including burials and several complex ritual features, were excavated during intensive monitoring.

The intensive monitoring and controlled grading program at LAN-63 and LAN-64 dramatically improved the understanding of the sites' occupation histories and functions. The renewed work at these sites contrasted with the original work performed by Van Horn (1987a). What emerged from the different firms' approaches to, and thoughts about, the area's prehistory were competing hypotheses to explain the use of and patterning at the bluff-top sites. The questions come down to whether there was a complex organization of space at the sites (SRI's hypothesis) or, alternatively, the space and activities were arranged randomly across the occupational area (Van Horn's argument). Further, was occupation of these sites temporary and seasonal or more permanent, and how long were the sites occupied—intermittently, for short periods of time, or even for long periods of time?

Radiocarbon dates and diagnostic artifacts from the sites demonstrated that they were occupied roughly simultaneously during the Intermediate period. In addition, radiocarbon dates indicated that LAN-64 is the oldest occupied site in the Ballona, with a component dating to the early Millingstone period. Cogged stones and discoidals at both LAN-63 and LAN-64 indicated that there was further likely evidence of a Millingstone component to LAN-63, although the context of these artifacts was unclear, because they were found during mechanical stripping. Reanalysis of artifact distributions by SRI (Hull and Douglass 2005) also revealed that there was likely a component of the site dating between the Late and Mission periods, based on projectile point types.

Most importantly, SRI's investigations at LAN-63 exposed a much wider range and a greater number of features. These finds led SRI researchers to conclude that there was a much greater diversity of features and artifacts than Van Horn (1987a) had reported. Also, SRI researchers argued for the site's having been used for a much wider range of activities than previously acknowledged and more than would be expected in a short-term camp occupied by a single family group. The ritual features suggested that the site was occupied by larger social groups, at least on a periodic basis.

Spatial analysis also revealed patterns in feature placement across the sites. Burials, for instance, were not placed in domestic areas but, instead, were found on the site's margins, along either the edge of the bluff or the southern margin of the site. Domestic refuse, on the other hand, was found throughout the site's midden, yet kitchen refuse, primarily shell, was specifically found in a depression within the middle portion of the site that separates the eastern and western knolls. There was also evidence for ritual activity similar to the ethnologically documented Mourning Ceremony, which featured the willful burning and destruction of personal possessions of the deceased as well as cremation of the body before burial of its remnants.

In contrast to LAN-63, SRI's evaluation of LAN-64 seemed to agree in large part with Van Horn's (1987a) assessment. Excavation and analyses revealed a site with little evident structure, although burial placement, as discussed below, did reveal some patterning. Seemingly, this site was occupied on a temporary basis only, perhaps in relation to subsistence practices centered on the resources of the Ballona Lagoon below. The domestic features there were also not as differentiated as they were at LAN-63. They can be characterized as having had utilitarian purposes, like processing foods. Further, the domestic features were scattered across the site, devoid of recognizable clusters or other patterning in their distribution. Still, some partitioning of space was apparent, in that burials were found only along the western margin of the site, removed from the domestic areas. Almost every burial from this site was cremated, which was only the case for some burials at LAN-63. This observation serves as further evidence that the sites were contemporary and were perhaps even occupied by (at least culturally) related groups. However, although there were features dating to the early Millingstone period at LAN-64 at the base of the deposit, we understand little about the occupation of that site during this very early time period besides the interpretation that it was a temporary camp where shellfish (a mixture of *Chione* and *Argopectin*) from the adjacent Ballona Lagoon was collected and consumed.

LAN-206: The Berger Street Site

LAN-206, also known as the Berger Street site, is located west of the Lincoln Gap, adjacent to LAN-63 and LAN-64 and slightly closer to the ocean and farther away from the bluff edge than the other sites (see Figure 11). The Berger Street site was known long before any formal testing or data recovery was performed. By the time Pence (1979) visited there in the late 1970s, the site had already been extensively looted and was also being destroyed by development. Pence recommended immediate data recovery, because he suspected that the site was a single-component Millingstone period occupation, given the presence of discoidals and the lack of mortars. In 1983, a combination of volunteers and staff from Archaeological Associates conducted limited data recovery on the site (Van Horn and White 1997a).

Van Horn and White (1997a:21) reported that the site was principally occupied during the early Millingstone period, given the single radiocarbon date of 6750 ± 80 B.P. The excavations produced a total of five cogged stones as well as a number of other ground and flaked stone tools and debitage, including manos, metates, abraders, a discoidal, cores, flakes, flake tools, choppers, scrapers, drills, and a single projectile point. All the stone tools were made of local materials—Monterey chert, metavolcanics, and quartzite. In addition to these artifacts, hammerstones, FAR, ochre, and asphaltum were also recovered. A fairly large bone sample representing 24 terrestrial-mammal species, a single human tooth (a molar), and several species of birds and reptiles was also recovered. In addition to these, 19 fish species (8 cartilaginous taxa and the rest bony fish) and sea otter were identified. Marine shellfish were also quite common, unlike at LAN-61, and mostly belonged to 3 species native to mudflats and intertidal zones: Venus clam or cockle, speckled scallop, and Pacific oyster.

Despite the fact that Pence (1979) understood the site to have a single component, Van Horn and White (1997a) concluded that there were in fact three components: Millingstone, Intermediate, and late Intermediate periods. The Millingstone period component appeared to have been a time of intensive fishing and shellfish collecting, and the early Intermediate period emphasized processing (grinding) seeds and terrestrial hunting. During the late Intermediate period, there appeared to have been considerable stone-tool production on-site, based on substantial amounts of debitage associated with the last occupational horizon.

In addition to the main locus of LAN-206, an additional locus, designated LAN-206A, was identified on the adjacent West Bluffs property, adjacent to LAN-64. Based on survey and testing, Van Horn and White (1997a) argued that LAN-206A was peripheral and had little research potential. Therefore, they recommended it not eligible for listing in the NRHP and the California Register of Historic Resources.

SRI later performed intensive monitoring during controlled grading at LAN-206A in 2003, as part of the larger data recovery operations at adjacent LAN-63 and LAN-64. Monitoring resulted in the recording of 10 prehistoric features, including a partial human burial. Despite these investigations and the additional features, SRI was unable to date the occupation of the site conclusively—a problem shared with the earlier investigations by Archaeological Associates. The presence of cogged stones and discoidals suggested that the site component dated to the Millingstone period. The presence of all features found on the northern end of the site boundary, along the edge of Hastings Canyon, suggested that it may have some affiliation with the Millingstone period component at adjacent LAN-64, although what sort of affiliation was unclear.

Recent Archaeological Research below the Bluffs

Prehistoric sites below the bluffs, although similar in many ways to those on top of the bluffs, had very different resources close at hand. On the bluff tops, temporary water-filled depressions and the extensive coastal prairie (Wigand 2005) offered site inhabitants a variety of terrestrial resources. Below the bluffs, sites are found on the margins of the prehistoric Ballona lagoon and associated wetlands. Nearby access to wetlands, a large bay or lagoon, and Santa Monica Bay offered inhabitants here a very different set of resources. Although the oldest site in the Ballona appears to have been on the bluff tops (LAN-64), LAN-62, just below the bluffs, dates to at least 6,000 years ago and contains an extensive, dense midden. Below, we describe previous work at archaeological sites below the bluffs.

LAN-47: The Admiralty Site

This site, located in Marina del Rey along Lincoln Boulevard, on the edge of the marina, was originally recorded in the 1940s, but all information from that time has been lost (Dillon et al. 1988:35) (see Figure 11). Unlike many others in the Ballona, the site is located on the northwestern edge of the prehistoric Ballona Lagoon and wetlands; almost all other sites are located on the opposite side of the lagoon, at the base of the bluffs. As discussed above, in 1961 Keith Johnson excavated a portion of LAN-47 and discovered a midden containing four burials in burial pits, stone bowl fragments, projectile points, lithic debitage, choppers, hammerstones, scrapers, a pestle, ground stone fragments, faunal remains, bone tools, antler harpoons, shell beads, and remains from shellfish resources (Meighan 1961). More than 20 years later, Brian Dillon and colleagues (Dillon et al. 1988) located a shell deposit in the southeast corner of the Admiralty Place Development that contained artifacts and subsistence remains indicating Late period occupation.

LAN-47 was subsequently investigated in 1989 by SRI (Altschul et al. 1992; see also Altschul et al. 2007). Although only a small fraction of the site was investigated (less than 10 percent of the original estimated site), the information return was high. The site was found to have been occupied for a relatively short period of time between approximately A.D. 1050 and 1150. By the time the site was occupied, the Ballona wetlands were in their final stages of sedimentation, and an estuarine lagoon environment prevailed. The prehistoric inhabitants of the site subsisted on plants and animals found in the marsh, particularly shellfish, waterfowl, fish, small mammals, and various seeds and berries. Surprisingly, little evidence of pelagic exploitation was found. In addition, there was also a lack of evidence for permanent occupation of the site. It appeared that LAN-47 represented a series of temporary camps established along the northern edge of the Ballona wetlands at various times throughout the year when resources were available. Four flaked stone technologies were identified at the site, ranging from finely controlled bifacial and microlith industries to the manufacture of expedient flake tools. The variation in lithic technology was mirrored in the range of lithic raw materials used. Although bone tips were identified in the collection, there was little evidence of technology related to the manufacture of other goods, including fishhooks and shell beads. Although no burials were found by the SRI excavations, only a small portion of the overall site was investigated; much of the site was destroyed in the 1960s, during the construction of the marina. Previous work at the site (Dillon et al. 1988) found multiple burials and other items that were not recovered by SRI.

LAN-54: Deane's Broken Mortar Site

LAN-54 is located near the historic confluence of Ballona Creek and the Ballona Lagoon (see Figures 3 and 11). The site was originally recorded in 1949, but prior to SRI's work, no subsurface investigations had been performed. Eberhart originally recorded the site as a prehistoric site along both sides of Culver Boulevard, probably centered "just S. of Culver Blvd. c. 50' W. of Alla Rd. [now the Marina Freeway]" (see Vargas and Altschul [2001:9] for a more detailed description of the original site-record forms). Later survey work by Pence (1979) and Van Horn (1984) suggested that the site may have been preserved under the then-recently completed Marina Freeway. In 1990, SRI surveyed in the vicinity of LAN-54 but did not find any surface indications of the site. In 2002, SRI personnel noted site materials, including dark soil, shell, and lithic flakes, along and between the Marina Freeway access ramps, but these appeared to have been redeposited in their locations at the time.

In 2000, SRI conducted a limited testing project at LAN-54 (Vargas and Altschul 2001) designed to identify intact site deposits and to determine the limits of those deposits. A series of six small trenches was placed in the vicinity of LAN-54, along both sides of Culver Boulevard. One trench (Trench 2) encountered an intact and largely undisturbed site deposit close to the site boundary as recorded at the SCCIC (Vargas and Altschul 2001:13–14). Within the SCCIC boundary of LAN-54, SRI's trenching revealed an area of greater disturbance adjacent to the remains of the Blue Goose Packing House, and Vargas and Altschul (2001) expected that only a small portion of the site as originally mapped might have remained. The preserved portion of LAN-54 lies southwest of the intersection of the Marina Freeway and Culver Boulevard, in the city of Marina del Rey, California.

SRI conducted data recovery at LAN-54 in June and July of 2002 (Keller and Altschul 2002), ahead of planned widening of Culver Boulevard. The project consisted of trenches, control-unit blocks, stripping units, and the investigation of 37 identified prehistoric and historical-period features and their surrounding matrixes. The discovery and control units revealed two areas of intact site deposits separated by a disturbed area under the center of the former Blue Goose Packing House foundation, where the artifact-bearing A horizon was entirely removed. The two intact prehistoric site-deposit areas were distinct in terms of both artifact and feature density. The intact deposit south of the packing house was significantly denser and contained most of the features identified at the site. To the north, the site deposit appeared truncated and contained only sparse amounts of very small pieces of weathered marine shell, few artifacts, and three disturbed features clustered along the western edge of the stripping area (Keller and Altschul 2002).

Artifacts identified in the field from all collection contexts included a wide variety of items—from manos, metates, pestles, and possible mortar fragments to hammerstones, cores, flakes, flaked stone tools, dart-sized projectile points, a large number of pieces of FAR, and manuports, as well as worked-bone tools (Keller and Altschul 2002). Faunal remains appeared to have been well preserved and were dominated by bay and estuary shell species (predominantly *Argopecten* sp., *Ostrea lurida*, and *Chione* spp.) but also included fish, bird, marine-mammal, and terrestrial-mammal bones (Keller and Altschul 2002). Upper fill and mixed levels also contained a significant number of cow or horse remains likely related to historical-period use of the site area.

Of the 37 features investigated at LAN-54, 4 were probably of historical-period age, 3 were prehistoric burial locations (containing four adult individuals), 3 were soil stains possibly indicating structural features dug into the C horizon, and the remainder were artifact concentrations containing a variety of materials, such as FAR, manuports, flaked and ground stone tools, marine shell, bone tools, and faunal remains (Keller and Altschul 2002).

LAN-60: The Centinela Site

LAN-60, the Centinela site, is an Intermediate period shell midden located at the base of the Ballona Escarpment, at the northeastern end of the project area (see Figure 11). The site was first recorded in 1936 by Malcolm Farmer during a survey he conducted in 1934 with Eugene Robinson (Farmer 1936) and later by Charles Rozaire and Russell Belous (1950). Van Horn (1984) concluded that the deposits at the Centinela site were not in situ but were bulldozed remains from the bluff-top Hughes site. In 1991, while monitoring construction at the Hughes site, SRI discovered intact midden deposits at LAN-60. SRI then performed a 4-day salvage operation during which 12 m^2 were excavated from what was designated Area C of the site. A 1-m-thick midden deposit was found to have been occupied for a relatively brief time during the Intermediate period, ca. 2100 cal B.P. (Grenda et al. 1994). The materials from the site indicated relatively short-term, seasonal occupations.

Inhabitants of the site subsisted on marsh plants and animals, particularly shellfish, waterfowl, fish, small mammals, and various seeds and berries. Little evidence of pelagic exploitation was identified in the collection. To assist in the processing of plants and animals, the prehistoric inhabitants utilized flaked and ground stone tools. Flaked stone production focused on expedient technologies, and the lithic collection was dominated by debitage and a few cores. Stone beads were found on site, but no shell beads were present. A single feature, a hearth, was recorded during data recovery.

No evidence for permanent occupation was found during data recovery. Although it is possible that a comprehensive examination of the site may alter this conclusion, it appeared that LAN-60 represents repeated, temporary camping activity.

LAN-62: The Peck Site

The Peck site, known also as the Mar Vista site, is located at the base of the Lincoln Gap, on an alluvial fan extending from the base of the Westchester bluffs. The site was first formally excavated by Stuart Peck as an Archaeological Survey Association of Southern California (ASA) field project in the 1940s (see Figures 3 and 11). Arris and Luhrs (1948) completed the site-record form for the ASA. Peck (1947) noted two distinct occupations that probably relate to Middle and Late period components. The upper occupation contained cremations; obsidian; soapstone bowls; large, deep mortars and pestles; pelagic fish; and shellfish (mostly scallops and "cockles"). The earlier occupation contained inhumations, small mortars, manos, large metates, and shellfish (mostly Pismo clam and abalone). The Peck site was later investigated by several investigators, including Dillon (1982; Dillon et al. 1983), King and Singer (1983), Archaeological Associates (Freeman et al. 1987; Van Horn 1984), and SRI (Altschul 1991; Altschul et al. 1991, 1992, 1998; Grenda et al. 1999; Vargas et al. 2005). All of these investigations indicated that LAN-62 was critically important. It was viewed as the most promising archaeological site in the Ballona—possibly a major site—and there was strong evidence for considerable time depth, extending the occupation of this part of the lagoon edge back into at least the Intermediate period (Grenda et al. 1999). The evidence of numerous cremations and inhumations at LAN-62 found by Peck in the 1940s suggested the presence of additional burials.

SRI conducted limited testing of LAN-62 on separate occasions in 1998, 1999, and 2001 and developed a testing plan including the use of mechanical bucket augers and trenching. In each of the programs, portions of LAN-62 were tested with success. Trenching and bucket augering revealed data in different levels of confidence, based on the amount of fill or disturbance in the immediate area. Although no burials were identified with the bucket augers, testing in some areas did reveal shell beads, which often are found with burials, and highlighted Peck's discovery of burials in the 1940s at the site. Generally, when site material was identified, it was thick along the base of the bluff and, depending on the exact location, sloped deeper the farther the site extended from the base of the bluff. Testing revealed that the Hughes era had truncated and disturbed significant portions of the site along the base of the bluff and that site material had likely been used as fill for extension of the runway in the 1940s, as described by Peck (1947). Based on the importance of the site and the long history of research there by various researchers, Altschul (1991) recommended it eligible for listing in the NRHP.

SRI conducted data recovery at LAN-62, Loci A–C, between September 2003 and August 2004 (Vargas et al. 2005). Excavations at Loci D and G occurred in September 2005 and April–May 2006, respectively (Van Galder et al. 2006; Vargas and Douglass 2009). Hundreds of test pits and numerous mechanical-stripping units were excavated. Archaeologists recovered hundreds of features, including human burials, rock clusters, activity areas, pits, artifact concentrations, animal burials, and thermal features. As discussed in Volume 3, a dense burial area containing hundreds of burials was revealed during these excavations and appeared to have been established during the Late period with a few burials; during the subsequent Protohistoric and Mission periods, hundreds of individuals were placed in this confined burial area. Much of the reporting in subsequent volumes of the PVAHP Series is focused on this burial area.

From the initial analytical phase of materials from Loci A–C, four temporal components were identified. A Mission period (A.D. 1771–1834) component was identified based mainly on the presence of diagnostic artifacts associated with burials, a Late period (ca. 1000–400 cal B.P.) component was identified as containing the highest artifact density at the site, and Intermediate period (ca. 3000–1000 cal B.P.) and Millingstone period (ca. 6000–3000 cal B.P.) occupations were identified (Vargas et al. 2005).

Preliminary analyses resulted in the identification of more than 75,000 pieces of faunal material and nearly 4,000 stone artifacts (Vargas et al. 2005). Faunal specimens dominated the sample, regardless of test pit, level, or stratum. The faunal specimens in the sample represented a minimum of 35 shellfish, 5 fish, 1 amphibian, 3 reptile, 4 bird, and 20 mammalian taxa. Also included in the collection were several starfish and coral fragments, along with nearly 400 riparian-snail shells. Marine-shell fragments—particularly bay clams, such as the common California Venus clam (*Chione californiensis*)—accounted for nearly 60 percent of the sample. Other economically important shell taxa included oysters, scallops, Pacific littleneck clams, and abalone. Fish bones were present, but in limited numbers (Vargas et al. 2005).

Based on the preliminary analyses, the inhabitants of LAN-62 relied almost exclusively on locally available Franciscan chert, basalt, and metaquartzite cobbles to meet their stone-tool needs. Other identified igneous materials included rhyolite, granite, and, occasionally, obsidian. Bifacial tools included a Cottonwood Triangular arrow point, a concave-based dart point, and three biface fragments (Vargas et al. 2005).

The excavations at LAN-62 Locus D revealed highly disturbed deposits with scant cultural materials (Van Galder et al. 2006). Excavations at LAN-62 Locus G revealed a relatively intact but sparse deposit overall and few features. Interestingly, the Locus G excavations, located farther out on the alluvial fan from Locus A, revealed prehistoric features on the edge of the wetlands-marsh deposit, which prehistorically interfingered with the alluvial fan with the ebb and flow of wetlands formation on the edge of the site. Despite the scarcity of cultural materials, the deposit was relatively thick, measuring more than 2 m deep in many places. Soil stratigraphy was complex at Locus A and included more than 16 identifiable stratigraphic breaks, as noted during fieldwork (Vargas and Douglass 2009).

Overall, then, LAN-62 continues to be thought of as the most important site in the Ballona. It contains the longest continuous occupation of any site in the Ballona, beginning at least 6,000 years ago. Although LAN-64 showed evidence of occupation at least 2,000 years earlier, LAN-62's occupation history appears to be less temporary. As discussed in Chapter 5 of this volume (the research design), the site's occupation history suggested that it was a persistent place in the Ballona used for purposes not undertaken at other sites; the formation of the burial area at the site during the Late period is one example. Much of the research for the PVAHP discussed in subsequent volumes of the this series focuses on LAN-62.

LAN-193

LAN-193, located along the base of the bluff east of LAN-211, rests on an alluvial fan at the mouth of two small drainages (see Figures 3 and 11). The history of LAN-193 has often been confused with that of LAN-62. According to both Pence (1979) and Van Horn (1984:33–34), LAN-193 was not documented until 1952, when Hal Eberhart recorded it as a village site. Although it would be a mistake to conclude that LAN-62 and LAN-193 are one and the same site, many discussions of LAN-193 have appeared to refer, instead, to LAN-62. For example, whenever Pence (1979) appeared to discuss LAN-193, the references were to Peck's (1947) report on the Mar Vista site, which clearly described LAN-62 (Altschul and Ciolek-Torrello 1997). It is doubtful that Peck ever excavated at LAN-193, and Van Horn believed that no professional archaeologist ever saw the site, which was paved over before it was recorded (Altschul et al. 1991:Figure 37; Van Horn 1984). R. L. Beals is purported to have excavated at LAN-193 in 1939 (Altschul and Ciolek-Torrello 1997:18), but in that case, as in those previously discussed, the artifacts he collected were more consistent with LAN-62 than with the sparse midden site that we found at the recorded location of LAN-193. It is possible that Beals's artifacts were from another village site that may once have existed at or near the current location of LAN-193.

SRI conducted remote sensing and testing at LAN-193 in 1998. Approximately 12 cores were excavated into the parking lot under which LAN-193 was located. The first of these cores produced a lithic artifact at 11–15 feet b/s, the only artifact discovered in a core there. Although it was impossible to correlate the core stratigraphy with the remote-sensing data, both methods pointed to undisturbed soils immediately below the parking lot. At some point after 1949, the parking lot was constructed, resulting in an unknown level of disturbance to the area. We suspect that the top portions of the site may have been truncated and possibly redeposited as fill within the Howard Hughes Industrial Complex during construction episodes. Monitoring activities to the north of the parking lot in the Howard Hughes Industrial Complex suggested that the area had been completely disturbed and that there was little chance that an intact archaeological site existed. Although artifacts were recovered during monitoring, they were probably redeposited from a nearby site, such as LAN-193.

Bucket augering at LAN-193 was designed to determine whether the possible darker soil horizons discovered in the cores and the contacts discovered by the remote sensing represented intact archaeological deposits. In particular, SRI was looking for a village site, as Hal Eberhart had described LAN-193. Twenty bucket augers were excavated in the parking lot; archaeological material was noted in 10 of them. SRI defined the site as covering an area roughly 225 m east-west by 40 m north-south. Site depths ranged from 3 to 14 feet below the ground surface, and the average depth of the deposit was about 3.5 feet. The data from the bucket augers suggested that the site was a low- to medium-density artifact scatter that did not conform to the site's original description. LAN-193 exhibited high lithic and faunal densities and an extremely low shell density.

As a result of testing, LAN-193 was recommended eligible for listing in the NRHP. Data recovery was conducted in 2000 in advance of construction in the area. Based on both testing and trenching in preparation for data recovery, an activity surface dating to the Intermediate period was identified. The activity surface was large and complex and contained numerous rock features, hearths, and pieces of ground stone, suggesting that LAN-193 was a processing area on the edge of the Ballona wetlands. As a result, the activity surface was a major focus of data recovery, in addition to control-unit excavation, which was done through the entire midden. Overall, outside the activity area, few intact prehistoric features were identified. Additional data recovery was performed on a historical-period component of the site that contained a large, extensive trash deposit. A combination of artifactual and archival work has revealed that this historical-period trash deposit is likely related to a 1920s hog farm located on top of the prehistoric archaeological site called the Kitahata Hog Ranch. Finally, monitoring of construction of the Riparian Corridor in 2005 revealed both additional prehistoric features (including three burials) and information that extended the site boundary farther to the east and west.

LAN-211

LAN-211, located 0.3 miles northeast of LAN-62, along the base of the bluffs, was recorded by Luhrs in 1948 as LA:3 (see Figures 3 and 11). Pence (1979) located LAN-211 near some fuel-storage facilities, in an area covered by a parking lot. Freeman et al. (1987:26) stated that Pence's site was 300–400 feet northeast of LAN-211 and that Pence was unable to find the original location because airport construction had completely covered the site. Freeman et al. (1987:26) relocated the site accidentally when cultural material from the fill was exposed on the surface. The intact deposits uncovered beneath the fill appeared to be from a multicomponent site. One component may be contemporary with the bluff-top sites, and the second is a Late to Mission period component occupied within the same broad time frame as the occupation of LAN-62 (Freeman et al. 1987:44).

Testing by SRI at LAN-211 revealed a substantial archaeological deposit (Altschul et al. 2003). The primary upper component of the site dated to the Protohistoric and Mission periods and was the first likely habitation site dating to that period in the Ballona. In addition to the predictable array of large- and small-mammal species, the faunal collection included a small amount of butchered-domesticated-cattle bone and the remains of exotic-animal species, such as pronghorn, swan, and a species of freshwater mussel. SRI also found that bony-fish species constituted a very high proportion of vertebrate fauna. In terms of tools, no evidence of Hispanic manufacture was found; tools were essentially traditional in form and material. The collection included numerous stone projectile points, bifaces, utilized flakes, ground stone, and a large number of tarring pebbles. Hispanic influence was reflected only through the presence of glass trade beads, a few bones of domesticated cattle, and three pieces of flaked glass. Based on testing, the site was recommended eligible for listing in the NRHP (Altschul et al. 2003).

Data recovery excavations conducted by SRI at LAN-211 from September through December 2005 consisted of 10 mechanical trenches and 370 1-by-1-m hand-excavated test pits distributed in five blocks of different sizes, the investigation of 50 features (including 3 burials), and mechanical stripping. The excavations revealed a highly variable cultural deposit that was intact and thick (over 3 m) in some areas and truncated and disturbed in other areas. The heaviest concentration of intact cultural materials was found in the central portion of the site, where most of SRI's efforts were focused.

Four major stratigraphic breaks were identified during data recovery at LAN-211. The upper portion of the deposit at LAN-211 contained a dense midden with a diverse collection of archaeological materials (Van Galder et al. 2006). Although this stratum was relatively thin (from 50 cm to just over 1 m), it contained large numbers of flaked and ground stone artifacts, faunal bone, worked bone, shell, ceramics, beads of stone and shell, and other botanical materials. Of importance in the collection from the upper stratum were materials introduced from contact with nonnative peoples, including glass beads, flaked bottle glass, possible European and Chinese ceramics, metal, and the bones of domesticated cattle. This portion of the deposit represented a Protohistoric (ca. 1542–1769) or early Historical period (ca. 1769–1834) occupation of the site (Van Galder et al. 2006). Most of the features encountered at the site were also found in the upper stratum. The density of cultural materials dropped off significantly in the lower strata, dating to the Intermediate period, and included small numbers of flaked and ground stone artifacts, sparse amounts of shell and faunal bone, and a few features.

LAN-2768

LAN-2768 is located on the eastern end of the project area, near Centinela Boulevard. The site was discovered by SRI's testing program in 1998 (Altschul et al. 1999), as well as through subsequent monitoring. It is a continuous deposit of archaeological materials that extends along the base of the bluff, from roughly LAN-60 to the Howard Hughes Industrial Complex and LAN-193 (see Figures 3 and 11). Testing has been conducted in several loci of the site, using a combination of hand-excavation units, mechanical bucket augers, and/or trenching. Because of natural and artificial fill in portions of the site, artifacts were found at depths ranging from 2 to 16 feet below the ground surface. Testing revealed a midden deposit containing a variety of shell, bone, lithic, and other artifacts in varying densities. The northwestern portion of the site, along the toe slope of the Westchester Bluffs, revealed the highest density of artifacts. Based on testing, the site was recommended eligible for listing in the NRHP (Altschul et al. 1999).

Data recovery at the site occurred in several phases between 2000 and 2007. The original data recovery was undertaken in advance of the construction of the Riparian Corridor. Additional data recovery was related to the construction of a pipe in the southern portion of the site as well as the construction of the Clippers' basketball facility. Generally, the site appeared to date to the Intermediate period and contained lithic artifacts in low density. As at LAN-193, the shell density was very sparse, suggesting that these two sites functioned as processing areas with a shellfish-resource focus, rather than as likely habitation areas. Data recovery also revealed a historical-period component to the site, with several cisterns and sections of railroad tracks and/or railroad equipment, that is likely associated with both the Hughes era and the Pacific Electric Trolley Line.

During monitoring of Riparian Corridor construction in 2005, SRI had the opportunity to further our understanding of the site. Monitoring revealed a number of prehistoric features as well as a few human burials and provided an opportunity to extend the site boundary farther to the southwest, along the base of the bluff, to within a short distance of the current site boundary for LAN-193.

Research Goals and Objectives of the Playa Vista Archaeological and Historical Project

John G. Douglass, Jeffrey H. Altschul, Richard Ciolek-Torello, Seetha N. Reddy, Benjamin R. Vargas, and Donn R. Grenda

This chapter presents a summary of research goals and objectives for the PVAHP. The PVAHP research design presented by Altschul et al. (1991) outlined several historic-context themes for the project. Three broad research themes were presented in the research design: (1) human-land relationships, (2) culture history and cultural dynamics of prehistoric settlement, and (3) historical-period development of the Ballona. In subsequent years, as we learned more about the archaeology of the Ballona, SRI built on the original research design and expanded these themes (Altschul 1991; Altschul et al. 1992, 1998, 1999, 2003; Vargas and Altschul 2001; Vargas et al. 2003) within the context of specific investigations. This chapter presents these themes, offers additional ones, and details what was known in the early 1990s, when the original research design was created, as well as how these themes have evolved with new data and insight over the past 20 years. The research theme related to late-historical-period development of the Ballona has been previously addressed (Greenwood and Associates 1995; SRI et al. 1991), and we do not discuss it here. We do, however, discuss in detail research themes related to early Historical period development of the Ballona, a theme that was not fully addressed in the original research design. An important point to be made here is that, although the research design for the project laid a strong framework for research on the PVAHP, it was used as a dynamic guide for research rather than a rigid structure. Below, we discuss the original themes of the research design, including what has since been learned in relation to them, as well as additional research interests.

Our overarching research goal for the PVAHP was to better understand the place of the Ballona in southern California cultural systems through time. The Ballona has a great time depth of human occupation (dating back at least 8,000 years) during which the environment saw vast changes. From early seasonal occupation by hunter-gatherers on the bluff tops to dense, complex aboriginal occupation during the early Historical period, the Ballona has been an important place longer than many other locations in southern California. During this time, there were movements of outside groups to the coast (Takic groups), drastic changes in settlement patterns and site structure, and the emergence of large residential base camps and dispersed communities. By not only discovering the patterns of change and continuity in the Ballona but also comparing them to patterns in other areas of southern California and farther afield, we hoped to come to a more informed understanding of human habitation in the Ballona and its relationship to surrounding regions.

Human-Land Relationships

A major goal of research was to reconstruct the paleoenvironment of the Ballona to determine whether additional work was warranted to search for buried cultural deposits. When SRI began working in the Ballona, numerous archaeological surveys of the region, spanning nearly 40 years, had been conducted. All these surveys focused on the surface, with very little attention to buried sites. Although many sites had been recorded on the bluff tops, few had been encountered in the wetlands or along the banks of Ballona or Centinela Creek. Our work at the Admiralty site (LAN-47), on the north edge of the Ballona Lagoon, outside the PVAHP (Altschul et al. 1992), however, convinced us that more sites might be found along the edges of the lagoon and the banks of the creeks. Moreover, we hypothesized that as sea level rose and more sediment from Ballona and Centinela Creeks filled the lagoon during the Holocene, the border of the lagoon would have retreated westward, stabilizing at intervals as climatic and tectonic conditions dictated. We expected that if we could define these stable lagoon edges, then through various geotechnical methods, we should be able to find buried sites that had limited surface expression.

In addition, PVAHP research on human-land relationships has focused on subsistence. For example, what are the long-term adaptations to a lacustrine resource base, and how was the changing landscape used during the time of human occupation in the Ballona? We also compare and contrast these patterns with regional subsistence patterns across prehistoric California and in coastal settings in other parts of the world.

Paleoenvironment

The first step in meeting our overall objective was to develop a study that could obtain data for paleotopographic and paleoecological reconstruction. The Quaternary history of the Ballona Lagoon was thought to be characterized by dynamic environmental changes. Most important were the shift from an open lagoon to an estuarine environment and the migrations of the Los Angeles River channel (see Altschul et al. 2007). These changes were the results of the complex interaction of lowering sea level, rapid uplift, and subsidence. We expect that these environmental changes had profound effects on prehistoric settlement and resource procurement in the region. Chapters 6–8 (as well as the appendixes) of this volume address research questions related to the paleoenvironmental reconstruction of the Ballona and how it is related to prehistoric occupation in the area.

Prehistoric Subsistence

When we developed the original research design, our understanding of prehistoric subsistence was that there was a shift from terrestrial to aquatic resources between the late Millingstone period and the Late period (Altschul et al. 1991). This shift was thought to be associated with a change in settlement preference from the bluffs to the lagoon. Although we documented shifts in subsistence through time, they were much more complex than previously thought, with apparent differences in subsistence strategies above and below the bluffs, as well as changes through time. We now have a more in-depth understanding of subsistence trends in the Ballona. These data should be used to test recent models of subsistence in coastal settings, as well as regional models.

As part of our research on subsistence, we studied several broad topics using PVAHP data. The first topic is related to the costly-signaling model, which has recently been proposed to understand subsistence trends during the middle Holocene in California and the Great Basin (Hildebrandt and McGuire 2002; McGuire and Hildebrandt 1994, 2005). At the end of the middle Holocene (ca. 4000 cal B.P.), hunting of highly ranked mammals (namely, artiodactyls) increased in central California and the Great Basin. By 1000 cal B.P., during the late Holocene, there was a decrease in hunting large game. Costly-signaling theory has been used to explain these trends, in which hunting of artiodactyls, which is seemingly inefficient compared to the hunting of other animals and protein sources, increased through time. Signaling displays and communicates information (including intrinsic value and qualities) through a variety of media. Hunting artiodactyls, argued McGuire and Hildebrandt (2005:698), is a way of communicating information to potential mates, allies, and competitors about personal attributes, such as hunting ability, leadership, cognitive skills, and generosity. Hunting larger animals uses meat as a medium of communication. McGuire and Hildebrandt (2005:695) have argued that these changes in subsistence are related to a shift in foraging currencies from calories to prestige.

Whereas data for some areas of California and the Great Basin suggest a rise in artiodactyl hunting, other scholars, using different data sets from central California, have argued for continuity in artiodactyl exploitation through time (Jones et al. 2002, 2008). One focus in our research is to examine these different trends in light of PVAHP data. How do patterns in the Ballona compare to those in central California? Did artiodactyl hunting rise during the middle Holocene in the Ballona? If so, was large-game hunting consistent through time, or were there variations to the pattern? What do the PVAHP data suggest about using costly-signaling theory along coastal southern California?

A second research topic regards the changing intensity of exploitation of marine resources over time in the Ballona. During the 8,000 years of recorded human occupation in the Ballona, the Ballona Lagoon changed from an open bay to a sediment-choked estuary. How did these changes in the local landscape affect the exploitation of marine and estuarine resources? Were there small, gradual changes in the harvesting of marine resources, such as those seen at Diablo Canyon (Jones et al. 2008), that suggest reliable resources that could accommodate increased harvesting pressure? Or, alternatively, were there major reorganizations of subsistence behavior? Deep-ocean transportation between the coast and nearby islands, such as Santa Catalina, are documented through the presence of steatite objects found on mainland sites dating at least as far back as the Intermediate period. Plank canoes (*tomol*) in the Chumash region to the north are documented at least as far back as 1,300 years ago (Arnold 2007; Des Lauriers 2005; Gamble 2002) and are associated with pelagic fishing. When did pelagic fishing begin in the Ballona, and what was its nature? What associated material-culture evidence of fishing exists in the Ballona? What physical evidence of fishing is present, and how does it compare to that in other regions in southern California? For example, what evidence is there of the use of compound fishhooks, simple fishhooks, harpoons, nets, or other implements for fishing?

Another research topic of note is plant use. As a marker for adaptive strategies, plant use is employed infrequently, primarily because of the lack of direct data and poor resolution for regional markers. Nonetheless, there have been observations at a gross level that associate nut use and its intensification during the Millingstone and Intermediate periods. Macrobotanical data from coastal southern California are markedly distinct from those in central and northern coastal California in terms of nut use. Nonetheless, scholars have applied models uncritically across coastal California. What is the nature of plant and nut use through time in the Ballona, and how does it compare to that in other areas? If there is evidence of intensified native-plant exploitation during the Protohistoric or Mission periods, is there associated evidence of cultivation of plants?

Another topic relates to culture contact and use of food by aboriginal groups in the Ballona. How did food preparation, use, and preferences change through time? How did food habits change through time as groups in the Ballona came into contact with other groups? There are two main contexts of culture contact in the Ballona. First, there are hypotheses that Takic groups entered the Los Angeles Basin during the end of the Millingstone period (see Chapter 3 of this volume for details), with changes in material culture during that period. Were there associated changes in subsistence during this period? Second, Hispanic settlers entered the Los Angeles Basin in the 1770s and were using the Ballona before 1800 as communal pastureland. There is documented evidence of Hispanic ranchers, associated with the Rancho de los Quintos, actively farming and herding animals in the Ballona by the early 1800s. What effect did this have on the subsistence strategies of the native inhabitants of the Ballona? Several scholars (Hackel 2005; Larson et al. 1994; Millikan 1995) have argued that, during the Mission period, the large increase in both farming and herding of cattle, sheep, and horses had a deleterious effect on the ability of Native Americans to continue their traditional subsistence patterns. What subsistence trends do we see during these periods of culture contact and social change? In what ways were new foods, if any, used and incorporated into the diet? What previous subsistence patterns, if any, ceased? Were native-plant populations in the Ballona affected by contact and by establishment of Hispanic settlement in the area? Do we see the effects of Hispanic contact in the macrobotanical record?

Related to subsistence, how were plants used in contexts unrelated to consumption? How were foods used in offerings, caches, and other features? The burial area at LAN-62, dating primarily to the Protohistoric and Mission periods (and which may include Late period burials), offers good data with which to study this topic, as large densities of floral remains are associated with the burial area.

Finally, the health of the past inhabitants was directly related, in part, to subsistence. By studying the human remains of past inhabitants of the Ballona, we are better able to understand signs of stress and the types of nourishment that they experienced. The burial ground at LAN-62 will be helpful in studying these topics.

Culture History and Cultural Dynamics of Prehistoric Settlement

Research questions related to this theme are organized into the following subthemes: chronology; technology, site function, and cultural interaction; cultural affiliation; prehistoric settlement, community, and persistent places; and culture adaptation.

Chronology

Like most archaeologists, we begin with time and space. Where and when did people live? Chronological data available in 1991 suggested that the nearby Westchester Bluffs occupation began during the Millingstone period, sometime between 5500 and 3000 B.C., and ended at the beginning of the Late period, around A.D. 1000. Below the bluffs, occupation appeared to have begun when the bluffs were abandoned, around A.D. 1000, with the possible exception of the area where Centinela Creek empties into the Ballona Lagoon. In 1991, it was unclear whether the hints of early occupation found at LAN-62 were an anomaly or the rule.

Today, we know that the earliest occupation in the Ballona occurred on the bluff tops on either side of the Lincoln Gap, which sits just above LAN-62. Radiocarbon dates from LAN-64 provide strong evidence that small groups probably camped in this area seasonally more than 8,000 years ago. All sites below the bluff were occupied at least as far back as the Intermediate period (1000 B.C.–A.D. 1000); some sites (including LAN-62) were occupied thousands of years earlier. At the other end of the chronological span, research has found no evidence for the Mission period village of Sa'angna (Altschul et al. 1991; McCawley 1996; Stoll et al. 2003; Van Horn and White 1997; Vargas 2003), which was reported to have been present in the Ballona (Altschul et al. 1991; Johnston 1962). Instead, archaeological investigations revealed substantial evidence for a Mission period occupation that our ethnohistoric research suggested was associated with the village of Guasna (Stoll et al. 2009). McCawley (1996) first speculated about this possible connection to a village named Waachnga in his book on the Gabrielino/Tongva. Citing ethnographic descriptions of the name Waachnga, variant spellings of the name in the San Gabriel Mission records, and the *diseño* for the Rancho Sausal Redondo, McCawley first suggested a possible tie to the village of Guasna. Van Horn and White (1997) disputed McCawley's suggestion, citing problems with how McCawley read the map and questioning the meaning of the name, Guaspita, as is shown on the *diseño*. More-intensive research with various Mission period documents and other copies of the *diseños* for the various Hispanic ranchos located in the area has bolstered SRI's argument for the location of a village named Guasna or Guaspet somewhere in or near the PVAHP area. When initial testing revealed strong evidence of occupation during the Protohistoric and Mission periods at LAN-62 and LAN-211, we created a cultural-adaptation model to guide subsequent intensive archaeological investigations at these sites (Vargas 2003; Vargas et al. 2003). These models are further discussed below.

In addition, regional models of Protohistoric and early Historical period occupation of southern California are tenuous or lacking. Most often, a Protohistoric or early Historical period component of a site may be known by the presence of glass trade beads or temporally sensitive shell beads but cannot be discerned from the rest of the archaeological record.

Unfortunately, many mainland sites in southern California have been subjected to years of destruction and of mixing from bioturbation. In portions of LAN-211 and LAN-62, we have uncovered intact deposits dating to the Protohistoric and Mission periods; these proved a unique opportunity to study this period in isolation. The ethnohistoric record for the Los Angeles Basin is based largely on data collected years after the end of the Native American occupation of the area. Rather than using the historical record as a tool for explanation of the archaeological record, our goal is to move back and forth between the archaeological and ethnohistoric records.

Technology, Site Function, and Cultural Interaction

Previous work at bluff-top sites by David Van Horn and his colleagues (Van Horn 1987a; Van Horn and Murray 1984, 1985; Van Horn and White 1997), as well as SRI's work at nearby LAN-47 (Altschul et al. 1992), suggested that the Ballona area was characterized by a material culture unlike that found elsewhere along the coast. The development of a small flaked-stone-tool, or microlith, industry apparently unrelated to the one developed on Santa Cruz Island suggested that cultural adaptation in the Ballona area involved a unique economic adaption. As a result of more-recent work as part of the PVAHP and other related data recovery excavations in the Ballona (including work presented in this series), it is apparent that microlith technology was not as prevalent as previously thought. Research questions related to technology centered on how prevalent and localized this tradition was, whether other facets of culture distinguish the Ballona from other groups, why this tradition may have appeared, and how the technology of the Ballona relates to that of inland sites, both economically and socially.

Several additional research questions are related to lithic technology. Across southern California, there is a general dearth of evidence of tool production, as opposed to simple maintenance of tools, from the Millingstone and early Intermediate periods (before ca. 2000 cal B.P.). What is the evidence of lithic production in the Ballona before the late Intermediate period?

The bow and arrow have traditionally been argued to have arrived in southern California around A.D. 500, during the late Intermediate period (Byrd and Raab 2007; Koerper et al. 1996; Koerper et al. 2002; Kroeber 1925). Hundreds of arrow points have been documented during the PVAHP. Two projectile points have been identified from contexts dating to the early Intermediate period (see Volume 3 of this series). How strong is the evidence that these points date to before A.D. 500? What evidence from sites outside the PVAHP is related to this issue?

Projectile point types offer a variety of types of information, including technological data, as well as inferences about sociocultural identity and trade. During analysis of concave-base Cottonwood Triangular projectile points, significant variations in length and thickness were found. What are the implications of these variations?

The use of raw materials, both local and nonlocal, in lithic-tool production varied through time in the analyzed collection from the PVAHP. What does this imply about trade and exchange through time in the Ballona? How do these patterns compare to those in other areas of the Los Angeles Basin? Are there patterns of resource exploitation through time in the record? What role did PVAHP sites play in raw-material-resource provisioning, exploitation, and consumption?

Ground stone has been an important tool for southern California hunter-gatherers for thousands of years. Ground stone tools were used for a variety of purposes, from grinding seeds and nuts to processing small animals. Given the multiple components of sites in the project area dating from roughly 6000 cal B.P. to the early Historical period, what patterns and functions can be seen at sites dating to different periods? Are there differences in the function and storage of ground stone through time? Does ground stone appear to have been connected to particular sites or settings?

In addition, what do the lithic tools in the PVAHP collection suggest about cultural connections, identity, trade, and interaction with other regions and cultural groups? For example, leaf-shaped Cottonwood Triangular points (also known as Canaliño) are culturally tied to the Chumash, located north of the project area. Other types of Cottonwood, Desert Side-notched, and Rose Spring (along the coast, referred to as Marymount) points are generally associated with inland and desert areas. How do the frequencies of these different projectile point types compare to those at other sites in the Los Angeles Basin, and what do the patterns suggest regarding coastal and inland interactions? The same can be asked for nonlithic tools, such as simple and compound fishhooks of shell and bone. Shell and bone fishhooks are diagnostic for time periods and can be attributed to cultural groups. Recent studies of possible culture contact in the Southern California Bight region (e.g., Arnold 2007; Jones and Klar 2005) are good examples of how these types of artifacts can be used to help understand possible culture contact. What is the evidence for shell or bone fishhooks in the Ballona? Was this technology used there? If so, were there changes in their use through time? If so, what might such changes suggest?

More generally, these questions are important not only for discussion of possible culture contact but also for an understanding of fishing technologies in the Ballona in general. What were the technologies used for fishing by the inhabitants of the Ballona? What is the evidence for these? Are there apparent differences in technology that could have been adapted for particular environments (bay/lagoon, nearshore, or pelagic fishing)? Is the evidence of fishing in the Ballona based on technology similar to or different from that found in other areas? What do the results of this comparison suggest?

Finally, technology can be seen not simply through individual artifacts but also through their use and accumulation in feature contexts. Given the hundreds of features identified in the project area, we should ask what types of features were present at sites in the project area through time, and how did they function? Are there differences in the function, organization, or spatial distribution of features through time? Are there specific feature types that may relate to a site's environmental setting (e.g., at the base of the bluffs vs. in the middle of the floodplain)? How do feature types and functions at sites in the project area compare to those of sites on the tops of the bluffs, other nearby Ballona-region sites, and sites farther away?

As has been suggested above, plank canoes (*tomol*) in the Chumash region to the north are documented as least as far back as 1,300 years ago (Arnold 2007; Des Lauriers 2005; Gamble 2002). These plank canoes were designed to carry heavy loads and/or numerous passengers and were constructed from dozens of planed redwood planks. Arnold (2007), Gamble et al. (2001), and others have argued that plank-canoe ownership was associated with high-status individuals. Des Lauriers (2005) has documented other types of oceangoing transportation besides plank canoes, including tule and dugout canoes. Arnold (2007:197–200) offered a detailed discussion of the material remains associated with plank-canoe construction, including large cakes of asphaltum, asphaltum plugs, redwood planks, planing tools (such as bone wedges and lithic or clamshell adzes), and milkweed fibers woven into line. What is the evidence, either direct or indirect, for plank canoes (including their production) and/or other seaworthy canoes in the Ballona?

Cultural Affiliation

According to various sources (Johnston 1962; McCawley 1996), the Ballona was occupied at the time of Spanish contact by the Gabrielino/Tongva. Others (Sutton 2009; Van Horn and Murray 1985), however, have argued that the Takin influence in the region is much older than previously recognized. Research questions related to cultural affiliation of indigenous groups in the Ballona area included the following: (1) Were the groups occupying sites below the bluffs culturally related to those residing on the bluff tops? (2) Is there evidence for pre-Gabrielino/Tongva or pre-Takic occupation in the area? (3) Can any sites in the area be associated with the village possibly named Sa'angna? and (4) How far back in time can Gabrielino/Tongva cultural traits be identified in the Ballona? Previous investigators had argued that throughout prehistory, the Ballona was used by small groups, none of whom lived there year-round. Today, we believe that the contemporaneous settlements above and below the bluffs formed a single, larger community that, by the Intermediate period, was sedentary during a portion of the year (Altschul et al. 2007).

The important question of Takic influence (that is, of Takic groups) in the region has been debated for more than 100 years. It has been consistently argued that there were two separate cultural groups living in the Los Angeles Basin over the past 8,000 years. Early in the human habitation of the area, an unnamed cultural group arrived, probably coming down the coast either on foot or by boat, and established itself in the area for thousands of years. The arrival of Takic groups from the Great Basin influenced cultural patterns and traditions in the Los Angeles area and established the cultural group known today as the Tongva or Gabrielino/Tongva. When did this occur? What are the prevalent traits associated with this intrusion? What was the result for local populations in the Ballona?

To help identify answers to cultural-affiliation questions for the more recent Mission period, we used information about Native American groups in portions of California documented by Spanish missions between 1769 and 1834. Cultural affiliation, although it can be discussed for all periods, can be more meaningfully addressed for the Protohistoric and Mission periods, for which such records are available. These records offer much information on cultural affiliation and ties between groups. For example, King (1994) has argued that there were Chumash surnames associated with the *ranchería* of Guaspet, located somewhere in the Ballona. In the same work, he identified Chumash surnames at the nearby *ranchería* of Comicrabit, located somewhere near Santa Monica, north of the Ballona. He has also suggested that there were strong marriage ties between Guaspet/Guasna and Santa Catalina Island groups. King (1994:11) has gone further and argued that the presence of Chumash surnames at Gabrielino/Tongva villages in the San Fernando Valley (El Escorpión) and at Comicrabit indicate that "the language boundary between the Chumash and Tongva [Gabrielino/Tongva] did not preclude social interaction." King has also asserted that the Chumash village of Humaliwo (Malibu) was a political center for both Gabrielino/Tongva and Chumash groups. Certainly, Mission documents, such as records of baptisms, marriages, and deaths of the inhabitants of the Los Angeles Basin, are important sources of data to better understand cultural affiliation and ties between groups. At the same time, some scholars have suggested that once Native Americans moved to the missions and began living there, patterns of marriage changed dramatically from their pre-Hispanic origins.

Material culture is certainly one piece in the puzzle for identifying cultural affiliation. Basketry, for example, has been clearly associated with particular cultural groups. Weaving techniques and designs are two important basketry attributes related to cultural affiliation. Projectile points are another important cultural-identity marker. Although not necessarily distinctive to a particular group, in southern California they do tend to indicate ties to particular areas. In the Mojave Desert north of the San Bernardino Mountains, for example, Cottonwood and Desert Side-notched projectile point types tend to have specific geographic distributions that may indicate ethnic or social differences (Mark Sutton, personal communication 2008). In the PVAHP collection, there were hundreds of Cottonwood projectile points yet only a few Desert Side-notched points. Among Cottonwood projectile points in the PVAHP collection, there were only a few leaf-shaped varieties (also referred to as Canaliños). What do these patterns indicate, if anything, about cultural affiliation? And, equally important, are these patterns meaningful indicators of cultural affiliations?

Finally, the burial area identified at LAN-62 offers an opportunity to investigate issues of cultural affiliation, culture contact, social identity, and social organization. Although a portion of the burial features in the burial area at LAN-62 could not be attributed to a particular period, many of those that could be dated fell within the Protohistoric and/or subsequent Mission period. The Mission period, as discussed above and in Chapter 3 of this volume, was a difficult time for Native Americans—one of fluctuating boundaries between ethnic and social groups. Chester King and John Johnson (1999) have discussed the idea that, given the surnames in Mission records, Chumash may have been living as far south as the Santa Monica area, immediately north of the Ballona. Along the margin of Chumash and Gabrielino/Tongva territory, there was certainly interaction and intermarriage. Gamble et al. (2001), for example, have suggested that the Chumash chief at Humaliwo (for which the modern town of Malibu is named) was from Santa Catalina Island (in Gabrielino/Tongva territory). Mission records suggested that at least one neophyte (i.e., a Native American who had been recruited and baptized by the mission) from Guaspet/Guasna, located in the Ballona, married a Chumash person from Muwu, located along the northern edge of Santa Monica Bay (King 1994:93–94). In addition, it is clear that, during the Mission period, gentiles (i.e., Native Americans who had not been recruited or baptized by the mission) were working in the fields and homes of ranchos and for the inhabitants of the Pueblo of Los Angeles. Gentiles took on new, Hispanic roles as cowboys, field laborers, and house staff and performed other nontraditional jobs. These arguments and facts suggest that, compared to prehistoric times, there was substantial social and political upheaval among the Chumash and Gabrielino/Tongva during the Mission period. The burial area at LAN-62 allowed a close examination of the social, political, and economic patterns represented by the individuals buried at that location during the Protohistoric and Mission periods. What roles and identities are expressed through burial features at LAN-62? Are they all traditional, or are there examples of more-Hispanic roles and identities? What evidence is there in the burial area of Gabrielino/Tongva and Chumash identities, and how is this expressed? How were traditional and introduced goods and ideas incorporated into the burial area?

Prehistoric Settlement, Community, and Persistent Places

Prehistoric settlement patterns in the Ballona are important aspects of human-land relationships. Certainly, settlement can be viewed in a variety of ways, from the physical relationships between a settlement and the surrounding environment and how people placed themselves across the landscape (à la Willey 1953) to a more culturally focused understanding of how and why the prehistoric inhabitants of the Ballona lived where they did. Since the very beginning of the project, SRI has been interested in understanding both general types of research topics. Traditionally, sites like LAN-62 and LAN-193 have been viewed as "villages" by archaeologists, but the defining traits of villages in southern California and how we identify them archaeologically are unclear. Although we have found deep and extensive middens, hundreds of features associated with daily life, ritual loci, and a highly concentrated burial area at LAN-62, it has been difficult to identify occupation areas in the Ballona that clearly represent what most anthropologists would regard as a village. We discuss this topic in greater detail in Volumes 2 and 5 of the this series.

Prehistoric communities in the Ballona also have been a topic of research. Early in the project, questions were raised as to whether the sites located on top of and below the bluffs were parts of the same community or were even temporally or culturally related to one another. As our understanding of site chronology in the Ballona has been refined over the years, it has become clear that the majority of sites in the Ballona were occupied during the Intermediate period, and that some sites were abandoned during the subsequent Late period. Altschul et al. (2007) have proposed that the cluster of Intermediate period sites near the Lincoln Gap—LAN-62 and LAN-211 below the bluffs and LAN-59, LAN-61, LAN-63, LAN-64, and LAN-206 on top of the bluffs—were part of one large community that persisted into the Late period and included intensive occupations at LAN-62 and LAN-211 and minor components at LAN-61 and LAN-63. This important issue is discussed in Volume 5 of this series.

Of all the sites in the project area, LAN-62 appeared to have had the longest occupation, extending from the early nineteenth century back at least 6,000 years. The very thick midden at the site contained strong examples of all the major occupational components identified in the Ballona. Certainly, some sites, such as LAN-64, contained significantly older components, but LAN-64 appeared to have a roughly 4,000-year gap in occupation between the early Millingstone and the Intermediate periods, whereas LAN-62 appeared to have been occupied almost continuously from the late Millingstone period through the Mission period. LAN-62, in fact, appeared to be an example of a persistent place (Schlanger 1992) in the Ballona. Persistent places, using Schlanger's (1992:97) terminology, are "neither strictly sites (that is, concentrations of cultural material) nor simply features of a landscape. Instead, they represent the conjunction of particular human behaviors on a particular landscape." Schlanger (1992:92) argued that persistent places can be created in three ways. First, they may be created through the recognition of unique qualities that make particular locations suitable for certain activities. These unique qualities may include the presence of freshwater, open marshland, good farmland, or vantage points. Second, persistent places may be created through cultural remains—such as hearths, shelters, or storage features—that allow and encourage reuse and reoccupation of an area. Third, persistent places may be created by the presence of cultural materials, such as grinding tools, that may be reincorporated into a systemic context through the process of reclamation, recycling, or reuse. Interestingly, Schlanger (1992:107) argued that persistent places evolve functionally through time. She argued that persistent places tend to form at former residential locations that later become peripheral (short-term camps), but others have more recently adapted Schlanger's concept in other contexts. For example, Littleton and Allen (2007) have argued that prehistoric burial areas are good examples of the persistence of place for aboriginal peoples. This concept is expanded further in relation to LAN-62 in the Discussion section at the end of this chapter.

Culture Adaptation

Based on the strong evidence of Protohistoric and Mission period occupation at LAN-211 noted in testing results, we developed a model of cultural adaptation that can be tested with data from subsequent intensive archaeological investigations at these sites (Vargas 2003; Vargas et al. 2003). These models are specifically focused on the late Protohistoric and Mission periods. The cultural-adaptation model combines the broad issues of subsistence, settlement, and technology under a larger rubric related to culture contact and also incorporates the archaeological, ethnographic, and historical data to present potential scenarios for early Historical period occupation in the Ballona area, as well as the accompanying patterns that might be seen in the resulting archaeological record. The scenarios differ largely in the inferred degree of interaction between Native Americans in the Ballona on the one hand and Missions San Gabriel and San Fernando Rey, the fledgling Pueblo of Los Angeles, or one of the Hispanic ranchos in the area (such as Rancho de los Quintos) on the other. The scenarios are Gentile or Renegade, Mission Support, and Rancho or Pueblo Support.

Gentile or Renegade Scenario

It is quite possible that LAN-62 and LAN-211 were occupied and used by non-Christianized gentiles, ex-neophyte renegades, or fugitive Gabrielinos/Tongvas. A gentile site is one that was inhabited by traditional native peoples who never entered the mission system. Throughout the Mission period, there were hundreds, if not thousands, of native peoples in the Los Angeles Basin who lived outside the direct sphere of Missions San Gabriel and San Fernando Rey. Review of baptismal records clearly shows that although these missions had influence over many *rancherías*, in some cases, only a few individuals were recruited, or baptized, from some of the *rancherías*. As a result, although some *ranchería* members may have chosen to enter the mission system, at least some in that community may have decided to stay independent and outside the direct influence of the missions. Another possibility is that LAN-62 and LAN-211 are renegade or fugitive sites: that is, sites created by estranged neophytes or runaways from the missions, living in the Ballona to escape retribution. Once natives entered the missions, were baptized, and became neophytes, it was understood that they were to maintain residence at the mission or mission establishment, except during brief trips to collect resources or to visit relatives (Engelhardt 1927; Johnston 1962; McCawley 1996).

There are few written accounts of military forays to gather runaways or renegade individuals. Nonetheless, it is clear from the writings of the missionary fathers that desertion was a problem. At Mission San Gabriel, until the year 1817, almost 10 percent of all converts deserted. Several small military incursions, such as that in 1811 to *rancherías* east of Mission San Gabriel, were usually in response to attacks on the mission or on other neophyte groups.

If Gabrielino/Tongva renegades were only briefly associated with the mission, it might be nearly impossible to differentiate the signature of a renegade site from one that was occupied by Gabrielino/Tongva gentiles. The difference between these occupations may be a matter of degree. An ex-neophyte renegade site might contain slightly more evidence of familiarity with mission commodities and practices, but there would be very little, if any, evidence of direct contact with Hispanic culture. Very few gentile settlements dating to the early Historical period are known in the Los Angeles Basin, and those identified are poorly represented in the literature. Sites that have undergone archaeological work generally lack conclusions regarding important considerations, such as site structure and integrity.

Gentile and/or renegade sites would be expected to have a generalized procurement strategy and a variety of taxa evident in the collection. Because of constricted collection range and the associated subsistence stress (overpredation), certain taxa might be represented by more juvenile or smaller individuals. Diet breadth expands predictably in response to constricted environmental circumstances (see Raab 1996; Raab et al. 1995). Domesticated-animal species probably would be found in gentile sites only in small quantities. At a renegade site, a slightly higher number of domesticates might be present, because ex-neophytes might have been more familiar with introduced plants and animals. The presence of significant numbers might indicate that the former neophytes were raiding cattle or other animals, a practice that was known to occur (Engelhardt 1927; Lightfoot 1995), even in the Ballona (Mason 2004). If domesticates were found, however, the butchering of the animals would likely have used traditional methods and a native tool kit.

In addition, in comparing this model to others to be discussed below, one would expect permanent, traditional settlement patterns, including structured use of space within the site; permanent houses in traditional styles; well-developed, diverse middens; numerous features representing a wide range of functions; formal burial practices (perhaps including a formal burial area) with traditional mortuary patterns; and the presence of ceremonial features.

Overall, although the difference in the archaeological signature between a renegade and a gentile site may be a matter of degree, we do expect some indication of contact with Hispanic lifeways, even if indirect. At renegade sites, we would expect the Hispanic influence to be more profound. Renegades, we assume, had some type of early relationship with the mission, however brief, and through this were exposed to Hispanic technology and goods. In both types of sites, the faunal collection should reflect a generalized subsistence strategy with permanent rather than seasonal occupation of the site, and many, if not most, of the lifeways expressed in the material culture found at the site should reflect the persistence of traditional practices.

Mission Support Scenario

In the Mission Support scenario, we hypothesize that neophytes in good standing and associated with Mission San Gabriel or San Fernando Rey might have established a camp in the Ballona for temporary subsistence procurement or in support of mission activities, such as basket making or ceramic manufacture. This scenario follows the view that Native Americans during the Mission period were relatively autonomous and able to continue many of their traditional practices outside and inside Hispanic institutions during the early Historical period.

Mission records (an admittedly biased source) from the early years of the mission system state that native peoples were not forced into the Christian fold. Engelhardt (1927), who wrote extensively on the practices at Mission San Gabriel, maintained that the Gabrielino/Tongva were free to choose whether they desired to become Christians. Although once gentiles chose to become converted, they were obligated to remain at the mission, the image of impoverished natives incarcerated within the mission walls is clearly inaccurate. Recent studies have indicated that some native cultural practices were tolerated, if not encouraged, by the fathers inside the mission system. On occasion, generally when prompted by necessity, neophytes were encouraged to leave the missions temporarily so that they could return to traditional subsistence practices to supplement meager diets. Mission Support sites, we expect, would have been short-term camps located within easy traveling distance from the host mission and established for the acquisition of traditional resources in areas where these had been traditionally exploited. There, neophytes might have pursued such activities as fishing, hunting, plant harvesting, shellfish collecting, and basket making.

Such camps would have lacked permanent structures, and middens would have been poorly developed and relatively homogeneous, with a limited number of animal and plant species. Because these sites would have been used for only a short period, they should reflect temporary, possibly seasonal, use and should contain evidence of highly focused subsistence activity and moderate or sustained contact with the missions. There would also be limited evidence of ritual activity or structured use of space. In addition, there would be evidence of a focused strategy of procurement and a low diversity of faunal remains. Although neophytes would probably have had greater access to domesticated plants and animals than gentiles, scant evidence of domesticates should be found in these temporary camps, especially if the function of the camps was to supplement the mission diet during times of shortage. We expect that during the early years of the existence of the missions, neophytes would have used a traditional tool kit, particularly in pursuit of traditional foods and raw materials. Lithic technology should reflect expedient manufacture and use of stone, and debitage should dominate the lithic assemblage at these types of sites.

Any nontraditional artifacts found would probably be associated with mission-related tasks or beliefs—e.g., crucifixes or rosary beads. Human burials should be few or absent at a Mission Support site, because Catholic practices necessitated burial at the mission cemetery. If people died away from the Mission or their native *ranchería*, they might have been cremated. If an interment did take place at a Mission Support site, we hypothesize that mortuary practices could mimic Christian styles, with few or no native artifacts interred with individuals. We did not expect to find evidence of traditional ritual activity at the site, following a neophyte's conversion to Christianity. Hackel (2003) and Douglass et al. (2007), among others, however, have argued that although neophytes were generally strongly tied to the mission and performed Catholic rituals, they also maintained strong Native American identity and continued to perform traditional rituals and practices. Raab (2009) has argued that the Chingichngish ceremonialism that flourished during the Protohistoric and Mission periods, though containing attributes rooted strongly in traditional ritual behavior, was also a "crisis religion," serving as a reaction to the intrusion of Hispanic colonialists. As a result, even in a temporary, seasonal habitation site occupied by neophytes, there might have been a mixture of Catholic and traditional ritual activity and paraphernalia.

In conclusion, then, a Mission Support site may appear very similar to a prehistoric seasonal or temporary resource-extraction camp, except for the presence of Hispanic items and perhaps Christian burial practices, if evidence of the latter is observed. Settlement would probably have been temporary, with little site structure; a poorly developed midden; few features, representing a restricted range of functions; and few (or no) burials, with those present located in an unstructured fashion or possibly exhibiting a Christian influence with respect to burial position and ceremony. A close relationship with either Mission San Fernando Rey or San Gabriel may be visible in the faunal collection, if evidence of a focused procurement strategy is discovered. That said, there probably would be few or no remains of domesticated fauna or of plants showing evidence of a focused procurement strategy.

Rancho or Pueblo Support Scenario

Finally, in the Rancho or Pueblo Support scenario, we hypothesize that the Mission period components of LAN-211 and LAN-62 were created by a group of gentiles, or possibly ex-neophytes, who were employed by Hispanic landowners. This scenario departs from the previous two scenarios in that the defining factor is not the type of cultural interaction between natives and Missions San Gabriel and San Fernando Rey but the relationship between Native Americans and their employers.

Native labor was economically important throughout California, and it was especially so in the Los Angeles Basin. Most of the labor involved in the founding of the Pueblo of Los Angeles was performed by non-Christian Gabrielinos/Tongvas (Engelhardt 1927). The pueblo was founded at the location of the Gabrielino/Tongva village of Yaangna in 1781; not long after, gentiles were regularly employed in the pastures, fields, and vineyards surrounding the little town. Communications between mission fathers, as well as journals and the recollections of visitors to the area, described the economic relationship between the budding pueblo and its native laborers (Engelhardt 1927; Greenwood 1989; Phillips 1980). Around the Pueblo of Los Angeles, gentiles were able to create economic labor relationships with pueblo settlers and to maintain a certain autonomy from the mission system while supplementing their native food sources. Gentiles worked as laborers in the fields and received one-third to one-half of the crops they harvested (Hackel 2005:311). These crops were primarily domesticated wheat, barley, and corn. During the late eighteenth and early nineteenth centuries, gentile Gabrielinos/Tongvas also worked as vaqueros and cooks and in a variety of other economic capacities and became important parts of the pueblo community (Hackel 2005:311). The settlement of Yaangna remained on the outskirts of the pueblo for many years, inhabited by native laborers and domestic servants. Mission records documented 65 baptisms at the village of Yaangna itself (as opposed to the normal pattern of baptism at the mission), and those baptized were from a large number of other villages, suggesting that Yaangna was a destination for Gabrielino/Tongva, perhaps those looking for work (Douglass 2009).

In 2003, when we wrote the research design for LAN-211, we knew that there was anecdotal evidence of Native American workers at Rancho La Ballona having lived at the base of the bluff. However, as determined from archival evidence collected during and after data recovery at both LAN-211 and LAN-62, it is now clear that those workers, dating to a period from roughly 1820 through perhaps the 1830s or 1840s, were probably Native Americans from elsewhere, as baptismal and pueblo records suggest they were from the Missions San Luis Rey and San Diego areas. Stoll et al. (2009) has documented that one baptism performed at Rancho La Ballona was actually of a neophyte from Mission San Diego rather than a Native American from the Ballona region. Our data suggested that LAN-211 and LAN-62 were used by the local native inhabitants until some time in the 1810s, before the establishment of Rancho La Ballona. Stoll et al. (2009:6) have also documented that from perhaps 1801 to 1809, a ranch named Rancho de los Quintos (named after its owner, Pío Quinto Zuñiga) operated in the Ballona and that the Quinto Zuñiga family had close contact with the inhabitants of the *ranchería* of Guaspet, located somewhere in the Ballona. For example, Quinto Zuñiga was the officiant at the baptism of a 30-year-old Gabrielino/Tongva woman from Guaspet in 1803, and his son, Quillermo, was the godparent to a child named José Francisco, a neophyte from Guaspet, in 1809. The children of Pío Quinto Zuñiga were half Native American; their mother was a neophyte from San Juan Capistrano (Stoll et al. 2009:6). It is clear, then, that if the inhabitants of LAN-62 and LAN-211 had contact with a local rancho, the closest one to these sites probably would have been Rancho del los Quintos.

There are two possible site types for this scenario: permanent and temporary. In a permanent setting, native laborers essentially "belonged" to a rancho, working and living there permanently. In the temporary site type, native laborers were employed temporarily, perhaps seasonally, and, when released, returned to their native village or *ranchería*. We suggest that the length of employment will have had a significant bearing on site structure: temporary sites will not have the same depth of deposit or diversity of features and artifacts that would be expected at a permanent workers' settlement.

The subsistence remains for this scenario ought to be distinct from the other proposed scenarios. Although some traditional subsistence practices probably continued, one of the defining characteristics of this site type will be the relatively large quantity of domesticated-animal remains in the faunal collection and their treatment. As discussed above, native ranch workers and fieldworkers were often paid for their services in goods, such as a portion of the crops they grew (Engelhardt 1927; Greenwood 1989; Hackel 2005; Johnston 1962; Kealhofer 1991; McCawley 1996; Phillips 1980). Beef would be expected to have made up a significant portion of the rancho workers' diet. Processing of food and other materials would probably also be different in this scenario; a much larger percentage of the faunal material would probably have been butchered using Hispanic techniques and metal tools. Thus, domesticates would be expected to make up a much larger relative percentage of this collection than of those from other scenarios.

Stone tools found in early Historical period sites should reflect a transition toward lower-quality, more-expedient tool types. Lithic collections should be dominated by debitage and utilized flakes and include little in the way of formal tools. Metal knives would have been present at ranchos and might have been given in payment to native laborers; so, stone-tool collections are likely to be dominated by expedient cutting and processing artifacts, such as utilized flakes used for processing meat rather than butchering. Locally available materials will probably dominate the collection, and nontraditional materials, such as ceramics and glass, will have been introduced.

In sum, then, the Rancho or Pueblo Support scenario will in some ways appear similar to the Mission Support model, with perhaps a temporary habitation area and expedient technology dominating the lithic collection. Unlike either the Mission Support or the Gentile or Renegade scenario, however, we would expect to find a much larger collection of domesticated plants and faunal remains at such a site, as well as a more diverse array of Hispanic tools and by-products. Burials and ritual activity may be traditional but may contain a wider array of Hispanic items with burials, perhaps associated with particular trades related to ranching and farming.

Discussion

On the basis of testing, we expected data recovery to yield Mission period components at both LAN-62 and LAN-211. Data recovery at LAN-211 (Van Galder et al. 2006) exposed a multicomponent site with evidence of occupation during the Intermediate, Late, Protohistoric, and Mission periods. Data recovery at LAN-62 (Vargas et al. 2005) uncovered a deep, stratified midden dating to between the late Millingstone and Mission periods, in addition to a large, complex burial area primarily dating to the Late period through the Mission period.

Given the data we collected at LAN-62 and LAN-211 during data recovery, the three models proposed in 2003 and described in the section above may not provide sufficient contexts for evaluating aspects of the remains identified at these sites. In part, this possible insufficiency is due either to new data identified at the sites (such as the burial area) or to new archival information that has come to light (e.g., Stoll et al. 2009). For example, these three models are portrayed in black-and-white terms; that is, LAN-211 was expected to have been used by either Gentile or Renegade groups, Rancho or Pueblo Support groups, or Mission Support groups. The burial area at LAN-62, as an extension, would have been used by one of these groups. In reality, these areas may have been used by a mixture of these groups at any given point in time. During the Mission period, individual Native Americans probably changed their identities through time in a fluid manner. The burial area at LAN-62, as will be discussed in Volumes 2–5 of this series, contained a mixture of burials, including some with Hispanic-originated artifacts and others with only aboriginal artifacts. It is likely that the burial area drew Native Americans from a much larger area than the archaeological sites in the project area. As a result, the grave goods associated with burials may suggest that there were aboriginals buried at LAN-62 who were renegades and/or gentiles, workers at nearby ranchos and the Pueblo of Los Angeles, and possibly individuals associated with the Mission San Gabriel. In the case of LAN-211, the Mission period component was probably used before and after the rancho nearest to the site (Rancho Los Quintos) was in existence. Rancho Los Quintos, as discussed in Chapter 3 of this volume, was in operation in the Ballona from approximately 1804 to roughly 1809. Although there were a few baptisms of residents of Guaspet during the 1790s, a large spike in baptisms from Guaspet occurred between 1803 and 1805, during the early years of Rancho Los Quintos (Stoll et al. 2009). This was probably not a coincidence. As a result, there may be evidence at LAN-211 for gentiles, neophytes, and Rancho or Pueblo Support Native Americans. As mentioned above in relation to the LAN-62 burial area, identities of individuals from LAN-211 may have evolved during their lives. During the Mission period, gentiles from LAN-211 may have begun working at nearby ranchos, for example, creating a pattern at the site of both gentile and rancho-supported people that cannot be distinguished archaeologically in the accumulated midden.

Generally, these three models of cultural adaptation are important, but they are more applicable as guidelines for understanding the contexts of LAN-211 and LAN-62. There was probably a plurality present at both sites, rather than a single identity. Following Silliman (2005; see also Silliman 2009), we must acknowledge that the Mission period in southern California was a time of colonialism rather than simple culture contact. Rather than short-term encounters, as culture contact implies, the Mission period was a time of sustained and severe alteration of the physical, social, and political arena in which Native Americans in the Los Angeles Basin had lived for thousands of years. The colonialism of the Los Angeles area was a process of cultural entanglement in which the native inhabitants were incorporated into a system of labor, religious conversion, and exploitation (Silliman 2005:62). Native Americans during this period adapted to colonialism in a variety of ways, including the three models discussed above, but also probably changed their identities and adaptations multiple times through their lives as situations changed.

An important part of our studies of LAN-62 and LAN-211 relates to how we may identify cultural and personal identity and culture change in the archaeological record. Take, for example, material culture and European artifacts found at Native American sites. At the Russian colony of Fort Ross, north of San Francisco (Lightfoot et al. 1998); the Mexican-era Rancho Petaluma in northern California (Silliman 2004); and the Chumash Mission period burial ground at Humaliwo (Bickford 1982; Gamble et al. 1996, 2001), evidence indicates that native peoples used and adopted European goods for either everyday use or special purposes but used them in ways that were not European but, rather, indigenous. In regard to the Chumash burial area at Humaliwo, for example, Bickford (1982:19–22) has documented parts of three European weapons buried with Native Americans. One of these, a pistol, was coated in part with asphaltum and was altered to be used as a receptacle of some sort. As will be discussed in Volume 3 of this series, two copper pots were identified in the burial area at LAN-62. One of these was wrapped in traditional textiles, and the bottom was smashed in a way similar to the deliberate destruction of ceramic and stone vessels by Native Americans in ritual contexts. Silliman (2005:66) suggested that examples such as these give little indication of acculturation, despite the presence of European artifacts at Native American sites and argued for studying material culture as not simply "native" or "European" but as items "taken up by individuals to forge their way in new colonial worlds" (Silliman 2005:68). These items and the identities created by Native Americans during the Mission period represent, and are part of, the resistance to, and residence in, colonial worlds (Silliman 2005:68).

Along the same lines, subsistence data from these sites offer much information regarding how the inhabitants of the Ballona reacted to colonial pressures. Certainly, there was a new economic landscape created during the Mission period, one that offered alternatives to traditional foods and uses of plants. At the same time, as Hackel (2005), Millikin (1995), and others have pointed out, this new economic landscape also placed pressures on traditional foods and plants via the introduction of animal herds and landscape-altering farming methods. Reddy (2009) has recently published some preliminary macrobotanical data from LAN-62 and LAN-211 and has argued that although introduced plants were used by the inhabitants of these sites during the Mission period, they appear to have been used in particular fashions. For example, there was a mixture of both native and introduced seeds in domestic contexts at LAN-211, indicating that specific introduced foods were consumed alongside traditional ones that had been collected for thousands of years. It is unclear whether Native Americans cultivated these introduced foods or obtained them as payment for labor. In contrast, Reddy (2009) detailed that only traditional plants were used as offerings in contexts adjacent to the burial ground at LAN-62. The incorporation of some introduced plants into some aspects of everyday life and the exclusion of them in other contexts are other examples of how the native residents of the Ballona wove their way through the new economic and political systems imposed on them during the Mission period.

The concept of history is an important aspect of understanding these patterns during the Mission period. History is something very different from a simple, linear ordering of events through time. In our view, history structures daily life. History dictates the meaning of places on the landscape and how they are used, how people relate to places and each other, and the ways in which people perform ceremonies and other activities. History is also a complex process through which the interactions of activities, practices, events, and circumstances create cultural and social change (Pauketat 2001, 2003). History refers to how activities, practices, intentions, and events are woven into a web of relationships that connects people to each other, to their ancestors, and to the world in which they live. The social and historical webs in which people live provide the foundation for understanding social life and social change. We view history as a means for understanding social relationships among people and places, who people are, where they came from, and the meaning of the past. Therefore, history was an important part of daily life to the inhabitants of the Ballona and played an important part in the identity and actions of these people during the Mission period.

It is within this context that we consider LAN-62 a persistent place on the landscape of the Ballona. As discussed earlier in this research design, persistent places (Schlanger 1992) are components of systemic landscapes that are reused over long periods while other locations are not. Through time, these persistent places change in function as the settlement moves and reorganizes (Schlanger 1992:107). For thousands of years, LAN-62 was occupied as a seasonal resource-procurement or perhaps habitation site located on an alluvial fan on the edge of the Ballona lagoon. It is possible that the alluvial fan on which the site is situated, as well as a seasonal spring running downslope from above, may have offered an advantage over other locales for early use areas below the bluffs. The bluffs overlooking the Ballona were occupied several thousands of years earlier, but LAN-62 appears to have been the first locale occupied below the bluffs. Whereas family members who died at LAN-62 were buried in irregular distributions at the site during the Millingstone and Intermediate periods, a specific and confined portion of the site began to take on a new function as a burial area during the Late period. Through time, as will be discussed in Volumes 2 and 4 of this series, this burial area became more and more compact, and its boundaries were demarcated by pieces of upright whalebone. It is possible that one factor in the creation of this area as a special location for burials related to the social memory and history of the site and its long occupational history—much longer than that of any other site in the Ballona. In Volume 5 of this series, we will expand and explore the idea of LAN-62 as a persistent place to better understand why the burial area was placed there and how the location may have been viewed by the prehistoric and early Historical period inhabitants of the Ballona.

During the Mission period, ethnic boundaries across southern California were in continuous flux as a result of a variety of social, economic, and political causes. Certainly, one strong effect on the movement of groups across the greater Los Angeles Basin was Mission San Gabriel. Soon after its establishment in 1771, Mission San Gabriel and, later, Mission San Fernando Rey recruited neophytes from farther and farther away from the missions proper. As a result, some villages were depopulated, and other ethnic groups may have moved into those vacated areas. For example, the Serrano moved into traditional Gabrielino/Tongva territory. This was certainly true in the traditional eastern Gabrielino/Tongva territory during the latter Mission period, as detailed by Bean and Vane (1995). As discussed previously in this chapter, King (1994) suggested a similar pattern along Santa Monica Bay, with the possibility of Chumash residing in traditional Gabrielino/Tongva territory. He argued that Humaliwo, a Chumash site, was a regional capital for both Gabrielino/Tongva and Chumash villages in the area. Important research questions for both LAN-62 and LAN-211 are the following:

What evidence of ethnicity exists? Does the evidence suggest that only Gabrielino/Tongva were present at these sites, or is there evidence to suggest the presence of other ethnic groups, such as the Chumash? Along these same lines, what evidence is there of social organization? Are burial patterns similar to those seen in Gabrielino/Tongva territory, or are there elements of those from Chumash territory? Data to answer these questions will be derived primarily from the burial ground.

Overall, then, we will use these three models as guides to our understanding of the Mission period as expressed archaeologically within the project area. However, as discussed above, the complexities of the patterns found at LAN-211 and LAN-62 are numerous and require additional consideration beyond what the models offer. We are interested in how the inhabitants of the Ballona responded to colonialism during the Mission period—how they may have variously resisted, adopted, and navigated changes such as new economies, damage to and restriction of traditional lands and resources, and religious conversion surrounding them. How did the identities of the native peoples change? The burial area at LAN-62 and the domestic context at LAN-211 will offer complementary, as well as distinct, insights into these questions.

Paleoenvironmental Background

Jeffrey A. Homburg and Diane L. Douglas
with contributions by Eric C. Brevik, Caroline Tepley, and Antony Orme

Models of landscape evolution are crucial for many archaeological studies, especially those in coastal settings and their associated estuaries. These environments are rich in resources that were utilized by prehistoric populations, like fish, shellfish, waterfowl, amphibians, and plants. The diversity and abundance of plants and animals available for human use has changed over time in response to environmental changes reflected in the landscape. Coastal lagoons were defined by Bird (1994) as areas of shallow water that were partly or completely sealed from the ocean by depositional barriers (sand or gravel) built above high-tide level by wave action. Bird (1994) also noted that the width of a marine entrance to a coastal lagoon is usually less than one-fifth the total length of the enclosing barrier and that coastal lagoons may vary in salinity from hypersaline to fresh. Throughout most, or all, of the last 6,000 years, the Ballona Lagoon has met Bird's definition of a coastal lagoon. Therefore, in this discussion, we refer to the Ballona Lagoon as a coastal lagoon, or simply "lagoon."

The dynamic interplay among geomorphic processes (e.g., sea-level change, sedimentation, longshore drift, subsidence, tides, storm events, and tectonic activity) results in the dramatic evolution of landforms and landscapes over different time scales (e.g., millennial, centennial, decadal, annual, and even shorter periods associated with individual storms). These processes affected the Ballona Lagoon and the surrounding wetlands of coastal southern California. Gradual infilling of the lagoon affected the availability of food resources in ways that had dramatic effects on human settlement of and adaptation to coastal California during prehistory.

A paleoenvironmental study was conducted as part of the PVAHP to provide insight into prehistoric use of the Ballona Lagoon over the past 10,000 years (see Figure 1). This study builds on an earlier paleogeographic model of landscape change (Figure 15) that was presented in the report on the Admiralty site (LAN-47) and the Channel Gateway site (LAN-1596H) (Altschul, Homburg, and Ciolek-Torrello 1992). Dates presented in this chapter are uncalibrated. The earlier model was not based on data obtained directly from lagoonal and wetland sediments; rather, it was based on changes in shellfish collections from previous archaeological excavations from the bluff and the wetlands that marked shifts from an open embayment to a closed and then semiclosed lagoon. It was also based on projections from previous studies of the development of similar lagoons in southern California reported by Antony Orme (personal communication 1991), a coastal geomorphologist and physical geography professor at UCLA.

The present paleoenvironmental study is modeled after the paleogeographic study by John Kraft, a geology professor at the University of Delaware, near the famous archaeological site of Troy in Turkey. Kraft and his colleagues collected cores from what is now farmland near the hilltop site of Troy. They analyzed sediment, pollen, mollusk, and radiocarbon samples from the cores and showed that strata dated to the time of the Trojan War were indeed indicative of an embayment that could be navigated by types of boats that existed at that time. This result matched historical accounts of the environment near the city believed to be Troy (Kraft et al. 1980, 1982). Kraft's research formed the template for the paleoenvironmental study of the PVAHP. The opportunity provided by the PVAHP is rare: the chance to core and reconstruct extensively the paleoecology of a lagoon that is known to have been important to prehistoric populations but has been the subject of little archaeological study.

The Ballona paleoenvironmental study reported herein was designed to complement the archaeological excavations at sites in the PVAHP area. This research was aimed at providing a geoarchaeological context for interpreting the distribution of habitats and the evolution of landscapes used by ancient peoples who lived in the Ballona. At the outset, there were two major research objectives: (1) reconstruction of Holocene landscape change in the Ballona Lagoon and adjacent wetlands and (2) evaluation of the relationship between archaeological-site distribution and Holocene landscapes. To meet these research objectives, an extensive coring program was completed to document the stratigraphy and to map the distribution of marine, estuarine, and terrestrial deposits during different periods. Analyses of sediment, chronometric, microfossil, and shellfish samples from cores to reconstruct the succession of landforms were completed and then integrated with archaeological data regarding site distributions in order to evaluate the effects of landscape change on human occupations in the Ballona.

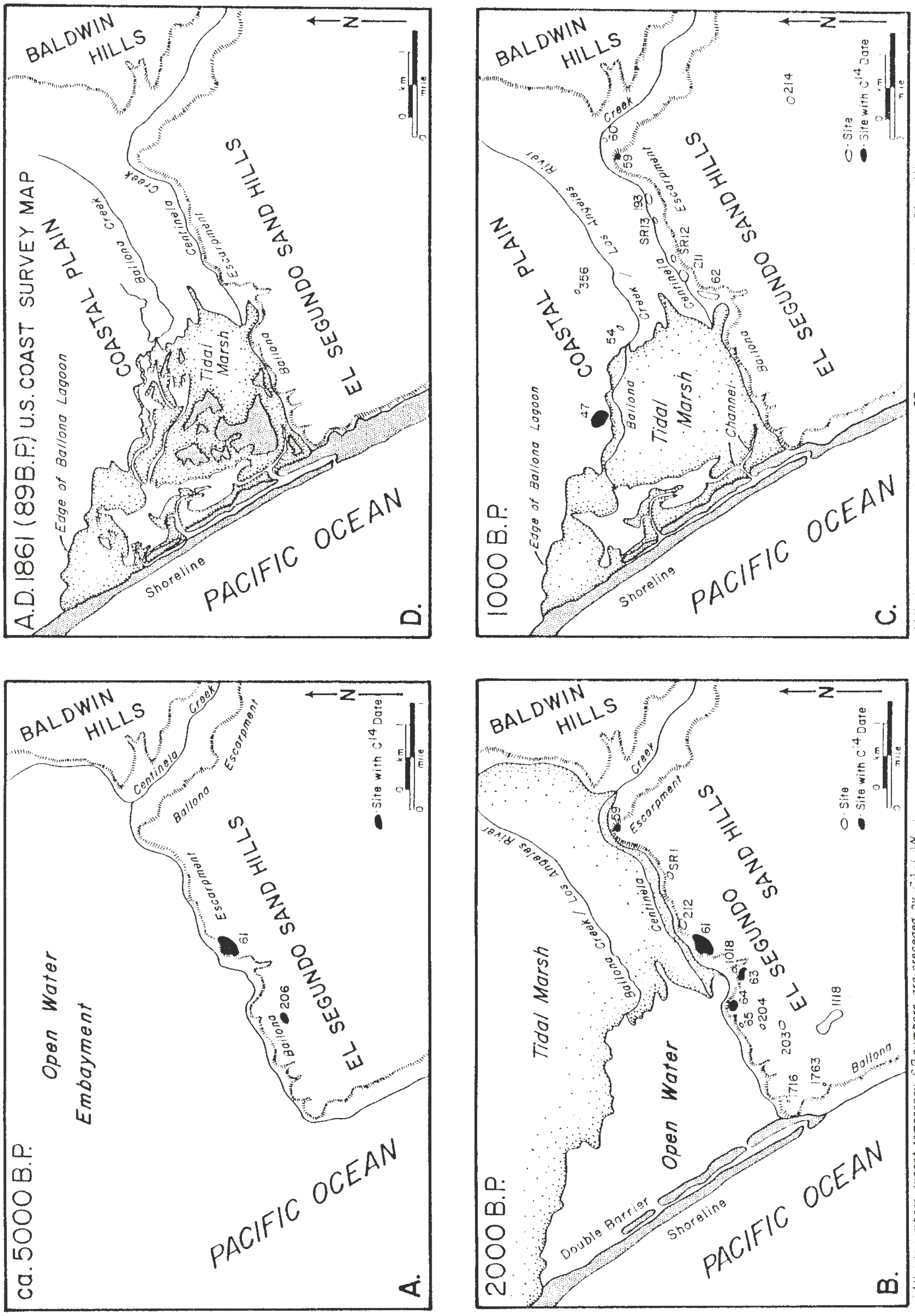

Figure 15. Previous paleographic model of the Ballona region (from Altschul, Homburg, and Ciolek-Torrello 1992:Figure 122). This reconstruction reflects the evolution of our understanding of local landscape change and the boundaries of the region's archaeological sites when this work was published.

Four distinct cultural adaptations were identified, each associated with a particular stage of landscape and lagoonal development over the last 7,000 years: (1) the Millingstone period (8500–3000 cal B.P.), marked by short-term occupations in bluff-top and alluvial-fan settings that overlooked a shallow bay or lagoon; (2) the Intermediate period (3000–1000 cal B.P.), characterized by an influx of population, distributed on bluff-top, creek-edge, and wetland settings; (3) the Late period (1000 cal B.P.–A.D. 1542), marked by population aggregation around the lagoon; and (4) the Historical period, which included occupations on the bluff and on alluvial fans associated with the Protohistoric (A.D. 1540–1770), Mission (A.D. 1770–1834), and Rancho (A.D. 1834–1848) periods. Results of this study indicate that estuarine conditions prevailed after a barrier at present-day Playa del Rey closed off part of Santa Monica Bay, about 4400 B.P. (uncalibrated). The resulting lagoon stabilized by about 3800 B.P. (uncalibrated) and then began shrinking dramatically after 1500 B.P. (uncalibrated), as it continued to fill with alluvium from Ballona Creek, the Los Angeles River, and Centinela Creek. Biotic productivity, however, increased over time as freshwater influences became dominant. Human settlement expanded from bluff-top settings to creek-edge alluvial fans at the base of the bluff and into seasonally dry wetlands that formed around the lagoon and tended to move westward through time. Initial occupation focused on the Baldwin Hills and Westchester Bluffs during the Millingstone period, shifted to riparian areas on the edges of alluvial fans next to Centinela Creek during the Intermediate period, and ended in settlements at and upstream of the mouth of Centinela Creek and in the wetlands around the Ballona Lagoon during the Late and Historical periods.

Current Environment

Three microenvironments have been identified in the Ballona area: (1) high tidal flats, consisting of salt marshes dominated by several species of pickleweed (*Salicornia*) and saltgrass (*Distichlis spicata*); (2) tidal slopes, characterized by a mudflat environment conducive to shellfish colonies; and (3) the estuary at the mouths of Ballona and Centinela Creeks, marked by riparian vegetation, such as willows (*Salix lasiolepis* and *S. laevigata*) and cottonwood (*Populus fremontii*). Today, typical salt-marsh species include members of the Chenopodiaceae family: pickleweed (*Salicornia virginica* and *S. subterminalis*) and seablite (*Suaeda californica*). Another chenopod, saltbush (*Atriplex*), is common in disturbed salt-marsh habitats (Gustafson 1981). Saltgrass is common around the salt marsh, in salt pans, and on sandy islands. The freshwater habitats are dominated by cattail (*Typha*) and tule (*Scirpus californicus*, *S. robustus*, and *S. olneyi*). Trees currently in freshwater habitats include cottonwood and willows. Historically, Ballona and Centinela Creeks also hosted sycamore (*Platinus racemosa*) and oaks (possibly coast live oak, *Quercus agrifolia*).

Prior to development, the slopes of the bluff above the marsh were probably covered by coastal sage scrub (Küchler 1977) dominated by coastal sagebrush (*Artemisia californica*), prickly pear (*Opuntia occidentalis*), deerweed (*Lotus scoparius*), and various grasses and members of the sunflower (Compositeae) family. Today, abandoned agricultural fields in the area host many weeds, including members of the Chenopodiaceae (*Salsola* and *Chenopodium*) and Brassicaceae (*Brassica* and *Raphanus*) families (Gustafson 1981). Similarly, prior to creation of the marina and other developments in the Ballona Lagoon, vegetation of the bay-mouth bar impounding the lagoon would have been different from today—in the past, this area would have hosted the Southern Seashore vegetation type (Küchler 1977). Currently, pink sand verbena (*Abronia umbellata*), beach-bur (*Ambrosia chamissonis*), and chamisso beach lupine (*Lupinus chamissonis*) are common on the barrier dune and on dunes in the lagoon.

Net littoral drift in the Ballona area is from north to south. Current mean tidal range is about 2 m, with a maximum range approaching 3 m (Antony Orme, personal communication 1999), making this a mesotidal coast. Barriers on mesotidal coasts tend to be short (approximately <15 km) and dissected by numerous tidal inlets (Martin and Domínguez 1994).

The climate of the California coast is classified as Mediterranean and includes two well-defined seasons: a temperate, wet winter and a moderate, dry summer. Mean annual precipitation is 350 mm. The dominant fall-winter precipitation occurs between October and March, with the heaviest rains from December through February. Summer rain is almost nonexistent. The high-pressure system developed west of the coast of California over the Pacific Ocean controls the coastal climate. The mean annual temperature at LAX is 20°C; the mean minimum is 5°C, and the mean maximum 32°C. Temperatures rarely exceed 38°C or go below freezing. Marine air masses keep the relative humidity moderately high year-round, generally about 65 percent. Fog is frequently present in the spring and summer but usually dissipates by noon.

Project History

This paleoenvironmental study was initiated to address research questions outlined in the research design for the PVAHP (Altschul et al. 1991:23–25). In particular, this study was designed to address questions pertaining to (1) identification of depositional environments and geomorphic surfaces in the project area, (2) establishment of the rate and timing of sedimentation in and around the Ballona Lagoon, and (3) examination of the relationship of landforms and landscape change to the distribution of archaeological sites in the project area. Fieldwork began with a reconnaissance on January 9 and 10, 1995, to identify possible core locations. Our initial plan was to place five cores at 1-km intervals, extending from the western edge of the project area (the west side of Ballona Lagoon and immediately east of Playa del Rey) eastward to the eastern boundary of the project area (the area where the Los Angeles Clippers' training facility was built in 2006–2007) (see Figure 3); this transect roughly parallels the base of the bluffs on the southern edge of the project area. At an approximate right angle to the first transect, another transect was planned, with cores spaced at 200-m intervals; this second transect extended northward from LAN-62, roughly paralleling the east side of Lincoln Boulevard. The two transects formed a cruciform, sampling the depositional environments represented inland from the coast and northward from the base of the bluff.

Because of heavy winter rains and high water in the marsh of the Ballona Wetlands, the cores could not be obtained when the task was first scheduled on January 24 and 25, 1995. Coring was rescheduled several times during the winter and spring of that year, but the rains and high water prevented us from completing the task until the summer dry season. Ten cores were obtained on August 23 and 24, 1995. While collecting the cores, we found that about half of the originally planned core locations were either inaccessible to a truck-mounted coring device or were in areas of contaminated soil, and they had to be moved to nearby locations that were accessible. The locations of the 10 cores (Cores 1–10) from the two transects are shown in Figure 16. Core 8 marks the cross-transect in the cruciform of core locations. The 10 cores were extracted using a hollow-stem auger, a device that permits intact sediment samples to be extracted from a barrel inside the auger. The cores were 5.1 cm in diameter and were extracted at depths up to 15 m b/s. Core segments were collected at 1.52-m intervals. Tony Morgan of Quaternary Investigations, Inc., in Colton, California, supervised the coring operation, assisted by Antony Orme and Jeffrey Homburg. An additional core (Core 11) (see Figure 16) was later collected by Owen Davis and Manuel Palacios-Fest using a handheld vibracore. This core was obtained from the lowest part of the Ballona wetland to sample the most recent sediment of the Ballona Lagoon in an area that was inaccessible to the truck-mounted, hollow-stem auger.

Several years after the original 11 cores were collected for the paleoenvironmental study of the Ballona, more than 200 additional cores were collected for the purposes of identifying and delineating the boundaries of buried archaeological deposits that had little or no surface indications of their presence; these cores were collected mainly from areas planned for development that were near or on known or suspected archaeological sites. Although these cores (those numbered higher than 11) were not collected specifically for the paleoenvironmental study, they were used, when possible, to fill in gaps in the Ballona stratigraphy and paleoecological data not obtained from the original 11 cores. Selected cores were used to describe and interpret the stratigraphy of the Ballona Lagoon, as well as to obtain additional sediment, radiocarbon, and mollusk samples, as needed (Table 1).

Complete descriptions were written for all cores (see Appendix A of this volume). Sediment analyses of the core samples included particle size, organic carbon, micromorphology, and mineralogy. Shellfish, charcoal, wood, and organic-rich sediments from cores were radiocarbon dated. Paleoecological analyses of pollen, diatoms, foraminifera, and ostracodes were completed, focusing mainly on Cores 1 and 8. Mollusks were also analyzed, but using a different set of cores (see Chapter 7 and Appendix B of this volume). Based on these analyses, depositional environments were interpreted, and representative stratigraphic cross sections of the lagoon were prepared.

Analyses focused on Cores 1 and 8 for the following reasons. Core 1 was placed to sample the juncture of the back side (the side away from the coast, to the east) of the barrier feature (a coastal spit on which present-day Playa del Rey is located) and the western edge of the Ballona Lagoon, an important feature of the landscape that was created by formation of the barrier. Core 1 was placed at this juncture to obtain a stratigraphic record that enabled reconstruction of the evolution of the Ballona Lagoon before, during, and after formation. Core 1 is crucial for providing an overall environmental context for the archaeology of the project area. By contrast, Core 8 was placed immediately north of the alluvial fan at LAN-62, so that we could reconstruct the environment at the transition between the lagoon and terrestrial environments as well as the local environment near this important site (see Volume 2 of this series for information on this site). Based on earlier investigations by Van Horn (e.g., Van Horn 1987a), from the start of the PVAHP paleoenvironmental study, we believed that LAN-62 had the longest and most intensive occupation span of all sites in the project area, an interpretation that was later proven correct by archaeological excavations. We hypothesized that Core 8 marked an area where the lagoon was stabilized for a substantial span of time, which could help explain why LAN-62 had such a long record of occupation.

Over the subsequent decade, the cores collected from the Ballona Lagoon were sampled, and several analyses were completed for the different studies—(1) stratigraphy by Eric Brevik, Jeffrey Homburg, Caroline Tepley, and Antony Orme; (2) ostracodes by Manuel Palacios-Fest; (3) pollen by Owen Davis; and (4) diatoms and foraminifera by Richard Boettcher and Stanley Kling. Most of the analyses were completed by the late 1990s. However, in 2003 and 2004, additional analyses were completed: mollusk analysis by Steven Shelley and interpretation of paleoclimate and paleoethnobotany by Peter Wigand, based on Owen Davis's pollen analysis.

Since 2000, the results of this paleoenvironmental study have been published in different venues before publication of this volume on the complete results. Several papers and posters were presented at professional meetings (e.g., the Society for American Archaeology, the Society for California Archaeology, the Geological Society of America, the Soil Science Society of America, the International Limnogeological Congress, and La Sociedad Mexicana de Paleontología) and published in

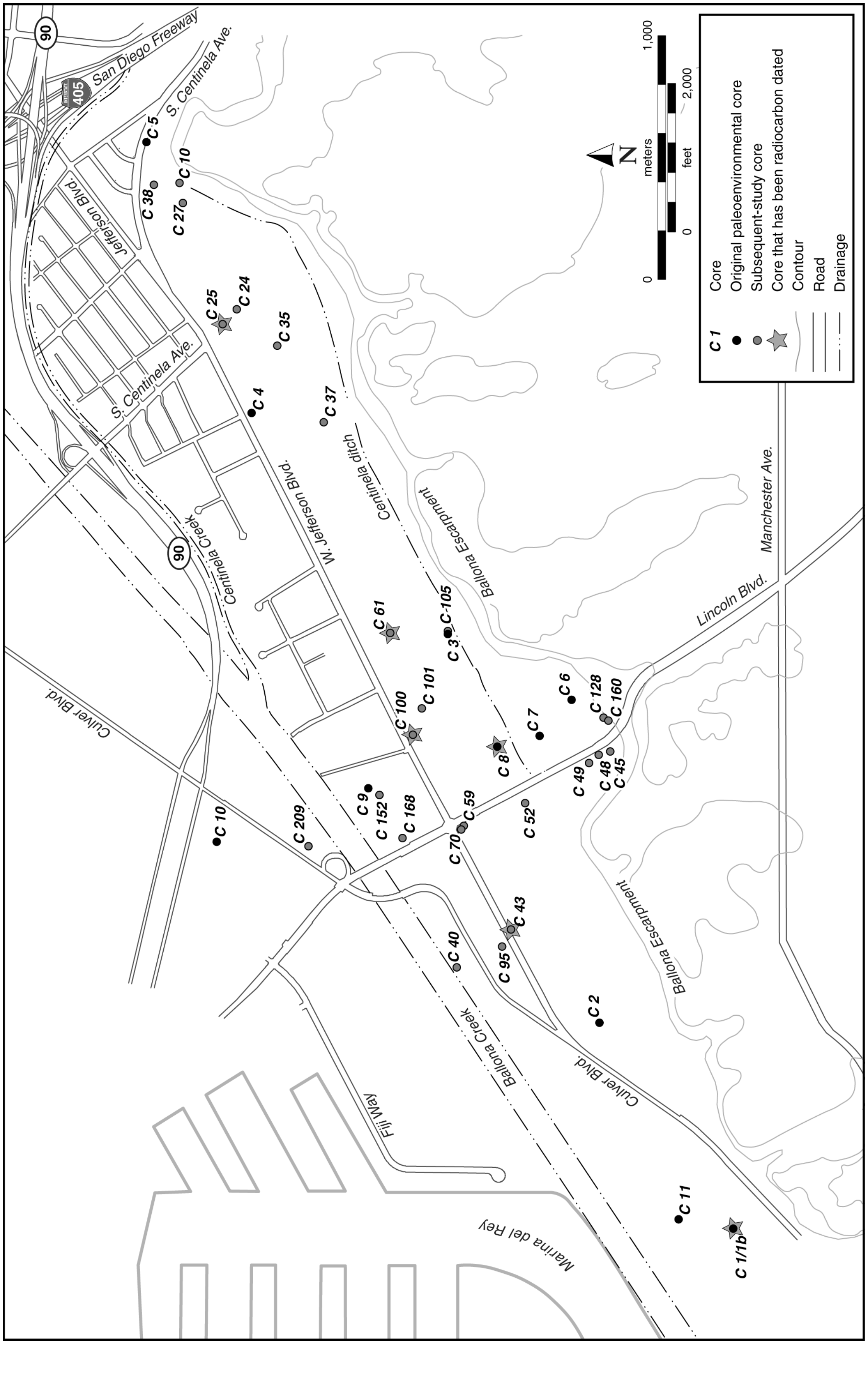

Figure 16. Locations of cores collected from the Ballona Lagoon.

Table 1. Cores, Archaeological Sites, and Other Sampling Localities Analyzed in Volume 1

Sampling Localities	Stratigraphy	Radiocarbon Dating	Mineralogy	Mollusks	Ostracodes	Pollen	Diatoms and Foraminifera
Core 1/1b	X	X		X	X	X	X
Core 5					X[a]		
Core 8		X			X	X	X
Core 10				X	X[a]		
Core 11					X	X	
Core 24	X			X			
Core 25	X	X		X			
Core 27	X						
Core 35	X						
Core 37	X			X			
Core 38	X						
Core 40				X			
Core 43	X	X		X			
Core 45	X			X			
Core 48	X			X			
Core 49	X			X			
Core 52				X			
Core 59				X			
Core 61	X	X					
Core 70	X			X			
Core 95	X						
Core 100	X	X	X	X			
Core 101				X			
Core 105	X						
Core 128			X				
Core 152	X						
Core 160			X				
Core 168	X						
Core 209	X			X			
LAN-62			X				
LAN-64			X				
LAN-211			X				
LAN-1932			X				
LAN-2676			X				
LAN-2768			X				
LAN-2769			X				
Playa del Rey beach/dunes			X				

Note: Stratigraphy is discussed in Appendix A, radiocarbon dating in Chapter 7, mineralogy in Appendix A1, mollusks in Appendix B, ostracodes in Appendix D, pollen in Appendixes C and C1, and Diatoms and Foraminifera in Appendix E of this volume.

[a] No ostracodes were recovered.

refereed journals (*Catena, Ciencias Marinas,* and *Proceedings of the Society for California Archaeology*). References include professional papers, posters, and publications by Altschul et al. (2005), Brevik and Homburg (2000, 2004), Homburg (2003), Homburg et al. (2001), Mbila and Homburg (2000), Palacios-Fest and Homburg (2002a, 2002b, 2002c, 2003), Palacios-Fest et al. (2007), and Shelley et al. (2003, 2004).

Sampling Design

In all, 25 cores were analyzed in this paleoenvironmental study. Table 1 summarizes the analyses of these cores (locations shown in Figure 16). As noted above, Cores 1 and 8 were the foci of the analysis. Most or all of the pollen, ostracode, diatom, and foraminifera samples were collected from those two cores. Unfortunately, the original 10 cores were discarded in 1996 before additional samples could be obtained for analysis. Fortunately, many samples had been collected from Cores 1 and 8 before the cores were discarded; pollen samples had been collected from these two cores at 10-cm intervals, and ostracode, diatom, and foraminifera samples had been collected from these two cores at 20-cm intervals. One problem we encountered was that Core 1 was discarded before radiocarbon samples were taken. To develop a chronology for this core, we collected a second core (Core 1b) from a location approximately 1 m away from that of Core 1. Radiocarbon dates for Core 1b were interpolated to Core 1 based on the stratigraphy of each core (see Appendix A of this volume). Additional ostracode samples were collected from Cores 5 and 10, but those samples were mainly from terrestrial deposits devoid of ostracodes and could not be used for the paleoenvironmental reconstruction. Radiocarbon samples had also been collected from Core 8, and pollen and ostracode samples had also been collected from Core 11, the one collected from the topographically lowest part of the Ballona Wetlands using a vibracore.

The stratigraphic study and radiocarbon dating focused on other cores from representative parts of the project area (see Table 1). Core 100 became especially important to the stratigraphic study, because it was taken closest to the original location of Core 8, one that had been discarded before its stratigraphy could be thoroughly analyzed. As with the stratigraphic analysis, we found that additional cores had to be analyzed to develop a comprehensive reconstruction of invertebrate (including mollusk) paleoecology in the lagoon. The invertebrate analysis relied on 15 cores. Because of the paucity of macroscopic mollusk shells in many of the cores, it was necessary to examine a larger number of cores to obtain a sufficient sample of mollusks. The absence or low frequency of mollusks was not surprising, given that the cores were only 3 inches (7.6 cm) in diameter. This small diameter required the collection of more cores in order to obtain a representative sample of mollusks from different stratigraphic units.

Environmental Summary

Geologic History of the Los Angeles Basin (the Ballona Lagoon)

Achieving an understanding of the paleoecological evolution of the Ballona Lagoon requires understanding the geology of the Los Angeles Basin. Southern California is, tectonically, very active. The Ballona is located on the southwestern block of the Los Angeles Basin (Figure 17) (Norris and Webb 1990), which is bounded by the Newport-Inglewood fault on the east, the Santa Monica Mountains on the north, and the Pacific coast on the west and south. The basement rocks are mainly green chlorite and blue glaucophane schists that are part of the Franciscan Formation. These rocks are always in fault contact with other basement rocks, have no known base, and have not been reliably dated. The best current estimate of their age is late Jurassic (ca. 150 mya) to late Cretaceous (ca. 65 mya) (Norris and Webb 1990) (Figure 18). During this period, the southern California coast was located to the northeast, in the area now occupied by the Sierra Nevada (Caughman and Ginsberg 1981).

According to Norris and Webb (1990), late Eocene (54.8–33.9 mya), Oligocene (33.9–23 mya), and early Miocene (23–16.5 mya) nonmarine sedimentary beds in the Santa Ana and Santa Monica Mountains indicated that the basin was above sea level during those times. By roughly 22 mya, the Los Angeles Basin broke apart because of the earlier subduction of the East Pacific Rise beneath that area. During the middle Miocene (16.5–11.6 mya), volcanic activity and the rotation of crustal blocks dominated geologic processes in the basin. By the end of the Miocene (ca. 5.4 mya), the Los Angeles Basin was flooded by the Pacific Ocean. During the Pliocene (5.4–2.5 mya), the central basin continued to subside while the marginal blocks, including the southwestern block, were uplifted. By the middle of the Pleistocene (ca. 1.2 mya), the ocean shoreline was probably along the Santa Monica Mountains to the north and the Whittier fault zone to the east. The Coast Range orogeny caused considerable uplift of the southwestern block during the middle Pleistocene (Norris and Webb 1990). That was the last major deformational episode in the Los Angeles Basin, and major tectonic uplift in the Los Angeles Basin probably ceased by about 300,000 B.P. (uncalibrated). However, the southwestern block is probably still undergoing very slow uplift (Norris and Webb 1990).

Reconstructions of the Ballona

Previous attempts to reconstruct the paleogeography of the Ballona were largely based on a general understanding of the

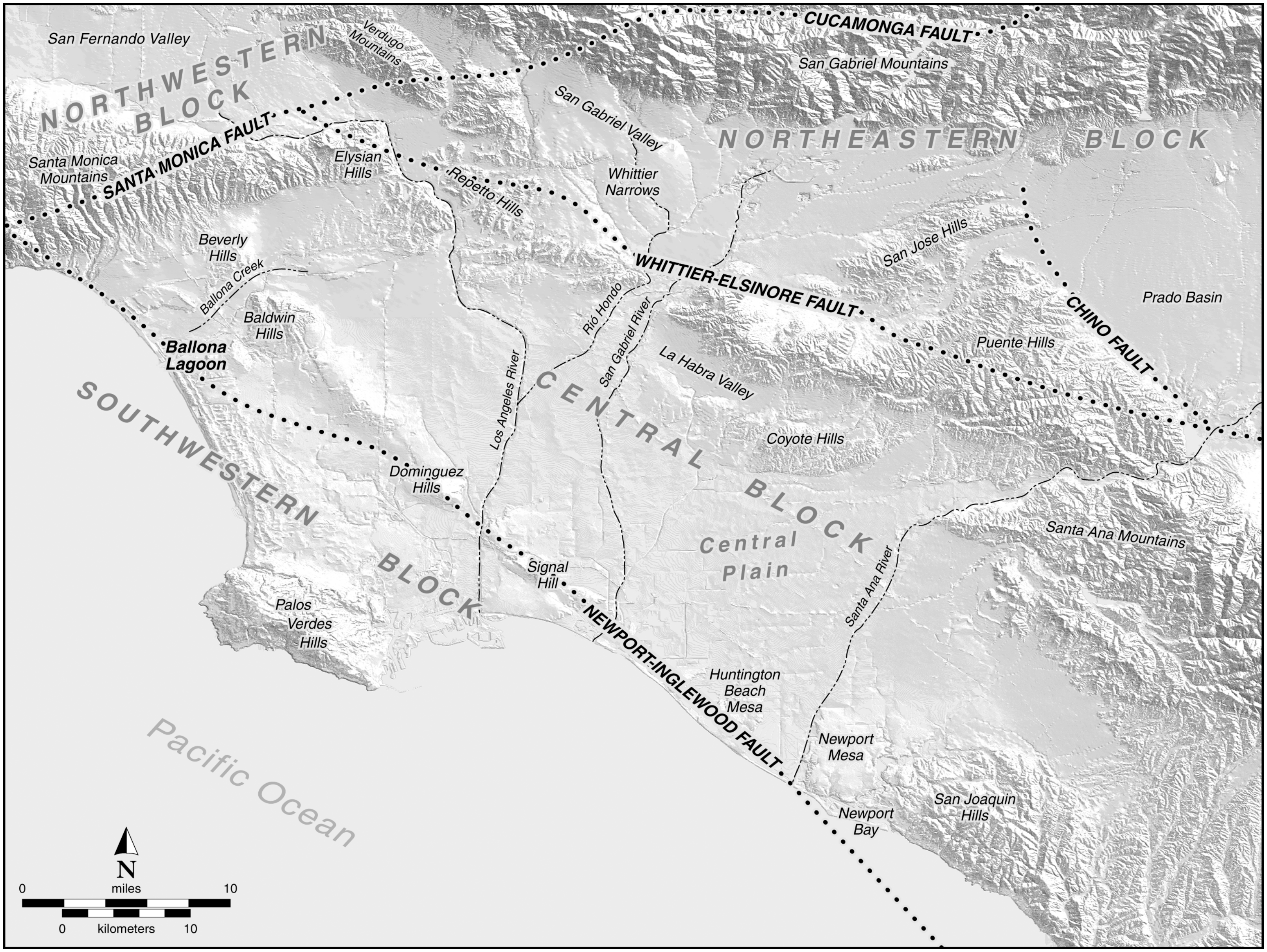

Figure 17. Structural geology of the Los Angeles Basin.

Figure 18. Geologic time periods.

Era	Period		Epoch	Millions of Years B.P.
CENOZOIC	Quaternary		Holocene	0.01
			Pleistocene	2
	Tertiary	NEOGENE	Pliocene	5
			Miocene	25
		PALEOGENE	Oligocene	38
			Eocene	55
			Paleocene	67
MESOZOIC	Cretaceous		Upper	100
			Lower	140
	Jurassic		Upper	160
			Middle	180
			Lower	200
	Triassic		Upper	205
			Middle	215
			Lower	250
PALEOZOIC	Permian		Upper	270
			Lower	290
	Pennsylvanian			330
	Mississippian			365
	Devonian		Upper	385
			Middle	390
			Lower	405
	Silurian		Upper	415
			Lower	425
	Ordovician		Upper	460
			Middle	485
			Lower	500
	Cambrian		Upper	515
			Middle	540
			Lower	570

area's geology as has been presented above, including the pattern of Pleistocene sea-level rise and an understanding of the general progression as a coastal lagoon fills with sediment. Locations of archaeological sites and their shellfish assemblages and radiocarbon dates were used to approximate the timing of infilling of the Ballona Lagoon (Altschul, Ciolek-Torrello, and Homburg 1992; Altschul, Homburg, and Ciolek-Torrello 1992). Detailed geologic studies often aid archaeologists who attempt to reconstruct the cultural history and paleoenvironmental dynamics of an area.

A primary goal of this study was to delineate the lagoon edge and to document how it moved over time, because the location of the lagoon edge was probably an important factor in determining how and why prehistoric land-use patterns shifted through time. "Lagoon edge" is not a technical term used by geoscientists, but because of the importance of this landscape position to the archaeological record, we have used it as a term in this study (see Appendix A of this volume). The lagoon edge, as defined for the purposes of this study, is basically equivalent to the intertidal zones shown in Figure 19.

Detailed environmental summaries have been provided by Altschul, Homburg, and Ciolek-Torrello (1992) and Grenda et al. (1994), as well as in Chapter 2 of this volume; therefore, such a summary is not presented here. The following discussion summarizes the historical-period and modern environment of the project area.

The project area is in semiarid coastal California and is bounded by a 30–45-m-high bluff (the Ballona Escarpment) and the Del Rey Hills to the south, the coastal plains to the north, the Baldwin Hills to the east, and the Pacific Ocean to the west (118° 30' W, 34° N). The Ballona Gap, on the north side of the Baldwin Hills, held a brackish lagoon that was nearly destroyed in the early 1960s by construction of Marina del Rey. The Ballona Lagoon, a large (6-km^2) freshwater and saltwater marsh, was fed historically by Ballona and Centinela Creeks.

Before recent development, the Ballona Lagoon was shaped by the local hydrology and tectonics. Grant and Sheppard (1939) suggested that the sharp escarpment to the south of the lagoon was the result of tectonism along a fault line and/or lateral migration of the ancestral Los Angeles River sometime during the Pleistocene. The El Segundo Sandhills south of the project area stretched from the bluff of the Ballona Escarpment south to the Palos Verdes Hills and inland for 3–6 miles. Local sediments and soils in the Ballona are characterized by a mix of unconsolidated silts, gravels, and sands associated with stream action; silt and sand associated with the lagoon; and sand associated with beach deposits.

Ballona Creek was often interrupted by a series of fault lines between the Ballona Escarpment and the Santa Monica Mountains, which caused patchy surface runoff and underground flow along its channel. The shifting channel of the Los Angeles River frequently joined Ballona Creek rather than flowing within its modern, now-channelized course toward San Pedro Bay (Gumprecht 1999). Historical records showed

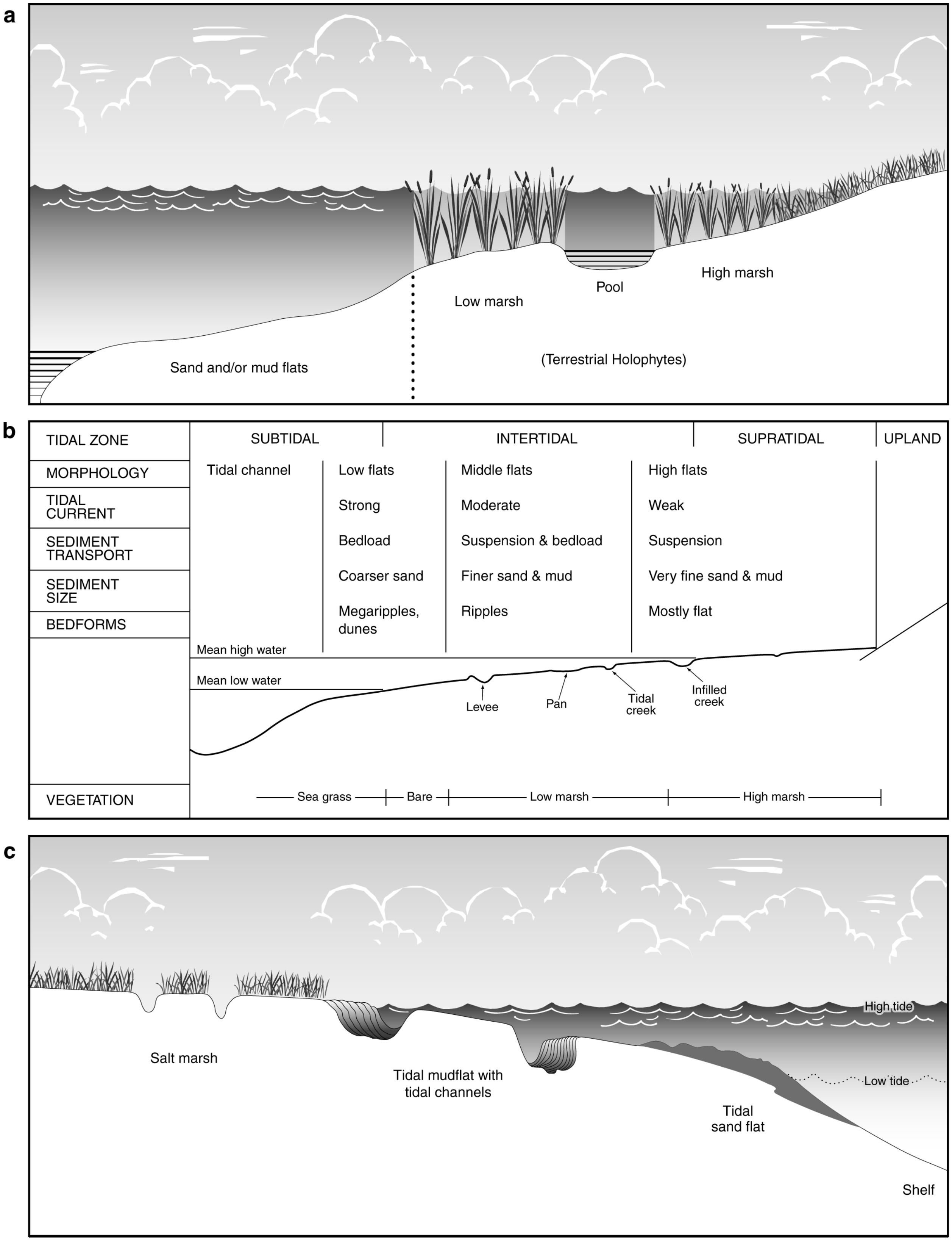

Figure 19. Three general models for the transition from lagoon to terrestrial environments adapted from (*a*) Reise (1985:Figure 2.2c); (*b*) Orme (1990:Figure 2.6c); (*c*) Daniels and Hammer (1992:Figure 6.11).

that significant flooding events occurred in 1815, 1825, 1862, and 1884. During the last two of those floods, some of the Los Angeles River floodwaters were diverted through Ballona Creek into the lagoon; further flooding was prevented by civil-engineering projects that started in the 1930s. The prehistoric record also showed evidence of frequent switching of the course of the Los Angeles River. Because of this switching, flow was insufficient to flush out the Ballona Gap; the result was an impounded lagoon formed behind the barrier feature where Playa del Rey was established. In 1887, the Ballona Lagoon was dredged to provide a harbor measuring 100 by 200 m and reaching depths of 1–3 m. The harbor was created in present-day Marina del Rey, which was again dredged in the 1960s. The original harbor was connected to the ocean by a canal dug northward along the natural channel. Channelization continued in 1904, when 27 km of canals 1–2 m deep were dug during development of the Venice community, north of the Ballona. These canals were connected to the Ballona Lagoon harbor.

Petroleum exploration in the area began in the 1890s, but it did not seriously impact the Ballona Lagoon until oil was discovered east of Venice's Grand Canal in December 1929. By 1931, there were 325 active oil wells in the Ballona Lagoon. A 1930 aerial photograph shows well derricks lining the Ballona Harbor canal (Figure 20). This south-facing photograph shows an extensive estuary-distributary system but no channelization of Ballona Creek. A 1938 aerial photograph, however, shows the wide Ballona Creek channel in flood (Altschul, Homburg, and Ciolek-Torrello 1992:Figure 123) (see Figure 8).

Activities associated with cattle ranching, flooding, and urbanization filled in the Ballona Lagoon and reduced freshwater flow to the marsh. The Gabrielino/Tongva referred to the Ballona Wetlands as *pwinukipar*, which means "full of water" (Caughman and Ginsberg 1987). The 1861 U.S. Coast Survey map (Chase 1861) shows an extensive body of open water in the Ballona Lagoon (see Figure 7). The diversion of the Los Angeles River in 1825 must have dramatically reduced the extent of freshwater marsh in the Ballona Lagoon. The 1815, 1825, 1862, and 1884 floods must have deposited silt in the lagoon, eroded from the uplands that were being subjected to livestock grazing. Maps drawn in 1861 and thereafter show progressively smaller open-water pools. Ballona and Centinela Creeks were modified by Japanese farmers in the 1920s and 1930s, by the petroleum industry in the 1930s and 1940s, and by the construction of the Culver City airplane factory (where Howard Hughes built the Spruce Goose) during the 1940s (Greenwood and Associates 1995). Sedimentation made it necessary to channelize Ballona Creek by 1938.

The following chapter summarizes the results of our paleoecological reconstructions of the Ballona Lagoon from roughly 6500 B.P. (uncalibrated) to the period when the area was covered in historical-period fill.

Figure 20. 1930 aerial photograph showing oil derricks in the Ballona (view to the south toward the Bluffs). (Courtesy Robert Strutsman, Negative No. B-1274.)

Paleoenvironmental Reconstruction of the Ballona Lagoon

Jeffrey A. Homburg and Diane L. Douglas
with contributions by Eric C. Brevik, Caroline Tepley, and Antony Orme

Introduction

The area around the Ballona Lagoon has been very geologically active over the last several million years. Understanding the geologic setting of this area and how it has changed over time, particularly during the last 7,000 years, is crucial to understanding how and why prehistoric human land-use patterns shifted in the Ballona. The purpose of this chapter is to give summary reconstructions of the environmental and geologic history of the Ballona during the Holocene, the time span germane to prehistoric human occupation of the study area. To put the evolution of the Ballona Lagoon and its use by prehistoric populations in context, we briefly review the climatology of the Pleistocene-Holocene transition in North America. Understanding the basic driving mechanisms of climate change during that pivotal time in human history helps us better understand the nature and timing of the changes in the landscape to which human populations adapted. The magnitude of changes in the landscape is correlated with the magnitude of climate change occurring on large (global), medium (regional), and small (local) scales; the paleoecological evolution of the Ballona was affected by climate change at all of those scales. The location of the Ballona relative to the regional structural geology and significant physiographic features that affected the formation and evolution of the lagoon is shown in Figure 17.

The Pleistocene-Holocene Climate Transition

The Pleistocene epoch, from 1.8 million to 10,000 years ago, was punctuated by four glacial/interglacial cycles. Although all of the dynamics that drive glacial and interglacial cycles are not understood, most scientists agree that cyclical variation in Earth's orbit around the sun (eccentricity and precession) and Earth's tilt on its axis (obliquity) are primary forcing mechanisms (Berger et al. 2006; Imbrie and Imbrie 1980; Kutzbach 1987; Milankovitch 1969; Muller and MacDonald 1997). On average, these cycles occur every 100,000 (eccentricity), 40,000 (obliquity), and 20,000 (precession) years. Glacial periods begin and end when the right combination of these cycles occurs, and different combinations of these cycles result in varying cold/warm and wet/arid conditions during glacial and interglacial periods (Imbrie and Imbrie 1980; Jansen et al. 2007; Shackleton et al. 2002; Williams et al. 1993). Transitions between glacial and interglacial periods can be punctuated by extreme climatic variation as Earth's dynamic systems respond to large-scale changes in atmospheric and oceanic circulation and corresponding variation in the mass balance of glacial ice on Earth.

The most recent glacial period, referred to as the Wisconsin in North America and Weichsel in Europe, lasted roughly from 115,000 to 18,000 B.P. (Mix and Ruddiman 1984; Petit et al. 1999; Ruddiman and Wright 1987). By 14,000 B.P., northern-hemisphere temperatures had nearly reached the mean of observed twentieth-century temperatures (Masson-Delmotte et al. 2006; Mott et al. 1986). This warm postglacial period, referred to as the Allerød, extended from approximately 14,000 to 11,000 B.P (Table 2). It was abruptly interrupted by an extreme drop in temperature around 11,000 B.P. that lasted about 1,000 years and is widely referred to as the Younger Dryas (Dansgaard et al. 1989; Lowell et al. 2005). In concert with reduced temperatures, precipitation increased, creating conditions conducive to the advance of ice sheets and alpine glaciers in the northern (Briner et al. 2002) and southern (Mahaney et al. 2007) hemispheres. Although the cause of this cold pulse is not completely understood (Lowell et al. 2005), many scientists have attributed the Younger Dryas to the Wisconsin ice sheet's melting, which caused a catastrophic release of floodwaters into the Great Lakes and, ultimately, the North Atlantic when glacial lakes broke through melting ice dams (Brevik 1994; Lowell et al. 2005).

By 11,000 B.P., the amount of solar radiation received in the northern hemisphere was at the highest it had been since the Eemian interglacial, 120,000 years ago (Kaspar and Cubasch 2006; Lorenz et al. 2006; Shackleton et al. 2002; Tarasov and Peltier 2003). By 10,000 B.P., northern-hemisphere temperatures were 6°C warmer than they had been during the Younger Dryas, and Earth had entered the Holocene

Table 2. Late Pleistocene to Holocene Climate Temperature and Precipitation Anomalies Relative to the Twentieth-Century Mean

Event Name	Time Period	Temperature	Precipitation
Last Glacial Maximum (Pleistocene)	18,000 B.P.	lower	higher
Allerød	14,000–11,000 B.P.	mean	mean
Younger Dryas	11,000–10,000 B.P.	lower	higher
Early Holocene	10,000–9000 B.P.	mean	mean
Altithermal	9000–4000 B.P.	higher	lower
Neoglacial	4000–2000 B.P.	lower	higher
Late Holocene	2000 B.P.–A.D. 750	mean	mean
Medieval Climatic Anomaly	A.D. 750–1000	higher	higher
Medieval Climatic Anomaly	A.D. 1000–1350	higher	lower
Late Holocene	A.D. 1340–1450	mean	mean
Little Ice Age	A.D. 1450–1530	lower	higher
Little Ice Age	A.D. 1750–1850	lower	higher
Historical period	A.D. 1850–1950	mean	mean

geologic period. Although the climate of the Holocene has been much milder than that of the Pleistocene, ongoing changes in Earth's orbital parameters as well as multiple atmospheric, oceanic, and terrestrial physical mechanisms have caused the climate to vary on decadal to millennial scales (Jansen et al. 2007). These events affected the characteristics of terrestrial and marine ecosystems in California (Graumlich 1993; LaMarche 1973), as well as elsewhere in North America (Betancourt et al. 1990; VanDevender et al. 1987), which, in turn, affected human adaptive strategies (Bonnichsen et al. 1987). Below, we briefly summarize some of the key climate events that influenced the formation and ecology of the Ballona, because these changes likely affected how Native Americans used this landscape.

Holocene Climate

By 9000 B.P., the northern hemisphere reached a period in which it received maximum summer solar radiation (about 8 percent higher than at present), which resulted in temperatures about 1.6 ± 0.8°C warmer than modern temperatures in the Arctic[1] (Kaufman et al. 2004; Lorenz et al. 2006). In North America, this warm period was coined the "Altithermal" by Antevs (1955) but is also referred to by several other terms in North America as well as other world regions (e.g., Climatic Optimum, Hypsithermal, Holocene Optimum, Holocene Thermal Maximum, and Holocene Megathermal) (Williams et al. 1993). This warm period lasted from 9000 to 4000 B.P., and maximum temperatures and aridity varied temporally and geographically in the northern hemisphere, corresponding to a variety of atmospheric, oceanic, and topographic factors (Kaufman et al. 2004). Maximum aridity in California is believed to have been reached between 5000 and 6000 B.P. (LaMarche 1973). The Altithermal ended when Earth's orbit changed and the incident solar radiation received in the northern hemisphere during summer was reduced (Lorenz et al. 2006). Between approximately 4000 and 2000 B.P., the temperature was 1–2°C cooler than the modern mean, and precipitation levels were higher, resulting in the advance of several North American glaciers (Clague and Mathewes 1996; Wood and Smith 2004). By 2000 B.P., the northern hemisphere was warming, and by 1500 B.P. (ca. A.D. 450), the climate of California had reached near-modern values. Over the past 1,500 years, the climate has continued to vary, with the most-marked warming occurring between roughly A.D. 750 and 1350 and the most-marked cooling occurring between A.D. 1450 and 1850 (see Table 2) In Europe, the 400-year warm interval is called the Medieval Warm Period, and the period of cold/wet weather is called the Little Ice Age (LIA) (Grove 1990; Lamb 1977). These climate anomalies occurred with varying intensity in different regions and at slightly different times and have been previously identified in tree-ring data for California (Graumlich 1993; LaMarche 1973). At the end of the LIA, northern-hemisphere temperature and precipitation regimes reached the mean for the twentieth century.

[1] "Modern temperature" refers to the observed mean temperature for A.D. 1950–2000.

Climate Change and Sea Level

The Wisconsinan-Weichsel continental ice sheets, which may have been nearly 1 mile thick (Hughes 1987), compressed Earth's crust in much of the northern hemisphere during the height of the last glacial maximum (LGM). Melting of the ice sheets at the end of the LGM resulted in isostatic rebound of Earth's crust (Peltier 2001) and eustatic sea-level rise[2] (Gross 1990; Orme 1990). The rate of sea-level rise varied from region to region, because Earth's crust responded differentially to the release of the immense weight of continental glaciers as they melted (Farrand 1962; B. Gutenberg 1941; Jansen et al. 2007; Peltier 2001). Even landforms not covered in ice during the LGM have experienced some isostatic rebound because of the elastic properties of Earth's crust, a dynamic response that continues today in many regions of the world (Peltier 2001). Paleoenvironmental reconstructions of coastal terraces have indicated that sea-level rise was occurring at a rate of 30 mm per year at the end of the LGM (Williams et al. 1993) and approximately 10 mm per year by 15,000 B.P. (Orme 1990). By 7000 B.P., sea level was approximately 100 m above the mean sea level of the Wisconsin-Weichsel glacial period (Bickel 1978; Kraft et al. 1982; Williams et al. 1993), but the rate of its rise had slowed considerably. Worldwide, modern mean sea level was achieved by around 6000 B.P. (Orme 1990; Williams et al. 1993), but in some regions, sea level underwent dramatic fluctuations between 5000 and 3500 B.P. (Kraft 1982). The current global rate of sea-level rise is estimated at approximately 1.5–2 mm per year and is attributed to a combination of natural forcing mechanisms (e.g., cyclic changes in Earth's orbit around the sun) and anthropogenic greenhouse-gas emissions (Randall et al. 2007). These mechanisms cause the atmosphere and oceans to become warmer, which, in turn, causes ice sheets to melt and sea level to rise (Gross 1990; Meehl et al. 2007; Randall et al. 2007).

Examples of fluctuating sea level have been examined in studies performed in Turkey by Kraft et al. (1980 and 1982) and in Brazil by Martin and Domínguez (1994). Kraft et al. (1982) found that sea-level rise in western Turkey exceeded the rate of tectonic uplift in the region from about 4000 to 5000 B.P., resulting in an overall increase in regional sea level. Since about 3500 B.P., sea-level rise and tectonic activity in the region have been roughly equal, leading to a period of relative stability in the shoreline position. In contrast to Kraft et al.'s (1982) work in Turkey, Martin and Domínguez (1994) found that tectonic uplift along coastal Brazil has exceeded the rate of sea-level rise over the last 5,000 years, resulting in lower regional sea level. The work of Kraft et al. (1982) and Martin and Domínguez (1994) illustrates why local studies are needed to understand varying rates of sea-level rise in different regions. Consideration of other coastal areas where changes in sea level have been studied provides some insight to processes in California (Bird 1994).

Archaeology and Climate Change

As noted above, the melting of the Wisconsin-Weichsel continental glaciers resulted in a sea-level rise of more than 100 m. As continental ice sheets and alpine glaciers retreated, the North American landscape was transformed—alpine and temperate forests became restricted to higher latitudes and higher elevations, and new communities of grasses, shrubs, and trees became established at lower elevations. As vast expanses of North America changed in response to warming, animals and humans migrated into formerly uninhabitable areas (Bonnichsen et al. 1987). In California, as in many other coastal areas of North America, new estuaries, lagoons, and, ultimately, marshes formed at the mouths of rivers that drained mountains and plains. Newly evolving lagoons and marshes provided a rich habitat for fish, shellfish, birds, and plants and were thus ideal locations for prehistoric populations to obtain resources and became focal points for human settlement. Reconstructions of the lagoon and marsh environments can lend insight into how these systems changed over time. By studying these changes relative to human use of the landscape, we can better determine the extent to which local and regional environmental factors influenced human adaptive strategies. Developing a more comprehensive understanding of environmental constraints on human settlement and subsistence in a particular region or area can help identify patterns of behavior and interaction with culture groups from other regions/environments that facilitated adaptation to the region or area. This chapter aims to reconstruct the environmental setting of the Ballona Lagoon and how it changed over time, with the hope of enhancing our interpretations of archeological remains recovered as part of the PVAHP.

Lagoon Formation and Evolution

The formation and maturation of each lagoon from open bay to marsh varies in its timing and nature because of the local geology—tectonic activity, the size and nature of the drainage basin, topographic characteristics of the landform in which the lagoon was forming, eustatic sea-level rise, and isostatic rebound. Figure 19 illustrates three general models of lagoon development. Microenvironments within a lagoon vary with distance from landforms, freshwater sources, tidal channels, and open bays. Further, the characteristics of every

[2] Mean sea level linked to the worldwide mass balance of glacial ice.

lagoon, estuary, and marsh vary as a result of fluctuations in the amount of freshwater or saline water it receives, sediment loading or erosion following floods, and changes in temperature and precipitation. These changes, in turn, affect which types of plants and fauna grow in different parts of the lagoon—some species are salt tolerant (halophytic) and do not live in areas where freshwater flushes into the lagoon; others cannot survive in saline environments. Many changes in the ecology and geomorphology of a lagoon are reflected in the microorganisms and macroorganisms trapped in the lagoonal sediments, as well as in the physical and chemical characteristics of the sediments. Paleoecological reconstructions of a lagoon can be obtained by coring different areas of the lagoon and studying the sediments and organisms found at different stratigraphic levels within the cores.

Microorganisms and macroorganisms are used as proxy data to reconstruct past environments. These organisms are used to reconstruct local, regional, and, at times, global climatic conditions under the principle of uniformitarianism, which postulates that the relationships between climatic conditions and environmental response have operated unchanged throughout the period of interest (Bradley 1985; Williams et al. 1993). However, all proxy data have limitations in their temporal and spatial resolutions. For example, diatoms and foraminifera can be transported in strong currents or storms from their habitats or from older geologic units to the site where they are ultimately buried and later discovered. Abundances of different microfauna in conjunction with an analysis of sediments in which they are recovered can help determine whether the microfauna were deposited in a flood, storm, or tidal surge, rather than having lived and died in that setting.

Like microfauna, pollens from different plants have different dispersal mechanisms, and these must be taken into consideration when reconstructing an environmental setting based on the pollen record. For example, pine (*Pinus* sp.) and oak (*Quercus* sp.) pollen grains are small and light and can be transported many miles from their places of origin before being deposited. Pine-pollen grains have air sacs that make them especially aerodynamic and subject to long distance transport. In the past, pine and oak species had a wider distribution in California than they do at present—growing in greater abundance on bluffs near the lagoon as well as on the more distant mountains. Their pollen grains can be transported by rivers and creeks as well as wind, and greater frequencies of pine and oak pollen can be expected in lagoons and near the mouths of tributaries to lagoons. Pollen from pine and oak trees can also be transported several hundred kilometers by wind; changes in abundances at lower elevations or at coastal sites might reflect changes in regional wind patterns (e.g., the duration and intensity of Santa Ana winds are affected by climate) as much as changes in the productivity of a population. Similarly, a reduction in the frequency of pine or oak pollen might reflect decimation of nearby forests by fire—a common occurrence in California. Herbaceous annuals and perennials occur in higher frequencies for a period of years after large fires, followed by increasing frequencies of sagelike shrubs (Hanes 1971; Ornduff et al. 2003). Given these variables, it is difficult to use variation in pine and oak abundance alone to reconstruct climate change. Entire collections of pollen from multiple species, along with other proxy data, provide the best picture of paleoenvironmental conditions at a site. Further, the condition (level of deterioration) and total counts of pollen provide a context for interpreting paleoenvironmental conditions. For example, highly deteriorated samples combined with a low pollen count can reflect the presence of a marine or other water environment at the coring location for that sampling interval. We used multiple proxy data to facilitate the development of a comprehensive reconstruction of the paleoecology of the Ballona. The methods used to obtain these reconstructions are discussed below.

Methods

To provide a comprehensive and reliable reconstruction of the paleoecological history of the Ballona Lagoon, we analyzed site stratigraphy (see Appendix A of this volume), mollusks (see Appendix B of this volume), pollen (see Appendix C of this volume), ostracodes (see Appendix D of this volume), and diatoms and foraminifera (see Appendix E of this volume). Details on the methods employed by each analyst and the results of their investigations can be found in the appropriate appendixes. Below, we summarize the methods and results of each of these studies. A map showing the locations of all cores collected for the PVAHP project is provided in Figure 16. A map showing which cores were used for the paleoenvironmental reconstruction of the Ballona is provided in Figure 21. Table 3 presents the radiocarbon-dating results from the cores; Tables 4 and 5 identify the cores used in the paleoecological reconstruction for the western and eastern parts of the Ballona, respectively.

Stratigraphy

The stratigraphic descriptions by Eric Brevik and Jeffrey Homburg focused on texture, color, associated shells, sedimentary structures, presence or absence of carbonates and other salts, and other noteworthy observations (see Appendix A of this volume). On the basis of these observations, the paleoenvironments represented in each core were identified. Particle-size analysis was performed using a sieve-and-pipette technique (Gee and Bauder 1986); organic carbon was determined with a LECO CHN-600 analyzer using the total combustion technique (National Soil Survey Center 1996) (see Appendix A1 of this volume). Organic-carbon samples containing free calcium carbonate were treated with diluted hydrochloric acid to remove inorganic carbon before combustion. Particle-size and organic-carbon data were used to aid in the paleoenvironmental interpretations.

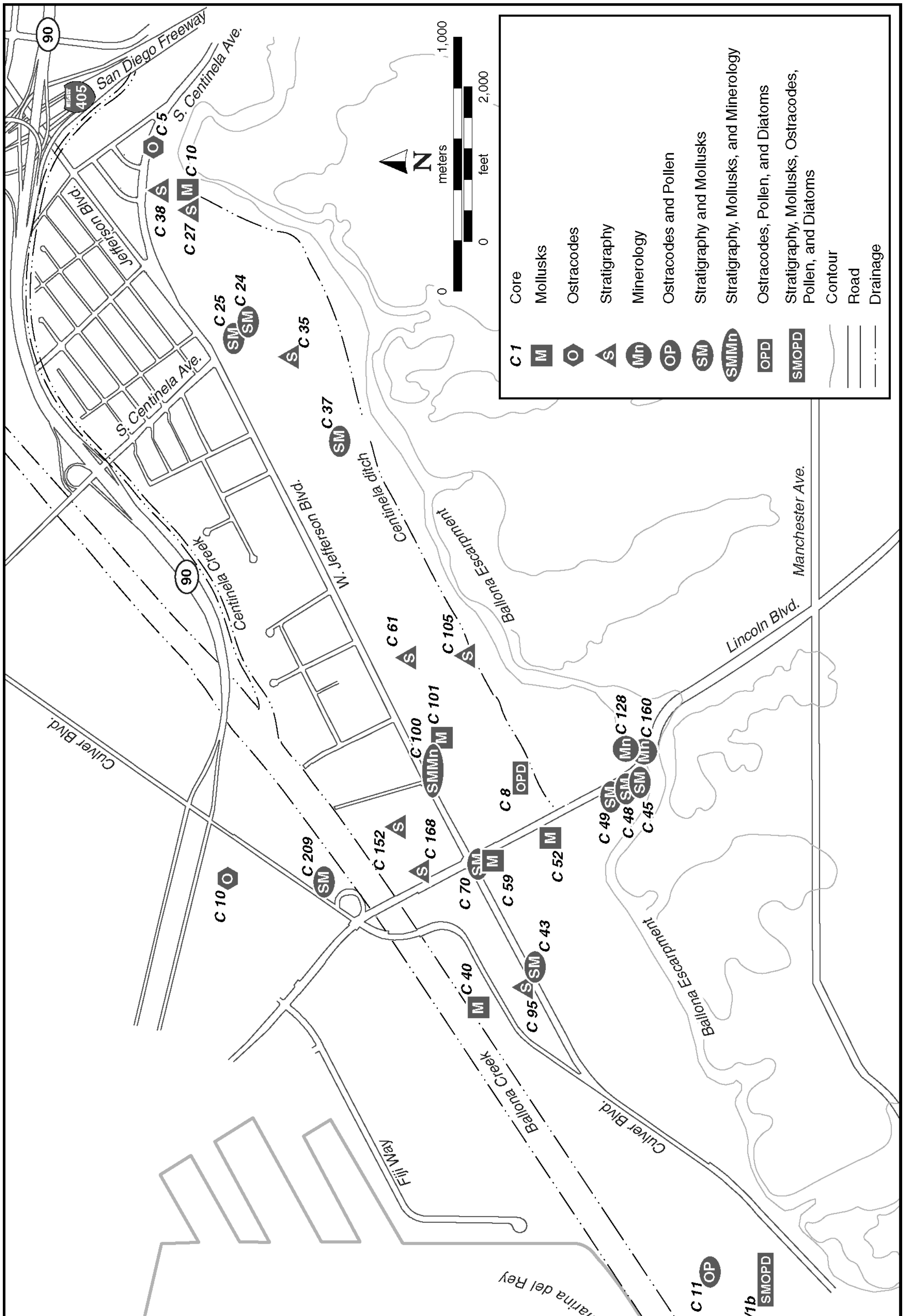

Figure 21. Locations of cores analyzed for paleoecological studies of the Ballona Lagoon.

Table 3. Conventional and Calibrated Age Ranges for the PVAHP Paleoenvironmental Study

Laboratory No.	Depth below Surface (m)	Elevation (m AMSL for Top of Sample)	Material Dated	$\delta^{13}C$ (‰)	Radiocarbon Age (B.P. ± 1σ)[a]	Calibrated Age(s) Obtained from Intercepts (cal A.D./B.C. Ranges for 2 σ)[b]
Core 1/1b						
Beta-131129	0.43	-0.32	charcoal	–27.2	730 ± 60	A.D. 1195 (1282) 1391
Beta-131130	0.84	-0.73	charcoal	–25.2	1980 ± 60	153 B.C. (A.D. 25, 43, 47) A.D. 131
Beta-131131	1.69	-1.58	California hornsnail (*Cerithidea californica*)	–2.7	2740 ± 40	996 (896, 875, 862, 847, 845) 808 B.C.
Beta-131132	4.83–4.88	-4.72	native Pacific oyster (*Ostrea lurida*)	+1.5	6220 ± 80	5359 (5228, 5223, 5210, 5161, 5148) 4863 B.C.
Core 8						
Beta-85584	3.67–3.73	0.27	organic sediments	–25.0	1070 ± 100	A.D. 694 (984) 1206
Beta-87297	6.60–6.65	-2.66	California hornsnail	–2.1	4610 ± 100	3638 (3366) 3024 B.C.
Beta-85914	8.31–8.40	-4.37	organic sediments	–26.2	6340 ± 40	5462 (5316) 5213 B.C.
Beta-85915	9.73	-5.79	charcoal	–26.0	5820 ± 60	4829 (4707, 4702, 4692) 4503 B.C.
Beta-85916	11.10–11.17	-7.16	organic sediments	–25.0	6580 ± 70	5635 (5512, 5498, 5485) 5380 B.C.
Beta-85917	15.03–15.10	-11.09	organic sediments	–26.7	11,140 ± 60	11,419 (11,193) 10,943 B.C.
Beta-85583	18.26–18.29	-14.32	organic sediments	–25.1	20,800 ± 110	invalid age for these calibration data
Core 25						
Beta-131133	6.65	-1.30	wood	–28.3	3480 ± 70	2009 (1859, 1845, 1771) 1621 B.C.
Beta-131134	8.05	-2.70	charcoal	–30.8	4060 ± 80	2879 (2615, 2615, 2578) 2352 B.C.
Beta-131135	8.90	-3.55	charcoal	–28.5	4610 ± 60	3619 (3366) 3102 B.C.
Beta-131136	9.57	-4.22	charcoal	–28.9	4830 ± 60	3708 (3641) 3384 B.C.
Core 43						
Beta-124363	4.17–4.30	-1.36	California hornsnail	–0.5	4380 ± 60	3328 (3012, 2983, 2956, 2954, 2925) 2884 B.C.
Beta-124364	9.95–9.98	-7.14	California Venus (clam) (*Chione* sp.)	–2.4	7520 ± 90	6499 (6401) 6164 B.C.
Core 61						
Beta-124365	4.32–4.57	-1.63	California hornsnail	–5.7	4670 ± 60	3635 (3499, 3457, 3435, 3377) 3348 B.C.
Beta-124366	4.74–4.80	-2.05	California hornsnail	–0.8	4900 ± 140	3977 (3660) 3368 B.C.
Beta-124367	11.89–11.92	-9.20	peat	–24.8	15,640 ± 50	17,341 (16,728) 16,180 B.C.
Core 100						
Beta-124368	4.60–4.75	-1.13	California hornsnail	–2.9	3960 ± 60	2619 (2468) 2290 B.C.
Beta-124369	5.08–5.13	-1.61	native Pacific oyster	–2.5	4790 ± 120	3889 (3635, 3553, 3542) 3348 B.C.
Beta-124370	5.27–5.30	-1.80	native Pacific oyster	–0.2	4790 ± 60	3693 (3635, 3553, 3542) 3377 B.C.
Beta-124371	14.16–14.37	-10.69	wood	–25.7	14,770 ± 120	16,338 (15,727) 15,173 B.C.

Key: AMSL = above mean sea level.

[a] Uncalibrated radiocarbon ages have been corrected for isotope fractionation using the $\delta^{13}C$ values.

[b] Radiocarbon ages were calibrated using the CALIB 4.3 program, based on the work of Stuiver and Reimer (1993). Calibrated age ranges were obtained from intercepts (Method A, with one or more intercepts between the conventional radiocarbon age and the dendrocalibrated calendar time-scale curve placed in parentheses between the 2σ age range) and from the probability distribution (Method B, with the probability in parentheses after each range). References for calibration datasets: (1) Stuiver, Reimer, Bard, et al. (1998) and (2) Stuiver, Reimer, and Braziunas (1998) (revised data set). Shell samples were from aquatic systems dominated by brackish water, and the percentages of marine and terrestrial carbon are unknown; therefore, no reservoir-effect correction was made.

Table 4. Cores Used to Reconstruct the Paleoecology of the Western Part of the Ballona

Proxy Data	Core 1/1b	Core 11	Core 43
Diatoms	X		
Foraminifera	X		
Mollusks	X		X
Ostracodes	X	X	
Pollen	X	X	X
Sediments	X		X

Table 5. Cores Used to Reconstruct the Paleoecology of the Eastern Part of the Ballona

Proxy Data	Core 8	Core 25	Core 61	Core 100
Diatoms	X			
Foraminifera	X			
Mollusks		X		X
Ostracodes	X			
Pollen	X			
Sediments	X	X	X	X

Organic-carbon data were used as a check on our paleoenvironmental interpretations. Barnes (1980) reported relative biomass production in a number of nearshore marine environments as follows: coastal areas (nearshore marine) < marshes < salt marshes < lagoons, with some overlap in production between most of these environments. After completing the organic-carbon analysis and organizing the data by depositional environment, we found the following trend: marine + tidal channel < marsh < salt marsh < lagoon edge < lagoon, with some overlap between individual environments. The organic-carbon data from the marine and tidal-channel areas were pooled because of the few data points and the similar readings obtained from these areas. Organic-carbon readings collected during this study ranged from 0.1 to 9.1 percent. Reise (1985) reported organic-carbon ranges from 0.2 to 5.8 percent on the tidal flats of a bay in the North Sea. The range in our organic-carbon values thus appears reasonable for the environments represented, and the distribution of organic carbon supports our paleoenvironmental interpretations.

Mollusks

Steven Shelley analyzed cores for mollusks that were collected as part of the PVAHP. His work focused on reconstructing prehistoric use of the Ballona, rather than on reconstructing the paleoecology of the lagoon, using invertebrates (see Appendix B of this volume). Thus, cores that were truly representative of a cross section of the entire lagoon were not collected. Analysis was restricted to cores that contained the best records of mollusks, because many of the cores contained few or no mollusks. Because the cores were too short to facilitate reconstructions extending to the late Pleistocene/early Holocene, his reconstruction was limited to roughly the past 5,000 years of record.

Auger holes collected for the archaeology study were drilled with a hollow-stem power auger with a 3-inch (7.6-cm) interior diameter. Vertical control was achieved by drilling in 1.5-m runs—in other words, the contents of the hollow stem were removed after every 1.5 m in depth that the auger advanced. The intent was to recover continuous cores. As each 1.5-m section was recovered, the core was removed and stored in boxes labeled with the core number, depth, and run-segment numbers. In practice, not all the cores were continuous. In some cases, material was lost from the bottom of the core barrel, especially in very sandy sediments.

In the laboratory, the cores were split in half, and a detailed stratigraphic description was written for each, including measurements of depth and information on color, texture, and sedimentary structures as well as notes on the presence of any fauna. These observations were used to select cores from which the invertebrate samples were analyzed (see Appendix B, of this volume). All the described depositional strata were examined for the presence of shells. Individual shells visible in the split core were collected. Approximately 250 ml of each stratum was washed, and the shell, if any was present, was collected and analyzed.

Pollen

Owen Davis analyzed pollen samples from Cores 1, 8, and 11, all from locations where the Ballona Lagoon stabilized and last filled with sediment (see Appendix C of this volume). Samples were collected at 10-cm intervals through the length of the cores. Pollen was extracted from 1-cm^3 or 5-cm^3 samples by routine acid digestion. For upland plants, approximately 300 grains of the pollen were counted per sample, whenever possible. The pollen of aquatic plants, spores of ferns and fungi, algae, charcoal, and other microfossils were not included in the sum; therefore, more than 1,000 microfossils could be counted per sample. Pollen clumps (aggregates) were counted as 4 grains each. In samples for which pollen abundance was low, counting continued until 200 grains were counted, if possible. When abundance was very low (that is, fewer than 200 grains found on an entire slide), additional slides were prepared, and at least 200 tracers were counted to obtain a reliable estimate of pollen concentration.

The pollen sum was the divisor for determining the percentages of pollen types, as well as those of spores, charcoal, and other microfossils. The pollen concentration was calculated for the pollen sum as an index of preservation and an indicator of the sediment-accumulation rate. For example, low concentration combined with poor preservation may indicate postdepositional deterioration of pollen and may make interpretation of the pollen problematic. In contrast, good preservation and low concentration might result from rapid sediment accumulation, which leads to excellent preservation.

Ostracodes

Manuel Palacios-Fest analyzed ostracode samples at 20-cm intervals from five cores (Cores 1, 5, 8, 10, and 11) (see Appendix D of this volume). All core samples were processed for ostracode recovery following Palacios-Fest's (1994) version of Forester's (1991) freeze-and-thaw technique. Samples were weighed with an electronic balance and disaggregated in hot, distilled water with Alconox (sodium hexametaphosphate). The sediments were then cooled before undergoing several freeze-and-thaw cycles of 24 hours each. The samples were washed with a No. 100 U.S. standard mesh sieve and rinsed with distilled water. The residues were then wrapped in paper towels and desiccated at 70°C in a drying oven. Finally, the residues were weighed to estimate the content of ostracodes per gram of sediment.

Cores 5 (the easternmost core collected for ostracode analysis) and 10 (one of the northernmost) were eliminated from the study, because no ostracodes were recovered from them, which suggested that the samples were mainly from terrestrial deposits devoid of ostracodes and could not be used for the paleoenvironmental reconstruction. In the other samples, a statistical count of 300 specimens was analyzed, when present, to determine richness and relative abundance of ostracode species. Because of high variability in ostracode content, samples with fewer than 300 individuals were considered small, and taphonomic criteria (e.g., fragmentation and abrasion) were used to determine their validity for paleoecological interpretation (Delorme 1969, 1989; Forester 1988). Sample reliability was defined by fragmentation, abrasion, coating/encrustation, redox, specimen color, and the disarticulation and adult-to-juvenile ratios by species. Mean percentages were estimated for each sample to identify the assemblage and the paleoenvironmental setting it represented. Autochthonous (indigenous) and allochthonous (nonlocal) species were differentiated to determine whether organisms were representative of a native population or were transported to the site. Residues were examined under a low-power stereoscopic microscope. Routine micropaleontological analysis was performed to determine fossil content and faunal composition. Paleoecological assemblages were defined and grouped according to species abundance, following Benson (1959) and McKenzie and Swain (1967).

Diatoms and Foraminifera

Richard Boettcher and Stanley King analyzed foraminifera and diatoms recovered from Cores 1 and 8 (see Appendix E of this volume). In total, 102 samples from these cores were analyzed. Core 1 (15.2 m long) consisted of 39 samples, 13 of which were fossiliferous; Core 8 (18.2 m long) consisted of 63 samples, 14 of which were fossiliferous. Most samples were collected at 20-cm intervals; occasional sampling gaps occurred in sandy intervals where there was no recovery.

Standard procedures were used to process the sediment samples for recovery of foraminifera and siliceous microfossils. Foraminifera were recovered by boiling small sediment samples in an industrial detergent and then wet-sieving through 850-µm- and 75-µm-mesh screens. Residuals were examined under a low-power stereoscopic microscope. Routine micropaleontological analysis was performed to determine fossil content and faunal composition. Siliceous microfossils were isolated from sediment samples with diluted hydrochloric acid to remove calcium carbonate. Insoluble residues were thoroughly mixed and allowed to settle in a beaker. After the coarse material had settled to the bottom of the beaker, fine fractions were removed from the top by pipette and were mounted on glass slides for examination under a light microscope. Siliceous-microfossil species were classified according to their affinity for freshwater or marine water; paleoenvironmental interpretations were based on the dominance of these two categories.

Summary of Analyses

As described above, each analyst followed conventional analytic methods to document the stratigraphy and to prepare and examine proxy data used to reconstruct the paleoecological history of the Ballona Lagoon. Below, we summarize the results of these investigations but do not describe every core in detail; for the detailed information, please refer to Appendixes A–E of this volume. Additionally, Wigand (see Appendix F of this volume) provides a comprehensive comparison of Davis's (see Appendix B of this volume) pollen study with other regional pollen reconstructions (Scott-Cummings 1991 and Mensing 1993). Wigand (see Appendix F of this volume) also provides a valuable discussion of how the palynological reconstructions of the Ballona Lagoon and other California lagoons correlate with regional climatic events and human use of the landscape. Below, we provide a synthesis of the paleoecological and sediment analyses performed for the PVAHP.

Methods for Synthesizing Data

To determine the timing of different paleoclimatic events and the formation history of the Ballona, we restricted our synthetic study to an analysis of radiocarbon-dated cores (Table 6; see Tables 2 and 3). As noted in Chapter 6 of this volume, Core 1 was extensively analyzed (stratigraphy, pollen, ostracodes, and diatoms and foraminifera) but never dated, and dates from Core 1b (collected 1 m away from Core 1) were used to develop a chronology for Core 1. Radiocarbon dates for Core 1b were interpolated to Core 1 based on the stratigraphy of each core (see Appendix A of this volume). Additionally, we needed a good sample of sediments and proxy data deposited in recent history (that is, an analogue). So, we extracted a core in the lowest part of the lagoon that could be reached for sampling

Table 6. Extrapolated Time Interval for Sediment Deposition within Cores 1/1b, 8, and 43

Time Interval, by Core No.	Span (years)	Depth (m)	Number of 10-cm Intervals	Extrapolated 10-cm Age (years)
Core 1/1b				
7380[a]–6220 B.P.	1,160	4.8–15.2	100	11.60
6220–2740 B.P.	3,480	1.7–4.8	31	112.00
2740–1980 B.P.	760	0.84–1.7	8	95.00
1980–730 B.P.	1,250	0.43–0.84	4	312.50
Core 8				
11140–6580 B.P.	4,560	11.1–15.1	40	114.00
6580–5820 B.P.	760	9.7–11.1	14	54.28
5820–4610 B.P.	1,210	6.6–9.7	31	39.00
4610–1070 B.P.	3,540	3.7–6.6	29	122.00
Core 43				
7600–4400 B.P.	3,200	4.17–9.9	57	56.14

[a] Please see note regarding Appendixes D and E included on the CD-ROM.

with the vibracore; Core 11 was located about 200 m northwest of Core 1. Pollen and ostracodes from the core were used to reconstruct the paleoecology of that area of the lagoon for the period spanning 1000 B.P. to the historical period.

Cores collected on the west end of the lagoon (Cores 1/1b, 11, and 43) were selected for analysis to facilitate reconstructions of how sediment transport in currents and tidal surges affected lagoon formation as well as how saline water affected variance in microhabitats of the lagoon through time (Figure 22). Note that the only datable mollusk material obtained from cores west of Lincoln Boulevard was from Core 43. Cores collected on the east end of the lagoon (Cores 8, 25, 61, and 100) were analyzed to reconstruct how freshwater influx and sediment deposition from Ballona Creek, the Los Angeles River, and Centinela Creek influenced lagoon formation and marsh development as well as variability in microhabitats over time (see Figure 22). These four cores were the only ones selected, because they were the only ones with available radiocarbon dates.

In order to compare the different types of proxy data analyzed for each core, we developed a sedimentation-age-rate model for each core that took into consideration different sedimentation rates between radiocarbon-dated events. This was essential because the analysts used different sampling intervals within the cores, and in some instances, analysts used different cores to reconstruct the paleoenvironment of the Ballona (see Table 1). To compare and contrast the results of the different analyses, we needed to establish a model that correlated radiocarbon ages and sedimentation rates within different levels of each core as well as among cores. Table 6 shows how different segments within each core were subdivided by radiocarbon-dated intervals; the rate of deposition by years was extrapolated so that the approximate ages of undated sample intervals could be obtained. For example, in Core 1/1b, a date of 2740 B.P. was obtained from 1.69 m b/s on California hornsnail, and a date of 6220 B.P. was obtained on an oyster shell recovered from 4.84 m b/s. The core segment between the dates was subdivided into 30 10-cm intervals, and each 10-cm interval was assumed to represent 112 years of deposition. Thus, the date for an observation made on a proxy-data sample for 3.84 m b/s (20 intervals above 1.84 m b/s) would be estimated as 4985 B.P. Through such extrapolation, we were able to refine the timing of marine transgressions and possible flood events and to identify more-localized and short-term changes in the Ballona that might reflect creek or tidal-channel migration rather than a marine transgression.

It is important to recognize that these extrapolated dates could be off by several hundred years if sedimentation rates actually varied significantly between the radiocarbon-dated intervals. Greater radiocarbon control is required to obtain a more accurate chronology of paleoecological changes in the Ballona. Nonetheless, because all of the proxy data from the cores were assigned to the same 10-cm interval, using this model facilitated the identification of transitions in the lagoon environment at a higher resolution than in previous investigations.

Results

The results of our paleoenvironmental reconstruction of the Ballona are subdivided into eastern (Cores 8, 25, 61, and 100) and western (Cores 1/1b, 11, and 43) areas of the lagoon and associated wetlands. The timing and nature of changes observed in the proxy-data assemblages and the correlations of these changes to climate periods are summarized in Tables 7, 8, 9, and 10. Below, we discuss the changes observed in each of the proxy-data assemblages for the eastern and western areas of the Ballona over the past 12,000 years.

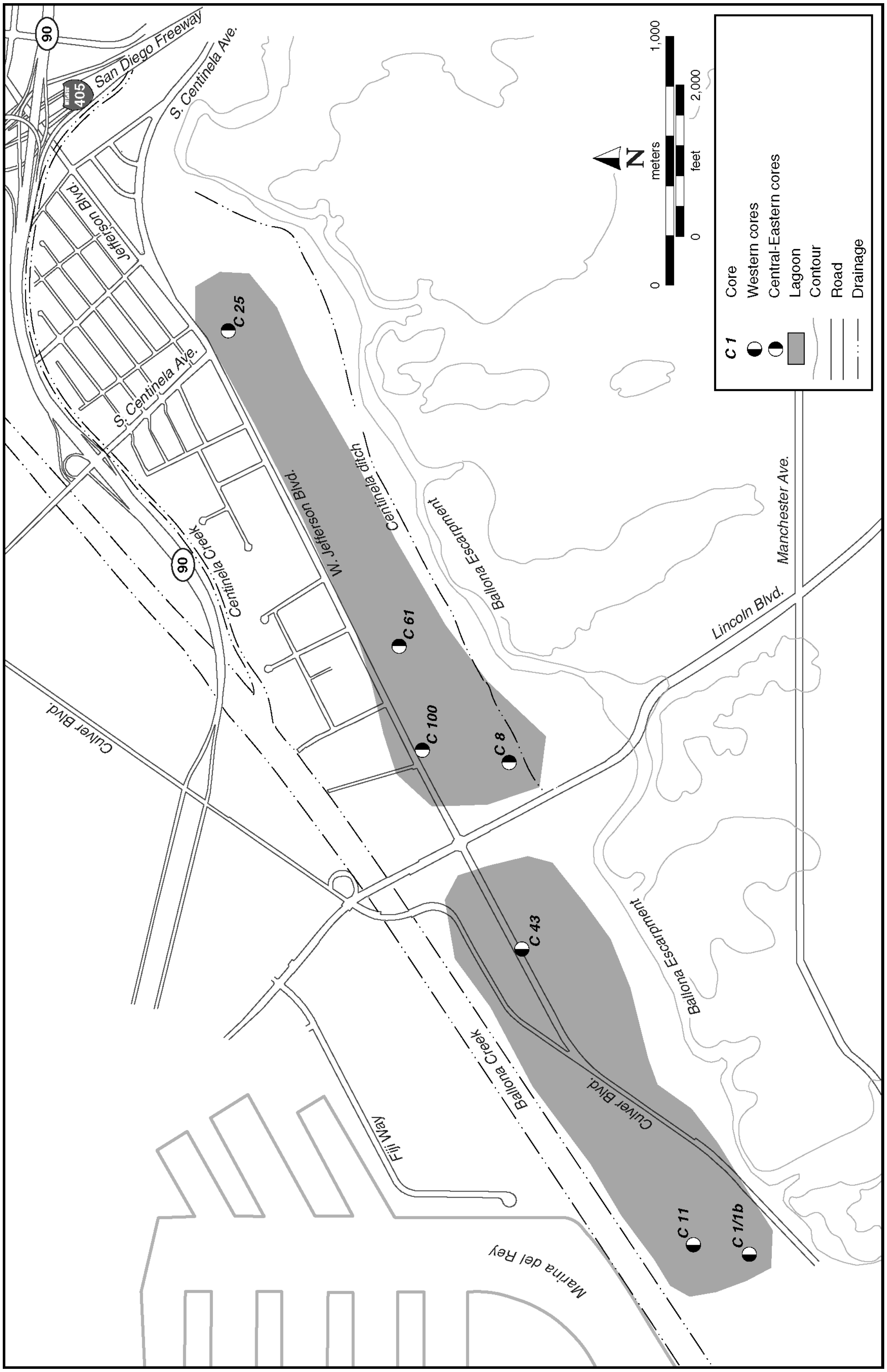

Figure 22. Locations of cores used to develop paleoenvironmental reconstructions of the Ballona Lagoon (east and west).

Table 7. Paleoenvironmental Reconstruction of the Eastern Ballona Based on Ostracodes, Diatoms, and Foraminifera

Climate Period	Time Period	Ostracodes (Core 8)	Diatoms (Core 8)	Foraminifera (Core 8)
Modern	A.D. 1850–present	Historical-period/disturbed.	Historical-period/disturbed.	Historical-period/disturbed.
Spans Medieval Warm Period (hot/dry) and Little Ice Age (cold, wet, and average)	1100–100 B.P.	No ostracodes.	No diatoms.	No foraminifera.
Spans end of Neoglacial and average conditions	2500–1100 B.P.	Primarily freshwater ostracodes.	Freshwater diatoms present at 400 cm below surface (ca. 1200 B.P.).	No foraminifera.
Neoglacial (cool/wet), slight warming[a]	3000–2500 B.P.	Primarily freshwater ostracodes.	No diatoms recovered from 4.3 to 5.8 m below surface.	No foraminifera.
Neoglacial (cool/wet)[a]	3500–3000 B.P.	Primarily freshwater ostracodes.	No diatoms recovered from 4.3 to 5.8 m below surface (between ca. 1200 and 3200 B.P.); intermittent freshwater to brackish lagoon, higher frequencies of freshwater diatoms.	*G. bulloides, G.* sp. and *Lenticulina* sp. were recovered, suggesting pulses of marine water reached the Core 8 location around 2300 and 1300 B.P.
Neoglacial (cool/wet)[a]	4000–3500 B.P.	Small percentages of brackish-water ostracodes present, diminishing upward in the core; higher frequencies of freshwater ostracodes.		No foraminifera.
Altithermal (hot/dry)	4500–4000 B.P.	Brackish-water-adapted ostracodes present, but higher abundance of freshwater ostracodes.	Intermittent freshwater to brackish lagoon, higher frequencies of freshwater diatoms.	Foraminifera present.
Altithermal (hot/dry)	5800–4500 B.P.	Brackish lagoon with increasing freshwater pulses 5800–4600 B.P.; high frequencies of freshwater ostracodes.	Intermittent freshwater to brackish lagoon, higher frequencies of freshwater diatoms.	Forams present throughout this period (*E. Incertum* and *Ammonia beccarii*).
Maximum Altithermal	6000–5500 B.P.	Strong marine presence from ca. 6000 to 5800 B.P., reverting to a predominantly brackish lagoon after 5800; more freshwater ostracodes present.	Intermittent freshwater to brackish lagoon, higher frequencies of freshwater diatoms, but some marine diatoms present.	Forams present throughout this period (*E. Incertum* and *Ammonia beccarii*).
Altithermal (hot/dry)	6500–6000 B.P.; at depth of 8.3 m, date of 6360 ± 40 B.P.	Primarily ostracodes adapted to brackish water, but freshwater ostracodes also present.	Intermittent freshwater to brackish lagoon; spike in marine diatoms between ca. 6300 and 6200 B.P. followed by abrupt decline in marine diatoms.	Forams present starting around 6400 B.P. (*E. Incertum* and *Ammonia beccarii*).
Altithermal (hot/dry)	7000–6500 B.P.; at 11.1 m below surface, date of 6580 ± 70	Primarily ostracodes adapted to brackish water, some transitional and marine ostracodes, a few freshwater specimens.	Intermittent freshwater to brackish lagoon. Freshwater diatoms dominated the assemblage, but marine diatoms were also present.	No foraminifera, suggesting terrestrial environment.
Younger Dryas (11,000–10,000 B.P.) and Altithermal (9000–7000 B.P.)	11,000–7000 B.P.	Primarily ostracodes adapted to brackish water, some transitional ostracodes and a few marine ostracodes; no freshwater specimens.	No diatoms.	No foraminifera.
Allerød warm period (end of Pleistocene)	14,000–11,000 B.P.	No freshwater ostracodes; one recovered, dated brackish-water ostracode (11,140 B.P.).	No diatoms.	No foraminifera.

Note: Freshwater ostracodes: *Herpetocypris brevicaudata*, primary freshwater species; *Candona crogmaniana* and *Lymnocythere* (?) sp. are next in freshwater frequency. Brackish, transitional, and marine ostracodes: *Cyprideis beaconensis* and *C. salebrosa.* See appendixes for more information on proxy data, sampling methods, and results.

[a] Low pollen counts and high levels of deterioration; same conditions held during 9500–8800 B.P., 7300–7000 B.P., and 6500–6000 B.P.

Table 8. Paleoenvironmental Reconstruction of the Eastern Ballona Based on Sediments, Mollusks, and Pollen

Climate Period	Time Period	Sediments (Cores 61 and 100)	Mollusks (Cores 25 and 100)	Pollen (Core 8)
Modern	A.D. 1850–present	Historical period/disturbed.	Historical period/disturbed.	Historical period/disturbed.
Spans the Little Ice Age	500–100 B.P.	(No dates) Core 100: intermittent marsh, aeolian lenses; Core 61: salt marsh.	No mollusks; terrestrial environment.	Primarily sagelike shrubs and flowering plants.
Spans the Medieval Warm Period (ca. 600–1100 B.P.)	2000–500 B.P.	(No dates) Core 100: intermittent marsh, aeolian lenses; Core 61: salt marsh.	No mollusks; terrestrial environment.	An expansion of grasses and Brassicaceae (cabbage-like plants) from 1500 to 1000 B.P. and a spike in pine from 1000 to 500 B.P.
Neoglacial (cool/wet), but warming, with major freshwater flood episodes 3200–2300 B.P.	3000–2000 B.P.	(No dates) possible period when lagoon edge expanded into Core 100 area again; Core 61: salt marsh.	No mollusks; terrestrial environment.	Dominated by cattails, rushes, and sedges. Spike in sunflower-type plants and ferns from 3000 to 2500 B.P.
Neoglacial (cool/wet), with major freshwater flood episodes	4000–3000 B.P.	(No dates) Core 100: intermittent marsh, aeolian lenses; Core 61: salt marsh.	No mollusks; terrestrial environment.	Primarily shrubs and flowering plants. Spike in sedges, cattails, and ferns from 4000 to 3500 B.P., a spike in pine around 3200 B.P., and an influx of algae at 3500–3000 B.P.
Altithermal (hot/dry), with episodic flooding	4500–4000 B.P.	Transition from lagoon edge near tidal channel to salt marsh at 4000 B.P.	Freshwater marsh, prone to flooding at Core 25 (hornsnail [*Cerithidea californica*]); at Core 100, tidal mudflat (oyster [*Ostrea* sp.]); by 4000 B.P., all mudflats silted over, indicating the area became a terrestrial marsh.	Dominated by xeric vegetation (shrubs, flowering plants, sage, and ragweed).
Altithermal (hot/dry), with episodic flooding	5000–4500 B.P.	Marine transgression 4600–4800 B.P.; Core 100 and Core 61 near tidal channel or at lagoon edge at 4800 B.P.	Marine transgression (4600–4800 B.P.); at Core 100, a shallow bay to tidal mudflat (oyster [*Ostrea* sp.]); freshwater marsh or area prone to flooding. Core 25 with Sprite snail shell (*Promenetus* sp).	Dominated by xeric vegetation (shrubs, flowering plants, sage, and ragweed).
Maximum Altithermal, with significant flood episodes	6000–5000 B.P.	Marine transgression 5800–6100 B.P. Core 100: intermittent marsh, aeolian lenses; Core 61: marsh.	No data.	Dominated by xeric vegetation (shrubs, flowering plants, sage, and ragweed).
Altithermal (hot/dry)	6500–6000 B.P.	(No dates) Core 100: intermittent marsh, aeolian lenses; Core 61: marsh.	No data.	Persistent marine influence (very low pollen counts—only a few flowering plants and grasses).
Altithermal (hot/dry)	7000–6500 B.P.	(No dates) Core 100: intermittent marsh, aeolian lenses; Core 61: marsh.	No data.	Expansion of sage and sagelike flowering plants; occasional flooding (underwater plants and some algae).
Altithermal (hot/dry)	7500–7000 B.P.	(No dates) Core 100: intermittent marsh, aeolian lenses; Core 61: marsh.	No data.	Persistent marine influence (low pollen counts); spike in pine, sunflower-type plants, and algae.
Altithermal (9000–7500 B.P.) (hot/dry)	10,000–7500 B.P.	(No dates) Core 100: intermittent marsh, aeolian lenses; Core 61: marsh.	No data.	Spike in grasses, shrubs, and flowering plants; occasional flooding (underwater plants); ferns, oak, and pine at 8500–10,000 B.P.

Note: Freshwater ostracodes: *Herpetocypris brevicaudata*, primary fresh water species; *Candona crogmaniana* and *Lymnocythere* (?) sp. are next in freshwater frequency. Brackish, transitional, and marine ostracodes: *Cyprideis beaconensis* and *C. salebrosa*. See appendixes for more information on proxy data, sampling methods, and results.

[a] Low pollen counts and high levels of deterioration; same conditions held during 9500–8800 B.P., 7300–7000 B.P., and 6500–6000 B.P.

Table 9. Paleoenvironmental Reconstruction of the Western Ballona Based on Ostracodes, Diatoms, and Foraminifera

Climate Period	Time Period	Ostracodes (Cores 1 and 11)	Diatoms (Core 1/1b)	Foraminifera (Core 1/1b)
Modern	1920s–present	Fill.	Fill	Fill.
Spans the Little Ice Age	500–100 B.P.		As below.	0.5–0.4 m below surface (ca. 360–100 B.P.): less than 10 foraminifera were recovered from the sample, including *Buccella* sp., *Uvigerium peregrine*, *U. Hootsi, Globigerina pachyderma, G.* sp., *Cassidulina cusimmani, C.* sp., and *Cibicides* sp.
Spans the Medieval Warm Period	2000–500 B.P	0.6–0.9 m below surface (730–2030 B.P.): freshwater specimens (*Cypridopsis vidua* and *Limnocythere staplini*) dominated the assemblage; a few brackish-water specimens also present (*Cyprideies beaconensis, C. salebrosa*).	0.86 m below surface (ca. 1980 B.P.) to surface: freshwater diatoms dominated the assemblage (*Thalassionena nitzachioidea, Anomoeoneis cosiata, Surirella striatula, Caloneis* sp., *Campylodiascus* sp.), but there was a decline in the number of specimens observed until 0.4 m below surface (ca. 100 B.P.); above this, the core was not sampled.	0.7–0.8 m below surface (ca 1980–1350 B.P.): only one *Globigerina pachyderma* was observed. No other foraminifera were recovered.
Neoglacial but slight warming	2500–2000 B.P	The assemblage was dominated by brackish-water specimens, but freshwater specimens were a constant. Around 2030 B.P., freshwater ostracodes dominated the assemblage.	Between 1 and 1.2 m below surface (ca. 2170–2360 B.P.): a single marine diatom was recovered, and only two freshwater diatoms were observed in the sample.	0.9–1 m below surface (2070–2170 B.P.): a single *Elphidium incertium* foraminifera was recovered.
Neoglacial (cool/wet), slight warming	3000–2500 B.P	The assemblage was dominated by brackish-water specimens, but freshwater specimens were a constant. Around 2980 B.P., freshwater ostracodes dominated the assemblage.	Low densities of brackish-water, freshwater, and marine diatoms were present in the assemblage, indicating occasional pulses of freshwater and marine water to this location.	None.
Neoglacial (cool/wet)	3500–3000 B.P	The assemblage was dominated by brackish-water specimens, but freshwater specimens were a constant.	2.1–5.7 m below surface (ca. 3320–6300 B.P.): marine diatoms were present but rare. Freshwater diatoms were present from 5.7 to 1.2 m below surface, but highest abundancies were from 1.4 to 4.5 m below surface.	None.
Neoglacial (cool/wet)	4000–3500 B.P	From 3800 to 730 B.P., the number of transitional and marine specimens declined significantly. The assemblage was dominated by brackish-water specimens, but freshwater specimens were a constant.	1.2–5.7 m (ca. 2360–6300 B.P.): freshwater diatoms were present, with the greatest abundancies 1.5–3.5 m below surface (ca. 2650–4820 B.P.). Marine diatoms were also present from ca. 3800 to 6300 B.P.	ca. 3800–6300 B.P.: *Elphidium Incertum, Ammonia beccarii*, and *Elphidium* sp. were present.

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Climate Period	Time Period	Ostracodes (Cores 1 and 11)	Diatoms (Core 1/1b)	Foraminifera (Core 1/1b)
Altithermal (hot/dry)	6600–4000 B.P	6400–4200 B.P., brackish-water ostracodes were abundant; transitional and marine species were also present, but in much lower frequencies. Freshwater specimens were also represented throughout most of this 2,200-year interval with moderately high frequencies (>30%) around 6400, 5000, 4100, and 3400 B.P.	ca. 2360–6300 B.P.: freshwater diatoms were present. Marine diatoms were also present from 3800 to 6300 B.P.	ca. 3800–6300 B.P.: *Elphidium Incertum, Ammonia beccarii*, and *Elphidium* sp. were present.
Altithermal (hot/dry)	6500–7380 B.P	Ostracodes were very rare between 7380 and 6400 B.P., and brackish-water specimens dominated this portion of the assemblage, although freshwater, transitional, and marine specimens were present.	6.8–12.45 m below surface (ca. 6360 and 7000 B.P.): freshwater (<25 specimens) and marine (<60 specimens) diatoms were observed but rare; less than 100 specimens were recovered from samples spanning this 640-year interval.	No foraminifera were recovered between 5.7 and 6 m below surface (ca. 6300–6350 B.P.), 7.6–11.33 m below surface (ca. 6450–6900 B.P.), and 12.3–12.6 m below surface (6990–7060 B.P.) and below 14.6 m below surface (7280 B.P.). From sediments spanning 6350–6450 B.P., foraminifera were very abundant. Between 6900–6990 and 7060–7280 B.P., less than 11 specimens were recovered from each interval.

Note: For details, see the following appendixes of this volume: mollusks, Appendix B; pollen, Appendix C; diatoms and foraminifera, Appendix E; sediments, Appendix A1.

Table 10. Paleoenvironmental Reconstruction of the Western Ballona Based on Sediments, Mollusks, and Pollen

Climate Period	Time Period	Sediments (Cores 1/1b and 43)	Mollusks (Core 43)	Pollen (Cores 1/1b and 11)
Modern	1920s–present	Fill.	Fill.	Fill.
Historical	A.D 1850–1920s	Salt marsh.	Marsh—freshwater snails.	An increase in flowering shrubs and saltbush and an influx of cattails and sedges.
Like modern mean	500–100 B.P.	Salt marsh.	Salt marsh transitioning to marsh—freshwater snails.	High levels of saltbush, flowering shrubs, and grasses; a peak in algae; and an increase in underwater plants. Some cattails and sedges 1000–500 B.P.
Like modern mean	1500–500 B.P.	Salt marsh.	Salt marsh with occasional freshwater intrusion—intertidal mudflat (some hornsnails [*Cerithidea californica*] and freshwater snails).	High levels of saltbush; flowering shrubs; some cattails and sedges; a spike in pine from 1500 to 1000 B.P.
Like modern mean	2000–1500 B.P.	Lagoon edge.	Salt marsh with occasional freshwater intrusion—intertidal mudflat (some hornsnails and freshwater snails).	Variable low to high saltbush.

Climate Period	Time Period	Sediments (Cores 1/1b and 43)	Mollusks (Core 43)	Pollen (Cores 1/1b and 11)
Neoglacial, but slight warming	2500–2000 B.P.	Lagoon.	Salt marsh with occasional freshwater intrusion—intertidal mudflat (some hornsnails and freshwater snails).	Between 2300 and 3000 B.P., brackish, saline with many large freshwater pulses (ferns, cattails, and sedges); spike in pine.
Neoglacial (cool/wet), slight warming	3000–2500 B.P.	Lagoon edge.	Core 1/1b indicated salt marsh with occasional freshwater intrusion—intertidal mudflat (some hornsnails and freshwater snails).	Brackish, saline with several significant freshwater pulses; freshwater marsh established about 3000 B.P.; high levels of cattails and sedges.
Neoglacial (cool/wet)	3500–3000 B.P.	Lagoon.	Salt marsh with occasional freshwater intrusion, transitions to intertidal mudflat by 3000 B.P.	Less marine-water influence, more freshwater mixing; variable low to high saltbush; more underwater plants and algae.
Neoglacial (cool/wet)	4000–3500 B.P.	Lagoon.	Salt marsh with occasional freshwater intrusion.	Less saline, more freshwater mixing; variable low to high saltbush; more underwater plants and algae.
Altithermal (hot/dry)	4500–4000 B.P.	Lagoon.	Mudflats became silted over between 4200 and 4000 B.P.; prior to this, intertidal mudflats; date of 4380 ± 60 is a mudflat (hornsnail shell and jackknife clam [*Tagelus californianus*]).	Less saline, more freshwater mixing; variable low to high saltbush; some underwater plants and algae.
Altithermal (hot/dry)	5000–4500 B.P.	Marine transgression (4800–4600 B.P.): ocean recedes, lagoon.	No data.	Low saltbush; increase in underwater plants and algae around 4650 B.P.
Maximum Altithermal	5500–5000 B.P.	Ocean recedes, lagoon with an open bay, continued infilling of sediments.	No data.	Low saltbush frequencies.
Maximum Altithermal	6000–5500 B.P.	Marine transgression (6300–5800 B.P.): high-energy lagoon near tidal channel.	No data.	Low saltbush frequencies.
Altithermal (hot/dry)	6500–6000 B.P.	Marine transgression (6300–5800 B.P.): open bay, continued infilling of sediments.	No data.	Low saltbush frequencies.
Altithermal (hot/dry)	7000–6500 B.P.	Sea-level rise decreases by 7000 B.P.; bay begins to infill.	No data.	Low saltbush frequencies.
Altithermal (hot/dry)	7500–7000 B.P.	At 7500 B.P., the core was at the lagoon edge, near a tidal channel; spit formation begins at the mouth of the Ballona as a result of tectonic processes, eustatic sea level, and isostatic processes.	No data.	Low saltbush frequencies.

Note: For details, see the following appendixes of this volume: mollusks, Appendix B; pollen, Appendix C; diatoms and foraminifera, Appendix E; sediments, Appendix A1.

Eastern Area (Cores 8, 25, 61, and 100)

11,000–6600 B.P.

No diatoms, foraminifera, or mollusks were identified in the cores from the eastern part of the lagoon in sediments predating roughly 7000 B.P. One brackish-water ostracode (*Cyprideis salebrosa*) was, however, recovered from a portion of the core dated to 11,140 B.P. The pollen analysis indicated that oak trees (*Quercus* sp.) and sage (*Artemesia* sp.) dominated the floral community on the bluffs above the Ballona in the early Holocene; pine (*Pinus* sp.) pollen was also present (ca. 10,000 B.P.). After 8500 B.P., an increase in grasses (Poaceae), shrubs, and flowering plants (Chenopodiaceae and Compositeae) indicated that xeric vegetation was becoming established in the vicinity of the Ballona, likely associated with Altithermal warming.

By approximately 8500 B.P., the landscape in the vicinity of Core 8 supported an increasing number of ostracodes adapted to brackish-water conditions (*C. salebrosa*, *C. beaconensis*, and *C. castus*). The presence, albeit in low frequencies, of algae and salt-tolerant (halophytic) plants (*Ruppia* sp.) indicated that pools of saline water were present in the area around Core 8. For the next 2,000 years, the eastern area of the lagoon appears to have remained predominantly terrestrial, experiencing only intermittent pulses of marine water, possibly via overflow of tidal channels during tidal surges or storms. For example, between roughly 8000 and 7800 B.P. and between 7400 and 7300 B.P., very low frequencies of transitional diatoms (*Cytherura johnsoni, Megacythere johnsoni*, and *Perissocytheridea swaini*) and marine diatoms (*Actinoptychus senarius* and *Stephanopyxis appendiculata*) were identified in the Core 8 samples. These low frequencies, less than 10 specimens per interval, suggested that these organisms were deposited in tidal surges. Freshwater diatoms (e.g., *Cocconeis placentula, Rhopalodia gibba*, *Caloneis* spp., *Surirella* spp., and *Epithemia* sp.) were present but rare—fewer than 10 specimens represented each species within each 10-cm interval from 8000 to 6600 B.P. Frequencies in the ostracode and diatom assemblages remained low until roughly 6600 B.P., indicating that this area of the lagoon was terrestrial during that interval. This interpretation is supported by the absence of foraminifera in the Core 8 samples spanning 8500–6600 B.P.

6600–4800 B.P.

Between approximately 6600 and 6500 B.P., there was a marked increase in freshwater ostracodes (*Cypria opthalmica* and *C. vidua*); freshwater specimens represented 90 percent of the assemblage. Freshwater diatoms (e.g., *C. placentula, R. gibba, Cypria* spp., *Surirella* spp., and *Epithemia* sp.) were present but rare. The increase in freshwater ostracodes and diatoms likely reflects an influx of groundwater from the alluvial fan at LAN-62 to the Core 8 location rather than an increase in precipitation or flooding. Brackish-water ostracodes (*C. beaconensis* and *C. salebrosa*) represented only a small percentage of the sample for this 100-year period. Evidence of temporary migration of Centinela Creek, rather than flooding, was also supported by the pollen data, which indicated that the sagebrush (*Artemesia* sp.) and shrub community was expanding and aridity was increasing during this interval. A small spike in *Ruppia* pollen in this portion of Core 8 also can be readily explained by migration of Centinela Creek to this area of the lagoon. From 6500 to 6050 B.P., this area appears to have remained primarily terrestrial, receiving intermittent pulses of freshwater and saline water.

Between 6050 and 5850 B.P., there was a notable spike in the presence of marine diatoms (*A. senarius* and *S. appendiculata*), foraminifera (*Elphidium incertum* and *Ammonia beccarii*), and ostracodes (*Loxoconcha tamarindoidea*), indicating a marine transgression. The same was suggested by low pollen counts in this interval. At approximately 5850 B.P., there was an abrupt decline in marine organisms, and the lagoon appears to have transformed into a brackish-water system. Only brackish-water ostracodes and freshwater diatoms were observed in the Core 8 sediment samples for the subsequent 300 years (until roughly 5540 B.P.), and no foraminifera were identified. This 300-year interval was also marked by an increase in the abundance of pollen, suggesting that the area around Core 8 was open to the air at least on a seasonal basis. Pollen percentages for sagelike shrubs and a variety of flowering plants (Chenopodiaceae and Compositeae) increased from 5800 to 5500 B.P., and concurrently, percentages of brackish-water plants, such as *Ruppia*, decreased; this shift suggests that the eastern area of the lagoon was becoming more xeric during this 300-year interval. The marine transgression and subsequent recession were undoubtedly tied to changes in eustatic sea level, which had not yet achieved equilibrium. The floral community indicated that the region was hot and dry, which fits other climate reconstructions for this period of the Altithermal in California (e.g., LaMarche 1973).

From 5500 to 4800 B.P., ostracodes adapted to brackish water continued to dominate the assemblage (80 percent). Freshwater ostracodes were next in abundance (5–10 percent). Transitional and marine specimens were also present, suggesting that marine water and freshwater occasionally flushed the area, likely as a result of tidal surges and flooding of Ballona Creek, the Los Angeles River, and Centinela Creek. The diatom and foraminifera assemblages also reflected this pattern—fewer than 5 marine diatoms and 20 foraminifera dated to this 700-year interval. Intermittent flooding was also supported by the presence of higher levels of *Ruppia* sp. and algae, particularly from 5200 to 5000 B.P. Percentages of pollen for sagebrush (*Artemesia* sp.), sagelike shrubs, and a variety of flowering plants (Chenopodiaceae and Compositeae) continued to increase throughout this period, indicating that the climate was warm and dry.

4800–3600 B.P.

From 4800 to 4600 B.P., there appears to have been a marine transgression, as evidenced by relatively high frequencies of foraminifera and increased numbers of marine and transitional ostracodes; oddly, only one marine diatom was observed in sediments for this interval. A marine transgression was also suggested by the extremely low pollen counts from 4800 to 4600 B.P. Concurrently, there was a small spike in *Ruppia* pollen and algae, indicating that the area around Core 8 was often submerged. Sediment composition and the presence of oyster shells (*Ostrea* sp.) in Core 100 indicated that the area 250 m north of and inland from Core 8 was located in a tidal mudflat. Roughly 300 m inland from Core 100, the landscape transitioned to a lagoon-edge environment, as evidenced by the presence of hornsnail shells (*Cerithidea californica*) in Core 61.

From 4600 to 3600 B.P., the eastern part of the Ballona reverted to a predominantly brackish-water system. The mudflats supporting oyster beds (*Ostrea*) and clams (Core 100) were buried by silt between 4100 and 4000 B.P. An increase in freshwater diatoms and ostracodes indicated that the eastern part of the Ballona experienced flood pulses during this interval; episodic flooding deposited the silt that buried the mudflats. Additionally, pollen grains recovered for this 100-year interval were highly deteriorated, indicating alternating wet and dry conditions. A spike in *Typha* (cattails) and the presence of ferns and algae from roughly 3700 to 3600 B.P. indicated that standing water was present. With the exception of the spike in cattails and ferns, the floral community near Core 8 was dominated by sagelike shrubs, sagebrush, various flowering plants, and ragweed. Farther inland from Core 8, the Ballona was a salt marsh, as evidenced by the hornsnail shells (*C. californica*) recovered from Core 25. Between 3700 and 3600 B.P., a tidal channel appears to have overflowed, as represented by a single foraminifera (*E. incertum*) and one marine diatom (*Coscinodiscus marginatus*); the overflow may have occurred as a result of a tidal surge or winter storm. The wet conditions reflected in the proxy-data assemblages for 4100–3600 B.P. corresponds well with the cooler/wetter conditions associated with the Neoglacial period in California (LaMarche 1973) and elsewhere (Clague and Mathewes 1996; Wood and Smith 2004); from 4600 to 4100 B.P., the environment appears to have been more xeric.

3600–1000 B.P.

From 3600 to 2000 B.P., the eastern portion of the Ballona became increasingly terrestrial as a result of the filling of the basin with sediment. No diatoms or foraminifera were identified in the sediment samples, and only a few freshwater ostracodes were observed in the sediment samples for Core 8. A decrease in salt-tolerant plants (Chenopodiaceae) and an increase in pine and ferns around 3100 B.P. and 3000 B.P. suggested that a cooler, more terrestrial environment was developing. By 2900 B.P., the environment appears to have become more arid, as indicated by an abrupt decline in pine and ferns and an increase in Chenopodiaceae and plants associated with the sunflower (Compositeae) family. One significant pulse of freshwater, possibly from flooding of Ballona Creek, was evidenced by an increase in the number of freshwater ostracodes observed in samples dating to around 2000 B.P. (n = 368). This number is much higher than in the samples for the previous 500 years, wherein a total of only 85 specimens were identified, averaging 17 specimens per 10-cm interval. This small flood event does not appear to have affected the plant community of the Ballona. From 2900 to 1000 B.P., the pollen assemblage remained largely the same, dominated by Chenopodiaceae and Compositeae. No marine diatoms or foraminifera were observed in any of the samples dating to 3600–1000 B.P., indicating that this area was no longer directly influenced by the ocean.

1000 B.P. to the Historical Period (A.D. 1850)

From 1000 B.P. to the historical period, the lagoon remained closed, and no diatoms, foraminifera, or ostracodes were observed in Core 8 samples for this interval. A decline in Compositeae corresponds with a marked increase in grasses and plants associated with the mustard (Brassicaceae) family, such as tubers like radish and cabbagelike plants similar to kale. These plants dominated the assemblage until approximately 500 B.P., at which time oak and Compositeae pollen increased in frequency once again. The plant community of the Ballona and surrounding bluffs was undoubtedly heavily utilized by people living in the area, and the increases in grasses and Brassicaceae may reflect selective collection and harvesting of these resources. Decline in less-palatable plants may similarly reflect human selection or weeding (elimination) of these varieties so that preferred plants could expand into other areas of the landscape. The decline in grasses and plants associated with the mustard family around 500 B.P., concurrent with an increase in oak pollen, could reflect a combination of cooler/wetter conditions associated with the LIA (making oak more abundant) as well as a human choice to gather grasses and other plants from elsewhere and to harvest acorns on the bluffs above the Ballona.

Western Area (Cores 1/1b, 11, and 43)

7500–6400 B.P.

The presence of very few marine and transitional ostracodes and only a few foraminifera (n <10) from sediments dating to roughly between 7200 B.P. and 6950 B.P. indicated that marine water only occasionally entered the far-western reaches of the Ballona, in all likelihood during tidal surges or winter storms. Very low frequencies of brackish-water ostracodes (*C. beaconensis* and *C. salebrosa*) dominated the assemblage for this period. For the period spanning roughly 7050–6950 B.P., no ostracodes, foraminifera, or diatoms were observed in the sediment samples, suggesting that the area was dry. For the period spanning 6950–6400 B.P., freshwater (n < 25) and marine (n < 60) diatoms were observed, but they were rare; less than 100 specimens were recovered. Foraminifera were also rare; less than 10 were identified in sediments spanning this 550-year period. This low frequency suggested that Core 1/1b was located at the edge of a bay until 6400 B.P. Pollen indicated that low levels of saltbush were present near Core 1/1b from 7500 to 6400 B.P. and that brackish-water plants (*Ruppia*) and algae were present from roughly 7000 to 6400 B.P.

Roughly 1,500 m northeast of Core 1/1b, at Core 43, the stratigraphy and invertebrates recovered indicated that this area was a sand flat at or below the high-tide line from roughly 7500 to 6400 B.P. A sand-flat environment was indicated by the presence of cockleshell fragments (*Assiminea californica*), oyster fragments (*Ostrea* sp.), sprite snail (*Promenetus* sp.), a Venus clam (*Chione* sp.), and a pillow barrel-bubble shell (*Acteocina culcitella*). It is important to note that the sampling intervals for sediments and invertebrates were at a much grosser scale than for any of the other analyses, mainly because of their sporadic presence in the core samples, and therefore could only be used to identify general trends rather than localized events in the Ballona.

6400–5400 B.P.

From roughly 6400 to 5850 B.P., ostracodes adapted to brackish water were moderately abundant in the Core 1/1b samples. The persistent presence of transitional (e.g., *Megacythere johnsoni, Puriana pacifica,* and *Xestoleberis aurantia*) and marine (*Loxoconcha tamarindoidea*) ostracodes, foraminifera (*Elphidium incertum*, *Ammonia beccarii*, and *Elphidium* sp.), and marine diatoms (e.g., *A.* cf. *splendens, A. senarius* and *S. appendiculata*) indicated that the area was often covered by the ocean. The sediments and assemblage composition indicated that Core 1/1b was located at the edge of a lagoon or tidal channel that routinely flooded with marine water. This period corresponds with the marine transgression identified in the eastern Ballona core assemblages, but the transition from a lagoonal edge to a tidal zone on a bay is more difficult to discern using proxy data than a marine transgression over a formerly terrestrial landscape. In addition to a marine influence, however, freshwater ostracodes and diatoms were represented in moderately high frequencies throughout this interval, indicating that the area intermittently received water from Ballona Creek. The pollen assemblage for this interval remained largely the same as that observed from 7500 to 6400 B.P., indicating a sustained marine influence until 5850 B.P. The invertebrate assemblage of Core 43—with its low frequencies of razor clams (*Tagelus subteres*)—continued to reflect a sand flat located at or below the high-tide line throughout this period.

Between 5850 and 5400 B.P., there was a reduction in the abundance of marine diatoms (<10 identified for this 400-year interval), but foraminifera were consistently present in moderate numbers (*E. incertum* and *A. beccari*). Similarly, marine ostracodes (*L. tamarindoidea*) and transitional ostracodes (*Xestoleberis banda, X. aurantia*, and *P. pacifica*) were represented throughout this interval, albeit in low frequencies (<10 percent of the assemblage). Freshwater ostracodes (*C. vidua* and *L. staplini*) were present, but in very low frequencies (<10 percent). From 5850 to 5400 B.P., this area appears to have been located at the edge of a brackish-water lagoon that received occasional pulses of marine water and freshwater. The pollen assemblage of Core 1/1b suggested that this area continued to be a lagoon-edge environment. Farther inland, at the location of Core 43, the presence of oyster shells (*Ostrea* sp.) and barrel-bubble shells (*A. culcitella*) indicated that the landscape was transformed from a sand flat to a mudflat during this time period.

5400–3000 B.P.

From 5400 to 4000 B.P., the paleoecology of the area around Core 1/1b remained largely the same, but slightly higher frequencies of marine and transitional ostracodes were apparent between 4900 and 4400 B.P., reflecting a slightly stronger marine influence during this interval. Based on the microfauna assemblages, this part of the Ballona appears to have been located at the edge of a lagoon but continued to receive occasional pulses of freshwater. The pollen assemblage changed little between 5400 and 4000 B.P., with the exception of a spike in *Ruppia* that lasted until roughly 4700 B.P. The higher percentages of salt-tolerant *Ruppia* may suggest that levels of evaporation were high, which corresponds with the warm/dry conditions of the Altithermal.

Oak, sagebrush, and Compositeae increased slightly from 4600 to 4000 B.P., indicating a slightly cooler/wetter environment than before. A decline in *Ruppia* indicated that pools of water in the Core 1/1b vicinity became less saline and experienced more freshwater mixing. A concurrent increase in the percentage of freshwater ostracodes (*C. vidua* and *L. staplini*) and diatoms (e.g., *Thalassionema nizschioides, Hantzschia* spp., and *S. striatula*) during this period further suggested that more freshwater was being flushed into the area via Ballona Creek. The invertebrate assemblage of Core 43 indicated that the mudflats there supported oysters (*Ostrea* sp.), hornsnails (*C. californica*), and jackknife clams (*Tagelus californianus*) until roughly 4300 B.P., when it transformed into a salt marsh supporting a variety of snails (*Physa* snail and *Physa* sp), cockleshell (*Assiminea californica*), and sprite snails (*Promenetus* sp.). The area around Core 43 remained a salt marsh until it was covered with fill during the historical period.

After 3800 B.P., foraminifera were extremely rare in the Core 1/1b samples, and there was a decline in marine diatoms concurrent with an increase in freshwater diatoms. Transitional and marine ostracodes were present in all levels of the core until about 3800 B.P., at which time there was an abrupt decrease in the abundance of these specimens that lasted until roughly 3200 B.P. The abrupt decline in marine ostracodes, marine diatoms, and foraminifera after 3800 B.P. supports previous investigations that postulated that the spit at the mouth of the Ballona closed around 3800 B.P. Ostracodes adapted to brackish water and freshwater remained more or less evenly represented in the assemblage until 3000 B.P., indicating that the area continued to receive pulses of freshwater throughout this period.

The pollen assemblage indicated that from 4000 to 3000 B.P., Chenopodiaceae and grasses increased in frequency. An increase in *Typha* (cattail) pollen and *Ruppia* around 3100 B.P. and the constant presence of algae suggested that this area of the Ballona was often covered by shallow water. The proxy data all indicated higher levels of precipitation from 4000 to 3000 B.P., an interval widely recognized as the Neoglacial period.

3000–1500 B.P.

The period spanning 3000–1500 B.P. was similar to the preceding 400 years. Core 1/1b represented a brackish-water lagoon that occasionally received pulses of freshwater. Brackish-water ostracodes (*C. beaconensis* and *C. salebrosa*) dominated much of the assemblage, but freshwater specimens (*C. vidua* and *L. staplini*) occasionally occurred in greater frequencies than brackish-water ostracodes. With the exception of a pulse of marine water or a tidal surge reaching this area around 2400–2300 B.P. and again between 2200 and 2000 B.P., the Core 1/1b area appears to have received little marine influence during this 1,500-year interval. Pulses of marine water were marked by the presence of a single marine diatom between 1 and 1.2 m b/s (2360 B.P.) and a few foraminifera between 0.7 and 0.9 m b/s (ca. 2100 B.P.). No marine diatoms were recovered from higher (more recent) samples in the core. From approximately 2070 to 1980 B.P., freshwater diatoms were more frequent in the core, but from 1980 to 1500 B.P., there was a steady decline in the total number of diatoms observed, indicating that this location received less freshwater during this period.

Pollen data indicated that the saltbush community near the lagoon varied from low to high in abundance between 3000 and 2000 B.P. A spike in *Typha* from 3000 to roughly 2700 indicated that water was abundant in the vicinity of Core 1/1b, and a spike in pine around 2300 B.P. indicated that the regional environment was cool and wet. Between 2000 and 1500 B.P., saltbush increased in abundance, and all other flora were only marginally represented: cattails, grasses, oak, pine, and Compositeae were present but in relatively low frequencies. The area around Core 1/1b had transitioned to a salt marsh by 1500 B.P.

1500 B.P. to the Historical Period (A.D. 1850)

The paucity of materials suitable for dating Core 1/1b did not allow for a high-resolution reconstruction of the paleoecology of this area from 1500 to 730 B.P., and above this, the core was destroyed and could not be analyzed. Core 11, located roughly 200 m northeast of Core 1/1b, was therefore used to reconstruct the paleoecology of the western portion of the lagoon from 730 B.P. to the historical period.

From 1500 to 730 B.P., pulses of marine water occasionally reached this part of the Ballona Lagoon, but freshwater organisms clearly dominated the assemblages. A pulse of marine water was indicated by fewer than 10 foraminifera (*Buccella* sp., *Uvigerium peregrine*, *U. Hootsi, Globigerina pachyderma, Globigerina* sp., *Cassidulina cusimmani, Cassidulina* sp., and *Cibicides* sp.) recovered from sediments for this interval. After 730 B.P., brackish-water ostracodes (*C. beaconensis* and *C. salebrosa*) represented 20–30 percent of the assemblage, and the remaining specimens were freshwater species (e.g., *C. vidua*, and *L. staplini*). Hornsnail shells (*C. californica*) recovered from sediments dating from 1500 to 500 B.P. indicated that a salt marsh was present in this area until ca. A.D. 1450; after this period, only freshwater snails were identified in the samples.

Pollen from Core 1/1b and Core 11 indicated that there were high levels of saltbush and a variety of shrubs, annuals, and grasses growing in the area for the last 1,500 years. The primary variance identified in the assemblage was an increase in algae between 500 and 400 B.P. (ca. A.D. 1450–1550) and a spike in pine pollen from 150 to 100 B.P. (ca. A.D. 1800–1850). Similarly, Compositeae pollen increased in frequency during intervals when there were reductions in Chenopodiaceae. The timing of these changes in the pollen assemblage appears to reflect the cooler/wetter period of the LIA (Graumlich 1993; Grove 1990). Pollen during these intervals was also deteriorated and occurred in low frequencies, suggesting alternating wet and dry conditions in the tidal marsh.

Summary

Our paleoenvironmental reconstruction of the Ballona indicates that the landscape surrounding the lower drainage of Ballona Creek/the Los Angeles River was primarily terrestrial until 8500 B.P. After that time, sea-level rise associated with the melting of the Wisconsin and Weichsel continental ice sheets (as well as melting glaciers and sea ice) resulted in the formation of a bay at the mouth of the Ballona Creek/Los Angeles River drainage system. By 7500 B.P., the area immediately west of present-day Lincoln Boulevard and north of Centinela Creek was a tidal sand flat (at Core 43) (see Figures 21 and 22), supporting cockleshell (*Assimenea californica*), oyster (*Ostrea* sp.), sprite snail (*Promenetus* sp.), and Venus clams (*Chione* sp.). Sea level was high enough at this time that tidal and/or storm surges occasionally carried pulses of marine water much farther inland, as observed in marine microfauna recovered from Core 8 (see Figures 21 and 22), located over 800 m inland from Core 43.

As massive ice sheets and glaciers in the northern hemisphere and Antarctica melted, sea level continued to rise. By 6400 B.P., the bay at the mouth of Ballona Creek/the Los Angeles River penetrated farther inland as the sea rose. Even the lower slopes of a large alluvial fan jutting into the drainage from the adjacent Ballona Escarpment were covered by seawater, at least temporarily (at Core 1/1b, roughly 1,500 m southwest of Core 43). Areas farther inland were also affected by the rising sea; pools of brackish water became established farther inland (Core 8), where tidal surges had formerly only occasionally penetrated. Sea level at the Ballona appears to have remained in stasis for several hundred years but then rose even higher. At roughly 6100 B.P., the sea transgressed farther, and the area near Core 8 was inundated by the ocean, as indicated by much higher frequencies of marine microfossils. These conditions persisted until 5800 B.P.

After 5800 B.P., eustatic sea level in many regions of the world lowered as a result of isostatic rebound and/or tectonic uplift. Sea level at the Ballona was similarly affected. For the next 300 years, the farthest-inland areas of the Ballona returned to a terrestrial landscape, and xeric vegetation became established as far west as Core 8. The sea even regressed from the western edge of the Ballona, and pools of brackish water settled there (at Core 1/1b); only occasionally did that location receive pulses of marine water, possibly during tidal or storm surges. However, eustatic sea level had not yet achieved balance, and around 5500 B.P., sea level rose again, and the Ballona experienced another marine transgression. Sea level did not reach the height attained nearly 1,000 years earlier, but as far inland as Core 8, the land was transformed from an arid landscape to a brackish-water lagoon. For the next 700 years (until 4800 B.P.), the portion of the Ballona abutting the southern escarpment was bordered by a brackish-water lagoon.

After 4800 B.P., sea level rose and transgressed farther inland, and the brackish-water lagoon was transformed into a marine lagoon. The pollen and microfauna assemblages of Cores 1/1b, 8, and 43 indicated that these conditions were sustained for nearly 200 years. After 4600 B.P., sea level receded, and the inland reaches of the Ballona became a brackish-water lagoon again (at Core 8). In contrast, the western part of the Ballona (at Core 1/1b) remained covered by seawater until roughly 4400 B.P., after which point the western edge of the Ballona was transformed into a brackish-water lagoon that persisted for several hundred years.

Between 4100 and 4000 B.P., a series of floods transported heavy sediment loads down Ballona Creek/the Los Angeles River and Centinela Creek and buried the intertidal mudflats and clam and oyster beds (*Ostrea* sp.) located on the eastern edge of the lagoon (as observed in Core 100, roughly 300 m northeast of Core 8). This period of flooding corresponds well with the transition from the Altithermal drought period to the Neoglacial pluvial period; after 5,000 years of aridity, the mountains, plains, valleys, and deserts of southern California would have been parched, and heavy rains would have easily eroded the landscape and transported sediments downstream to the mouths of rivers, streams, and creeks. These floods do not appear to have had a significant effect on the microhabitat of the western part of the Ballona. Pollen and microfauna data recovered from the western part of the Ballona (Cores 1/1b and 43) (see Figures 21 and 22) indicated that a brackish-water lagoon persisted in this area from 4400 B.P. to roughly 3800 B.P.

After 3800 B.P., the Ballona lagoon remained largely closed to the sea and continued to shrink as a result of infilling. Areas farthest inland became increasingly terrestrial, gradually transforming from salt marsh to coastal plain. Similarly, the area of the lagoon nearest the coast (Cores 1/1b and 43) was transformed and, by 1500 B.P., had become a salt marsh that persisted until the historical period. Occasional storm surges carried marine organisms into the salt marsh, but in general, the environment of the Ballona remained constant until the area began to be developed and settled in the 1800s.

Other Cores in the Ballona

Sediment reconstructions performed on other cores collected from the Ballona support the above synthetic reconstruction. Reconstructions derived from these other cores are described below in order to paint a more complete picture of the Ballona's evolution from 7000 B.P. to the historical period. The locations of these cores are shown in Figure 16. As sedimentation rates within the lagoon began to exceed sea-level rise around 7000 B.P., extensive marshes and tidal flats formed along the margins of the Ballona Lagoon. At that time, the main feature in the Ballona area was a marshy alluvial fan projecting out into the bay from a large gap in the Ballona Escarpment (Figure 23). Present-day Lincoln Boulevard (see Figure 3) descends along this fan and through this gap. The fan had formed before 16,000 B.P., and its edge maintained a position near Core 209, or roughly the present-day Lincoln-Jefferson intersection, until approximately 3000 B.P. This fan was a stable geomorphic feature that provided ready access for prehistoric populations on the bluff tops to exploit lagoonal resources.

By 5000 B.P., the barrier was still forming across the mouth of the coastal inlet (see Figure 23). Sediments were starting to accumulate around the fringes of the inlet, creating marshes that flanked a large lagoon that was roughly 5 km long by 3 km wide. A sandy area or "island" of higher and better-drained land was present in the marshes around Core 35, in the eastern end of the study area.

Sediment infilling continued, leading to more-extensive marshes and a more confined lagoon by 4000 B.P. (see Figure 23). The area of higher, sandy ground persisted around Core 35, and a coastal plain probably started to form in some of the more-landward portions of the Ballona area. It is important to note that the lagoon edge still persisted near Core 209, maintaining approximately the same position occupied by the leading edge of the fan noted in Figure 23. The higher,

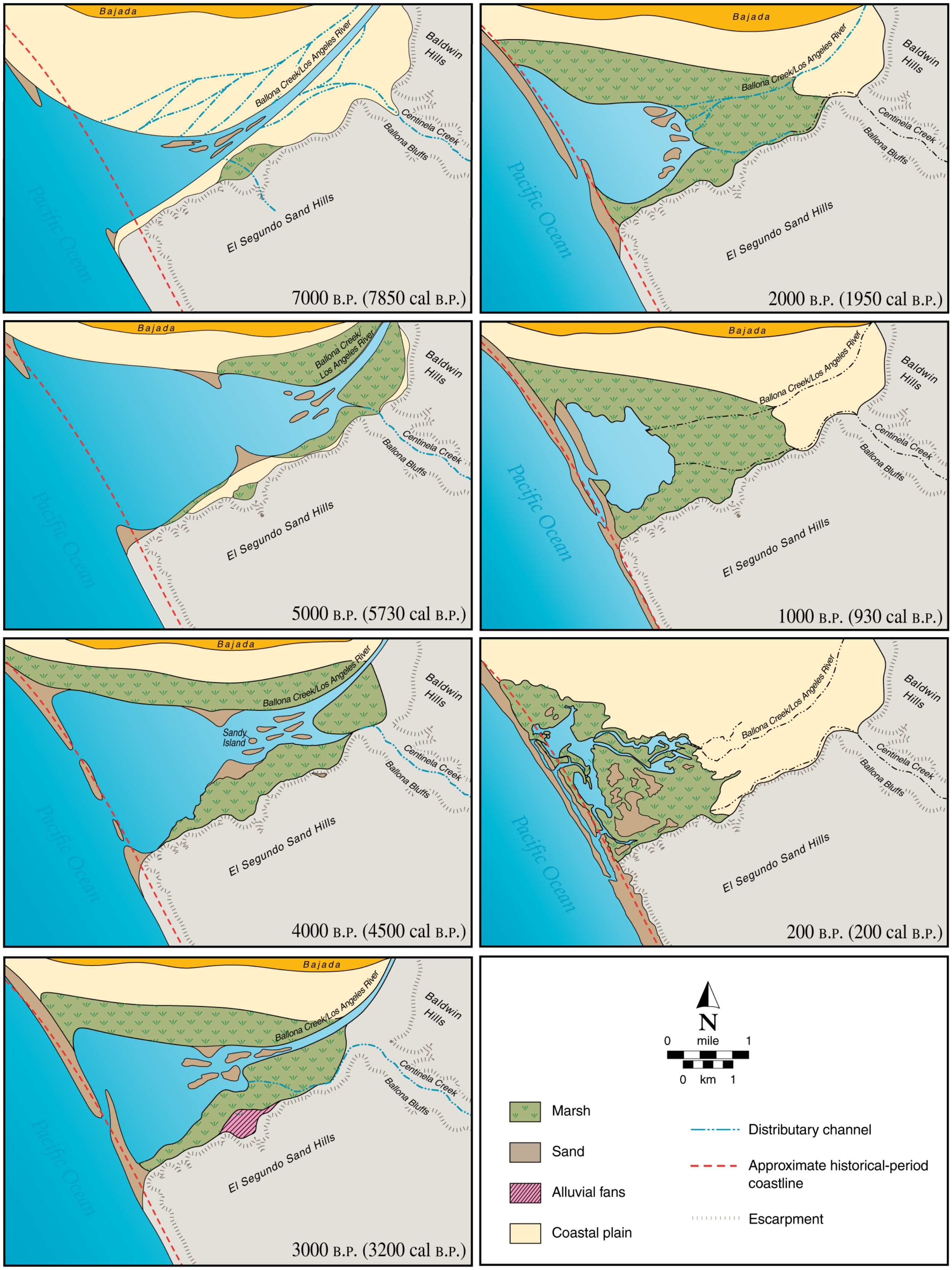

Figure 23. The history of the Ballona Lagoon at seven approximate dates in the past, as reconstructed from data in the present study combined with the models depicted in Figure 15 and the geologic history of the Los Angeles Basin. Dates are given in radiocarbon years.

sandy ground around Core 35 shifted to the east by 3000 B.P. to the area around Core 25 (see Figure 23). The Ballona Lagoon continued to shrink as it was filled with sediment. It is likely that the lagoon filled in more quickly from east to west than along the north-south axis, because both Ballona and Centinela Creeks enter the lagoon at its east end. These creeks, particularly Ballona Creek (and for much of prehistory, the Los Angeles River), would have carried a relatively high sediment load, much of which would have been dropped as its discharge entered the marshes and lagoon. This interpretation is supported by the sedimentation rates calculated for this study (see Appendix A of this volume), which were often two to three times higher at the east end of the study site (e.g., Core 25) than farther west. The coastal plain would also have expanded at that time.

The lagoon edge began to retreat from the vicinity of Core 209 by 2000 B.P. (see Figure 23), which probably indicates that sediment from Ballona Creek and the Los Angeles River had filled in the lagoon up to that point. There was an area of higher, sandy ground around Cores 70 and 100, below the large gap in the Ballona Escarpment. The Ballona Lagoon continued to shrink because of sediment infilling, and the coastal plain continued to advance seaward.

By 1000 B.P., the Ballona Lagoon was confined to a small remnant of its former size of some 5,000–6,000 years earlier as the lagoon edge retreated from the Ballona Escarpment along all or most of its length (see Figure 23). By that time, the lagoon was probably quite shallow throughout its extent, and marshes were probably forming along the landward sides of the barrier. A substantial dune field appears to have formed near Cores 25 and 38, and coastal-plain formation was well advanced.

Figure 7 (200 B.P.) shows the Ballona Lagoon as mapped by the U.S. Coast Survey in 1861 (Chase 1861). The lagoon was separated from the open ocean by a double barrier and had largely filled with sediment. There were several sandy "islands" that were higher and drier than the surrounding marsh. Ballona Creek, the Los Angeles River, and Centinela Creek were the primary freshwater conduits to the lagoon, and the coastal plain had developed over much of the former lagoonal expanse during the previous 5,000 years. The rapid infilling of the Ballona Lagoon is not surprising, because lagoons and their associated wetlands are often features that are short-lived, from a geologic perspective (Bird 1994; Eisma 1998; Orme 1990).

Figure 24 shows a cross section of the different stratigraphic units identified in the Ballona Lagoon. Figure 25 shows the locations of the cores used to develop these cross sections in plan view.

Conclusions

Stratigraphic reconstruction of the Ballona Lagoon indicates a system that was probably in static equilibrium with sea-level rise after about 7000 B.P. Therefore, lagoonal evolution was driven primarily by sediment infilling rather than by sea-level transgression or regression. Sedimentation rates were higher near the mouths of Ballona and Centinela Creeks and in the marshes alongside these creeks, indicating that sediment deposition from overland drainage systems was largely responsible for lagoon infilling.

Support for our general late Pleistocene and Holocene reconstructions of the Ballona is provided by previous studies. Poland et al. (1959) described the general subsurface geology of the Ballona. They found a sand-and-gravel unit, referred to as the "50-foot gravel," at depths of 48–67 feet (15–20 m) b/s in the Ballona area. Overlying the 50-foot gravel are thick silt and clay deposits that include lenses of sand and peat. In some areas, these deposits contain decomposing organic matter that creates pockets of methane and hydrogen-sulfide gas. In general, the 50-foot gravel is consistent with deposition of marine sands as the Pacific Ocean transgressed into the area between 15,000 and 7000 B.P. The silt and clay with interbedded sand and peat are consistent with the various environments found in and around coastal lagoons. The evolution of the Ballona Lagoon from roughly 7000 B.P. to the late nineteenth century was similar to that of other lagoons in southern California (see Chapter 8 of this volume). The map developed by the U.S. Coast Survey in 1861 (Chase 1861) provides the best record of the Ballona in a natural state, albeit late in its history (see Figure 7). This map depicts both Ballona and Centinela Creeks running from the coastal plain onto a broad zone of tidal marsh that, in turn, surrounds a lagoon sheltered from the ocean by a sandy double barrier. The lagoon shown on Chase's (1861) map is located approximately where Marina del Rey was built.

It is important to note that Ballona Creek and the Los Angeles River were much more important than Centinela Creek in the evolution of the Ballona Lagoon and the estuary that flanked it. Although Centinela Creek, a spring-fed drainage, provided freshwater on a more consistent basis, which was especially important to human settlement, Ballona Creek and the Los Angeles River were more important drivers of the geomorphic system in terms of the volume of freshwater and sediment they contributed to the lagoon and estuary—the Los Angeles River more so than Ballona Creek. The Los Angeles River mainly drained into the Ballona throughout much of prehistory, an assessment based on the submarine delta fan offshore in Santa Monica Bay, which is much larger than where the Los Angeles River now drains into the ocean at Long Beach in San Pedro Bay. The Los Angeles River switched course across the Ballona Gap numerous times historically, but now it is artificially confined within a concrete-lined channel to Long Beach. The Los Angeles River clearly provided most of the sediment to the delta fan in Santa Monica Bay, because it drains about 550 square miles, which is about five times the size of the Ballona Creek watershed. There is a distinctive micaceous alluvium associated with Centinela Creek that indicates that its channel was primarily confined to an area near the bluff, in contrast

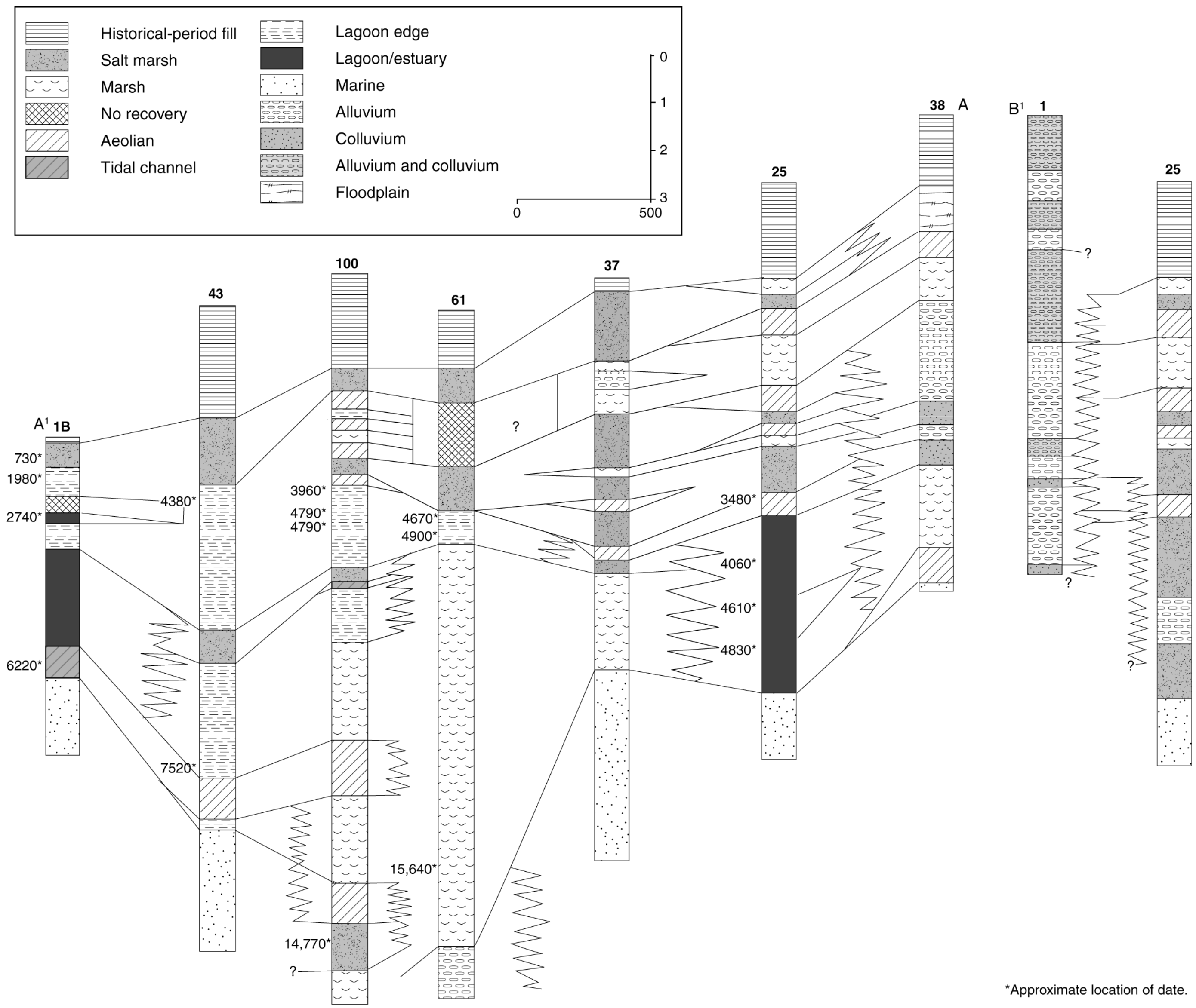

Figure 24. Cross sections of the study area: A–A' and B–B'. The number at the top of each stratigraphic column is the core number (see Figure 25). Numbers beside columns are radiocarbon ages (B.P. ± 1σ) (see Table 3).

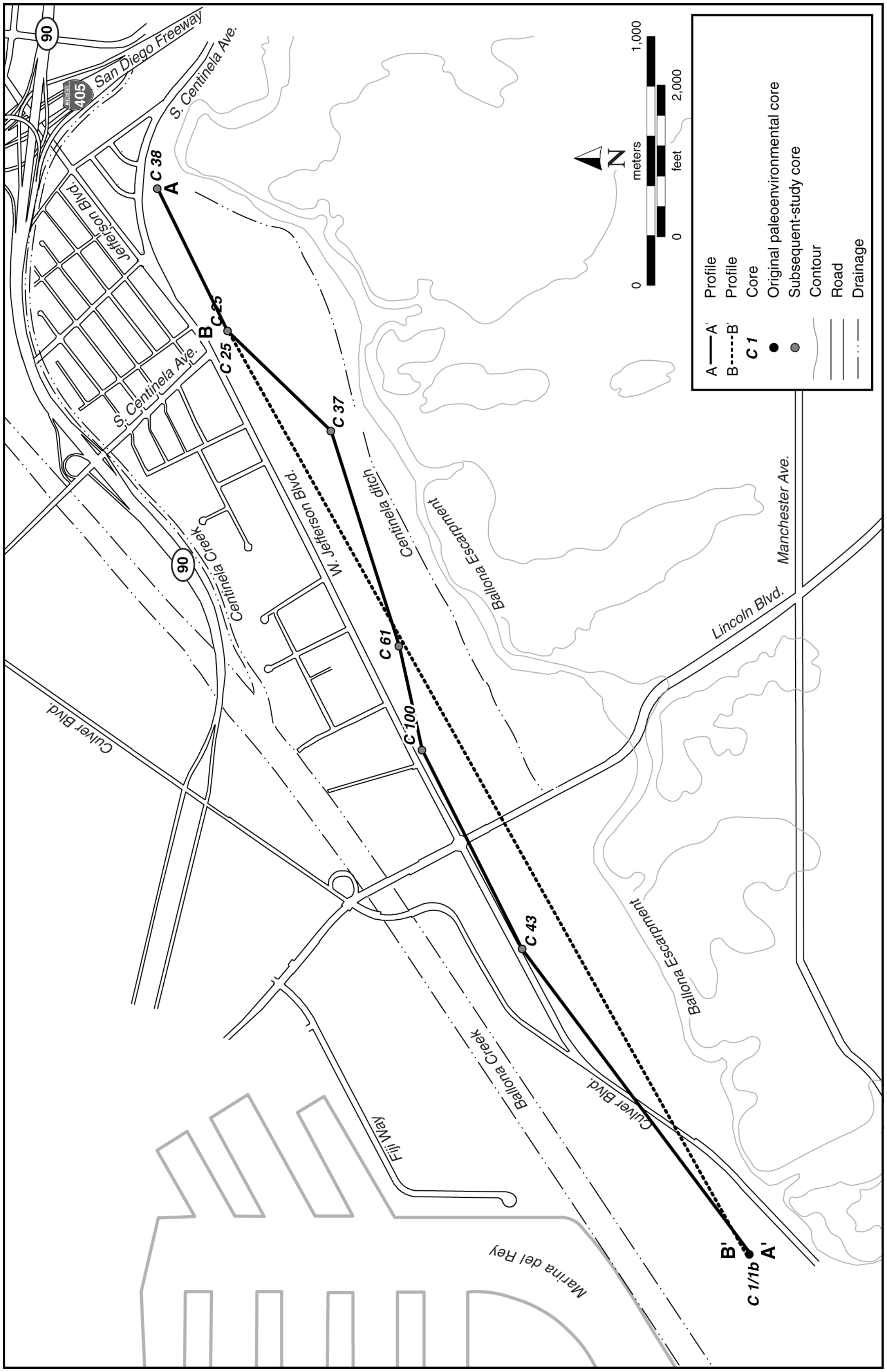

Figure 25. Plan view of core locations used to develop cross-sections of the Ballona Lagoon.

to the more-widespread silty and clayey alluvium associated with Ballona Creek and the Los Angeles River.

Both Ballona and Centinela Creeks have been subjected to lateral stream migration during their histories. Evidence for this migration has been seen at some archaeological sites, such as LAN-211, located along the base of the Ballona Escarpment. For the purpose of this geomorphic study, however, too few exposures were observed, and no radiocarbon dates were obtained. Therefore, there was insufficient temporal and spatial control for modeling lateral stream migration.

The earlier model for the Ballona Lagoon proposed by Altschul, Ciolek-Torrello, and Homburg (1992; Altschul, Homburg, and Ciolek-Torrello 1992) reconstructed the lagoon at three periods: 5000 B.P., 2000 B.P., and 1000 B.P. There are no significant differences between the previous model and the model proposed here for the 2000 and 1000 B.P. time frames. The existing differences are minor and inconsequential, given the amount of temporal and paleoecological control available for these reconstructions. The major difference between the results presented in the previous model and those in this study is the time of barrier formation, which led to closure of the open-water embayment and thus to the formation of the lagoon. The previous model depicted barrier formation as occurring sometime between 7000 and 3000 B.P., whereas this study shows that the barrier was forming by about 6300 B.P. and was completed by about 4000 B.P. As previously noted, the 6300 B.P. time of barrier formation is indicated by a radiocarbon date from Core 1b (see Table 3 and Figure 23); further support is provided by microfossil studies (see Appendixes D and E of this volume). Most radiocarbon dates and all paleoecological studies were initiated several years after Altschul, Ciolek-Torrello, and Homburg (1992; Altschul, Homburg, and Ciolek-Torrello 1992) proposed their model. Their general model relied mainly on radiocarbon dates and shellfish and artifact assemblages from archaeological excavations on top of and at the base of the Ballona Escarpment (see Freeman 1991).

However, the currently proposed model has constraints. To model the evolution of the lagoon more completely and accurately, it is necessary to obtain more dating control in the eastern part of the study area, and additional cores and radiocarbon dates would be helpful in areas north of Core 209. Nonetheless, our work focused on the areas most pertinent to the archaeological record. Thus, it provides a sound basis for geoarchaeological modeling of shifts and changes in human settlement and land use. A stable shoreline existed in the vicinity of Core 209, near the present-day Lincoln-Jefferson intersection, for several thousand years. It offered prehistoric human populations a good location for exploiting the lagoon's resources. Several sandy "islands," or areas of higher ground, existed in the marshes surrounding the Ballona Lagoon, some of which were located during this study, as at LAN-54. These sandy islands were better drained than the surrounding wetlands and thus provided land that was available for human occupation on at least a seasonal basis. In the following chapter, we discuss the evolution of the Ballona Lagoon in relation to its use by prehistoric populations and to other lagoons in southern California.

Human Adaption to Coastal Wetlands: The Environmental Context

Jeffrey A. Homburg, Richard Ciolek-Torello, Seetha N. Reddy, and Dennis R. Gallegos

The Ballona Lagoon was one of the richest and most diverse microenvironments in the Los Angeles Basin. In the 1870s, the Ballona Lagoon was home to a dense population of fish, waterfowl, and sea mammals and was renowned for its hunting and fishing. Once known locally as "Ballona Bay," it is now home to the large inland harbor and community of Marina del Rey. But its historical use masks an even longer and more-intense occupation by the indigenous inhabitants of the Los Angeles Basin. Like many coastal wetlands in southern California, the Ballona was attractive to native peoples for more than 8,000 years, a fact attested to by the large number of prehistoric sites recorded in the area.

Since 1989, SRI has conducted an intensive research program combining environmental reconstruction and archaeological investigations in the Ballona (Altschul et al. 1992; Altschul et al. 1993; Altschul et al. 1998; Altschul et al. 1999; Altschul et al. 2005; Grenda and Altschul 1994; Grenda et al. 1994). From the beginning, we, like many archaeologists, have argued that changes in human use of the southern California coast were tied directly to the evolution of wetlands. Unfortunately, the history of most wetlands is poorly known. Even in wetlands where a significant amount of archaeology has been performed, little attention is generally given to reconstructing the natural environment. In part, this disparity in effort reflects the nature of historic-preservation compliance, in which the emphasis tends to be placed on the archaeological resources. The PVAHP differs in this regard, because the research design focused less on site-specific objectives and more on regional questions, one of which was how humans adapt to dynamic environmental settings, such as wetlands (see Chapter 5 of this volume).

In the preceding chapters and in the appendixes of this volume, we have compiled abundance and diversity data for ostracodes, mollusks, foraminifera, siliceous microfossils (mainly diatoms, but also silicoflagellates), and pollen. These data sources are used as proxy measures by which we have reconstructed Holocene paleoenvironmental conditions in and near the Ballona Lagoon. In this chapter, we summarize our current paleoenvironmental reconstruction of the Ballona; populate the changing wetlands through time with people, as inferred from earlier archaeological studies; and examine human adaptation to this coastal environment. To place our work in a broader regional context, we begin with a summary of the paleogeography and settlement histories of other southern California coastal wetlands. The multisource, relatively high-resolution reconstruction of the Ballona will then serve as the environmental backdrop for the analytical studies and synthetic interpretations presented in the remaining volumes of the PVAHP Series.

California Coastal Wetlands

On a geologic time scale, California's coastal wetlands are recent landscape features resulting from the complex interaction of geological processes (e.g., sedimentation, subsidence, and tectonism) and global changes in sea level (Nardin et al. 1981). The rapid rise of sea level, resulting from deglaciation over the past 15,000 years, induced the formation of coastal wetlands by inundating coastal river valleys to form bays, estuaries, lagoons, and salt marshes (Nardin et al. 1981; Orme 1990). As a result, most of California's coastal wetlands are geographically isolated landscape features and are relatively small when compared to the extensive wetlands present in other parts of the United States.

Although limited in extent compared to those of eastern North America, California's wetlands are more extensive than those of any other western state except Alaska. There are 110 major coastal wetlands in the state; they represent diverse habitats ranging from the undeveloped estuaries and marshes around tidal-flushed river mouths in the north to the highly urbanized saline lagoons, embayments, and salt marshes in the south. This diversity of wetlands is mainly the result of California's position at the edge of a dynamic continental land mass, where sea level and land elevation were in flux during the Holocene.

The primary significance of California's coastal wetlands is their range of habitats and their role in maintaining biodiversity (Boicourt 1993). Large-scale evolutionary processes have produced a highly variable coastal zone with numerous relatively isolated and unique wetland landscapes. Pacific Coast wetlands differ in fundamental ways from wetlands in other parts of North America, especially in terms of topography, geology, hydrology, climate, and species composition. For example, one major difference between California's wetlands and those of the U.S. Southeast is the paucity of peat marshes in the West. Extensive periods of inundation or near saturation are needed to form peat deposits. Wetlands in California tend to dry out for much of the year, at least those areas above those that were affected by tidal activity.

Geologic records associated with estuaries provide a unique source of information about continental and marine cycles that have affected human adaptation in the past. These cycles include both short-term components (e.g., seasonality or human activity) and long-term components (e.g., isostatic or eustatic sea-level changes). Isostatic changes are caused by changes in the level of the land masses as a result of thermal buoyancy or tectonic effect; eustatic changes are associated with global changes caused by melting of ice sheets. Sedimentation in estuaries is influenced by a complex combination of tidal currents, oceanic waves, locally generated waves, river discharge, precipitation, temperature, and local flora and fauna (Clifton 1982). Also important are geologic agents like tectonism, subsidence, isostatic and eustatic changes of sea level, climate change, and human activities that have altered the hydrology, drainage, and topography.

Although many coastal lagoons and estuaries in California were formed with the rise in sea level prior to and during the Holocene, the geologic and settlement histories of these lagoons differ. In general, the overall trend of increasing freshwater influence during the Holocene is similar among southern California wetlands, but physiographic, tectonic, and climatic differences affect such features as lagoon size and sedimentation rates, which, in turn, affect salinity rates and biotic communities. Differences along the coast range from relatively small "variations on a theme" to wholesale differences that led to fundamentally different human responses. Lagoons and estuaries discussed in this chapter are shown in Figure 26 and listed in Table 11, arranged from north to south.

Common to all of the lagoon histories is the rise in sea level, which flooded coastal valleys ca. 10,000 years ago; the stabilization of sea level ca. 3,000–4,000 years ago; and the formation of cobble (Batiquitos Lagoon) or sand-bar barriers (Ballona Lagoon and the Las Flores lagoon). The stabilization of sea level and the formation of barriers led to the closure of some lagoons to the ocean and the rapid sediment infilling of lagoon basins as the outlets to the ocean were closed. In some cases, lagoons continued to function as shallow saltwater mudflats, producing shellfish throughout the Holocene; in other cases, lagoons functioned as freshwater mudflats, with an increase in plant resources but a loss of lagoonal shellfish. In still other cases, lagoons simply closed (for the most part) to the ocean, and with the lack of saltwater, shellfish died off. Some of these closed lagoons, such as Batiquitos Lagoon about 1,500 years ago (Gallegos 1987), reopened to form shallow mudflats with shellfish.

The greatest sedimentation rates generally occurred after 4,000 cal B.P. with the stabilization of sea level, especially for those lagoons where sand or cobble bars formed. Infilling of lagoons, however, may not have been caused solely by the stabilization of sea level—it may also have been the result of higher precipitation ca. 3800 cal B.P., as noted by Enzel et al. (1992) for the Mojave River drainage basin and by Davis (1992) for San Joaquin Marsh.

Lagoons and estuaries occur along the Pacific Coast from Morro Bay in San Luis Obispo County, California, to Baja California Sur in Mexico. The paleogeography and settlement history of these many lagoons are not equally well documented. In most cases, information on settlement and subsistence is available from archaeological investigations, but data on paleogeography are sparse or entirely absent. In the following discussion, we highlight paleoenvironmental research and human occupation along the central California coast and the San Diego County coastline. Our discussion is by no means comprehensive; instead, it aims to highlight relevant research and, in doing so, provide insights into future comparative studies.

The Central California Coast and the Northern Bight

In this section, we discuss the paleogeography, paleoenvironment, and human settlement of areas comprising the central California coast (Santa Cruz, Monterey, and San Luis Obispo) and parts of the Northern California Bight (Santa Barbara and Ventura Counties). In this region, resource-rich embayments were formed along the coast as sea levels rose in the early Holocene and deep canyon-river mouths were drowned (Jones, Fitzgerald, et al. 2002:94). The coast was dominated by exposed shoreline with both rocky and sandy substrates that shifted throughout the Holocene. Elkhorn Slough and Morro Bay are the major estuaries/lagoons. There also may have been a paleoestuary (at Halcyon Bay) in the southern part of San Luis Obispo that disappeared by the Late Holocene as a result of rising sea levels and sediment infill (Fitzgerald 2000; Jones, Young, et al. 2002).

In contrast to our research in the Ballona, in which we focused on paleogeography, researchers along the central California coast have focused their paleoenvironmental reconstructions, particularly in the Santa Barbara Channel area, on such paleoclimatic conditions as oceanic-temperature changes (Glassow et al. 1994; Jones and Kennett 1999) and long-term drought conditions (Jones et al. 1999). Paleoclimatic factors have attracted the most attention for the later periods of prehistory, when population increased and large, permanent villages were established along the coastline and on the Channel Islands of central California and the northern portion of the Southern California Bight. For example, Arnold (1987, 1992a, 1992b, 1992c, 2001) has argued at length that increases in sea-surface temperatures led to declining

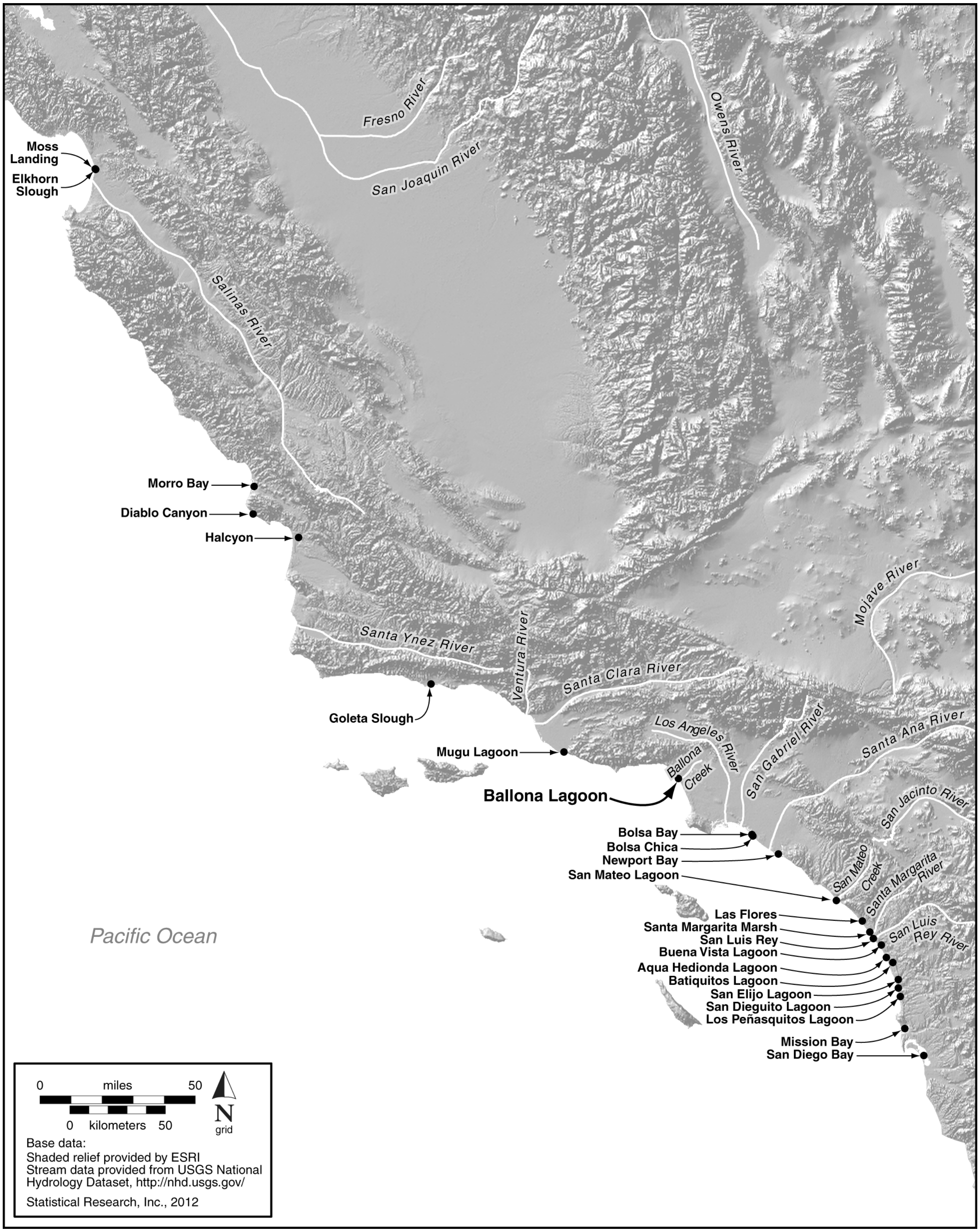

Figure 26. Major lagoons along the southern California coast.

Table 11. Paleoenvironmental and Occupational History of Lagoons in Central and Southern California

Lagoon/Estuary (North to South)	Developmental Highlights	References
Elkhorn Slough and Morro Bay	Lagoon formed (15,000–7000 B.P.); lagoon flourished after 5400 B.P. and 4800–3000 B.P.; human occupation starting 10,000 B.P. to Spanish contact; prehistoric population peak 5400–5000 B.P.	Atwater, Hehey, and Hedd 1977; Bloom 1971; Emery 1969; Hildebrandt et al. 2002; Jones, Young, et al. 2002; Joslin 2006; Lajoie 1972; Mikkelsen et al. 2000.
Halcyon Bay	Lagoon open (7000–5000 B.P.); lagoon closed (5000–3000 B.P.); decrease in estuary use 4800–3000 B.P.	Atwater, Hehey, and Hedd 1977; Bloom 1971; Emery 1969; Hildebrandt et al. 2002; Joslin 2006; Lajoie 1972.
Mugu	Lagoon formed about 3000 B.P.; human settlements by 2400 B.P.; prolonged drought (?) A.D. 1100 and 1250.	Martz et al. 1995; Warme 1971.
Newport Bay/Bolca Chica	Formation of a marine lagoon (8300–8000 B.P.); brackish estuary (ca. 6000–5000 B.P.); marine lagoon (4500 B.P.); Santa Ana River shifted, leading population movement (5500 B.P.); opening of lagoon (1350 B.P.).	Davis 1990, 1992; Hurd and Macko 1989; Palacios-Fest 1996.
San Mateo	Filled with channel and floodplain sediments (5000–3000 B.P.); evidence of human occupation (4200 B.P. to Spanish contact).	Byrd 1996; Reddy et al. 1996; Waters et al. 1999.
Las Flores	Freshwater lagoon around 10,000 B.P.; filled with channel and floodplain sediments (5000–3000 B.P.); channel sands (5000–4500 B.P.); evidence of human occupation (7600 B.P. to Spanish contact).	Byrd 1996, 2003; Reddy 2005; Reddy and Pope 2005.
Santa Margarita and Ysidora Basin	Brackish-water lagoons formed (8800 B.P., 7000–5400 B.P.); siltation and alluvial sedimentation (after 5400 B.P.); lagoon filled in after 4700 cal. B.C.; brackish-water marsh developed by 4000 cal. B.C.	Byrd 2005; Davis 2005; Inman 1983; Palacios-Fest 1996; Reddy and Pope 2005.
San Luis Rey	At 12,000 years B.P., sea level had risen to about 30 m below mean sea level, creating a narrow, sinuous lagoon; human occupation dated from 7300 B.P.; rudimentary information on lagoon evolution.	Masters 1994; Vanderpot et al. 1993.
Buena Vista	Rudimentary information on lagoon evolution; human occupation by at least 6000 B.P.	Flower et al. 1979.
Agua Hedionda	Lagoon formed prior to 9000 B.P.; on the basis of radiocarbon dates, the lagoon was open prior to 9,000 years ago and continued to 3000 B.P.; no radiocarbon dates noted between 2000 and 3000 B.P.; continuous radiocarbon dates from 1300 B.P. to historical-period contact.	Gallegos 1991; Hubbs et al. 1965.
Batiquitos	Lagoon formed over 9,000 years ago; closed between 3000 and 1000 B.P.; reopened 1500 B.P. to historical-period contact; human occupation from 8000 to 3500 B.P. and 1500 B.P. to historical-period contact.	Gallegos 1985, 1992; Hubbs et al. 1965; Miller 1966; Warren and True 1961.
San Elijo	Sequence of estuary deposits starting 10,000 B.P.; second lagoonal formation 7750–7250 B.P.; open lagoon conditions 6200–5000 B.P.; sedimentation peaked 4000 B.P.; closed lagoon conditions 3500–1000 B.P.; open lagoon conditions 950–650 B.P.; before A.D. 1880, a fully tidal estuary system.	Byrd et al. 2004; Byrd and Reddy 2002; Foster 1993; Laton et al. 2002.
San Dieguito	Given early radiocarbon dates, the lagoon was formed prior to 9000 B.P.; continuous occupation from ca. 9000 to 3300 B.P. and from ca. 1600 B.P. to historical-period contact.	Linick 1977.
Los Peñasquitos	Rudimentary information on lagoon evolution; lagoon formed during the late Pleistocene (20,000–10,000 years B.P.); lagoon has short periods of connection with the sea alternating with longer periods of stagnation; continuous human occupation from 10,000–8000 B.P. to historical-period contact.	Byrd and Reddy 2002; Mudie et al. 1974.
Mission/San Diego Bay	Rudimentary information on lagoon evolution; San Diego Bay formed prior to 6000 B.P.; occupation of the San Diego River valley and bay from ca. 8000 B.P. to historical-period contact.	Masters 1998.

food productivity, reduced freshwater supplies, and crowding at the beginning of the Late period (A.D. 1150–1250). The stresses caused by these changes served as stimuli for emerging elites to reorganize labor and intensify specialized craft production (shell beads, in particular) on the northern Channel Islands and trade between the islands and mainland. By contrast, Raab, Bradford, et al. (1995) argued that increasing sea-surface temperatures in the southern Channel Islands were actually favorable for marine production. Raab and Larson (1997) suggested that drought evidence explains the serious stresses faced by the region's population at the beginning of the Late period better than sea-surface temperatures. These stresses were manifested by a peak in evidence of poor health and violence at that time (Arnold et al. 2004; Walker and Lambert 1989:210). Regardless of whether these stresses were caused by changes in sea-surface temperature, drought, or some other environmental factor, there is little evidence for a decline in marine resources (Jones and Kennett 1999). To the contrary, with higher population densities and defined territories, the Late period witnessed an intensification of marine-resource exploitation along the Santa Barbara coast, changes in available resources, the adoption of new fishing strategies (Colten 2001; Pletka 2001), increased regional trade, and political centralization (Arnold 1992b).

Some of the earliest work on human occupations and paleoenvironmental reconstruction of coastal lagoons along the central California coast was done at Elkhorn Slough (Patch and Jones 1984). Located in central Monterey Bay, Elkhorn Slough is an estuary situated midway between Santa Cruz and Monterey, and its mouth forms part of the Moss Landing Harbor. Elkhorn Slough is similar to the Ballona Lagoon in that it is a drowned river valley; such valleys are common along coastlines with wide coastal plains (Pritchard 1967a, 1967b). The evolution of Elkhorn Slough was similar to that of the Ballona and probably began with a rapid rise in sea level between 15,000 and 7,000 years ago (Atwater, Hehey, and Hedd 1977; Bloom 1971; Emery 1969; Lajoie 1972). Archaeological sites such as MNT-229, MNT-228, and MNT-234 around Elkhorn Slough have revealed human occupation in the area over the last 6,000 years (Dietz 1988; Jones and Jones 1994). There were localized environmental changes that had a dynamic effect on settlement around Elkhorn Slough; for example, in the Intermediate period (3000–1000 cal B.C.), much of the lagoon area was abandoned in response to hydrographic shifts (Hildebrandt et al. 2002; Joslin 2006). Populations moved to the nearby Pajaro River estuary during this time (Newsome et al. 2004). Recently, oxygen-isotope study of shellfish from sites in central California has provided insight into changes in seawater temperatures and their effects on resources (Jones and Kennett 1999; Jones et al. 2008). Oxygen-isotope determinations from prehistoric California mussel showed relatively stable, seasonal harvesting patterns between 3600 cal. B.P. and historical-period contact (A.D. 1769). Using these data, scholars have proposed that two interdependent groups with distinct, seasonal settlement strategies occupied the area (Erlandson 1994; Jones 1991; McGuire and Hildebrandt 1994; Mikkelsen et al. 2000). These consisted of inland people (reliant on acorns and other fall nut crops) and coastal inhabitants (less involved with acorns and fall nut foods). Furthermore, scholars have argued that the inland groups were collectors who followed a migratory seasonal round, whereas the coastal populations were less mobile. These findings highlight the strong influence of coastal environments and resources on hunter-gatherer mobility.

The occupation history along the central California coast has considerable depth, as is apparent from recent research at Diablo Canyon that included SLO-2 and SLO-1797. SLO-2 is located on a coastal terrace, and SLO-1797 (the Cross Creek site) is situated 9 km from the present shoreline. The Cross Creek site (SLO-1797) revealed a stratigraphically discrete midden dating to 9900–9340 cal. B.P. (8350–7700 cal. B.C.) (Jones, Young, et al. 2002, 2008). What is unique about the Cross Creek site is that it may be the only mainland shell midden in California that has yielded terminal Pleistocene and early Holocene dates in association with a sizable assemblage of formal artifacts. Typically, sites dating to the early Holocene have few artifacts. By contrast, large numbers of grinding implements and crude core and flake tools were recovered from the early component (transcending terminal Pleistocene and early Holocene) at the Cross Creek site (Jones, Fitzgerald, et al. 2002). The tools and associated fauna from these contexts do not support big-game hunting characteristic of the terminal Pleistocene; instead, they suggest a gathering economy.

The diet of early Millingstone coastal populations in this region was relatively broad and included exploitation of shellfish, fish, birds, mammals, and terrestrial plants. Residential patterns are suggestive of a highly mobile population (Jones, Fitzgerald, et al. 2007). Faunal remains recovered from SLO-2 indicated a dominance of deer, pelagic birds, and rabbits, with rocky-coast fish and shellfish in lower frequencies. At SLO-2 and SLO-585 (Diablo Canyon sites), deer represented 51 percent and cottontail rabbits represented 16 percent of the Millingstone faunal assemblage. Flightless duck were 12 percent of the Millingstone faunal assemblage, but there was a marked decline in flightless-duck bones in the next period of occupation at SLO-2 (2250–950 cal. B.P.), when the species eventually became extinct. Jones, Fitzgerald, et al. (2007; see also Jones, Fitzgerald, et al. 2002) concluded that early Millingstone (8000 B.C.–3500 cal. B.C., as per Jones, Fitzgerald, et al. 2007:137) coastal populations had a strong preference for large mammals (deer). Interestingly, stable-isotope analysis of Millingstone-age burials from SCR-60 (north of Elkhorn Slough) suggested that the human diet was composed of 70–84 percent marine food (most likely shellfish, given the lack of fish and marine-mammal remains at the site) (Newsome et al. 2004).

Dramatic shifts in settlement and subsistence occurred in the Late Millingstone (4950–3000 cal. B.P.) (also referred to as the Hunting Culture period by Jones, Stevens, et al. 2007) and Intermediate (3000–1000 cal. B.P.) periods. As population increased, use of estuary resources intensified, and resources from the outer coast were incorporated into the diet. The early Millingstone occupation consisted of short-term campsites used by small groups of people who focused on the use of nearby estuary and terrestrial resources. Shellfish, elasmobranch (sharks and rays), and schooling fish, such as silversides, along with terrestrial mammals, were the mainstays of the diet (Jones, Stevens, et al. 2007; Mikkelsen et al. 2000:181). The late Millingstone period occupation, at Morro Bay estuary for example, witnessed an intensified use of the estuary and a more-permanent occupation (Mikkelsen et al. 2000:182). Shellfish remains included a diverse range of estuary species as well as taxa from sandy-beach habitats. Marine-mammal bone increased in frequency, along with a major increase in the abundance and diversity of fish, primarily from nearshore habitats (Jones, Stevens, et al. 2007). Sea-otter exploitation, for example, increased over time to 17 percent at SLO-2. The presence of mortars and pestles and acorn nutshells from these Millingstone period collections suggested that the mortar-pestle-acorn complex emerged around 5500–5000 cal B.P. in the Morro Bay estuary (but much earlier further to the north, as evidenced by the research at sites in Diablo Canyon). Mikkelsen et al. (2000:183) indicated that the sand barrier and presumably the lagoon were well established at that time, providing an abundance of resources from estuary, sandy-coast, and rocky-outer-coast habitats and a variety of terrestrial habitats. Mikkelsen et al. (2000:182–183) argued that population in Morro Bay may have peaked at about 5400–5000 cal B.P., because inhabitants of the Mojave Desert may have moved to the coast as a result of increasing aridity in the interior (Grayson 1993; Warren 1968) and a decrease in seawater temperatures offshore that would have increased marine resources (Glassow et al. 1994; Jones and Kennett 1999).

Mikkelsen et al. (2000:184) further suggested that occupation of Morro Bay was little affected by the regionwide Medieval Climatic Anomaly, and Hildebrandt and McGuire (2002) argued for an amelioration of the climate and an associated increase in population. Unlike the Santa Barbara Channel, where populations apparently responded to the severe droughts caused by this event by intensifying the exploitation of pelagic and other marine resources, there is little evidence for a pelagic fishery at Morro Bay. Rather, Morro Bay appears to have continued to be a rich resource zone, as evidenced by a number of sites, including a major residential site (SLO-239) where estuary and rocky intertidal resources were both intensively used. Jones, Fitzgerald, et al. (2007) argued that after 950 cal. B.P., there were dramatic changes in the settlement-subsistence systems along the central coast, with an increase in both mammal (marine and terrestrial) and fish exploitation and a decrease in shellfish use. There has been debate regarding whether a coastal abandonment occurred in the Late period (700–200 cal B.P., as per Jones, Stevens, et al. 2007). Late period middens at Big Sur and Morro Bay did not support this abandonment model; however, there is a consensus amongst scholars that, typically, Late period sites occur in higher frequencies away from the coast.

Somewhat different settlement and subsistence patterns are evident at the paleoestuary of Halcyon Bay in Pismo Beach. A more-permanent occupation is suggested in this area during the Millingstone, as compared to Morro Bay and other locations along the coast (Jones, Young, et al. 2002:94). Like other areas of the northern coast, the early Millingstone period occupation of Halcyon Bay focused on estuary resources; there was little evidence for the use of sandy- or rocky-coast species (Jones, Young, et al. 2002:92). The late Millingstone (4800–3000 cal B.P.) witnessed a decrease in the use of estuary species and a concomitant increase in the exploitation of sandy- and rocky-coast species. Exploitation of marine mammals and artiodactyls also appears to have increased, although fishing remained focused on small, schooling fish that could be captured with nets and seines in estuary and nearshore habitats (Jones, Fitzgerald, et al. 2002:93).

Moving south, considerable evidence of human occupation is available from Goleta Slough and other areas of the Santa Barbara coast, although the paleogeography of this area is poorly documented. Erlandson (1994) argued that most early Millingstone period settlements in this region were occupied on a relatively permanent basis by people subsisting on small seeds and shellfish. Others, however, have argued for a much more mobile settlement pattern in which populations moved among a variety of coastal and inland habitats (Jones 1991; McGuire and Hildebrandt 1994; Mikkelsen et al. 2000:181). Mikkelsen et al. (2000:183) have suggested that population densities increased dramatically after 5400 cal B.P., as the marine resource base improved, as a result of a decrease in surface seawater temperature, and acorn use intensified. The estuary resource base is also postulated to have improved at that time, although the absence of paleogeographic reconstructions limits our ability to understand how changes in resource use may have been related to the development of the coastal wetlands along the Santa Barbara Channel. In summarizing coastal occupations north of the southern California Bight, Glassow et al. (2007) noted that populations expanded between 9450 cal. B.P. and 8450 cal. B.P. (for example, at SBA-52 on southern Vandenburg Air Force Base) and depended primarily on shellfish, with hunting and fishing as minor components. The nature of the settlements—mainly residential bases (as argued by McGuire and Hildebrandt 1994) vs. a more-complex network of smaller, specialized camps (Glassow 1996)—is still debated. There was a marked decrease in population between 8450 cal. B.P. and 5900 cal. B.P., most likely caused by environmental factors that may have reduced resources (marine and/or terrestrial) (Kennett 2005). Starting around 5900 cal. B.P. and until 3000–5000 cal. B.P., populations started growing again in these coastal areas (as also suggested by Mikkelsen et al. 2000). More-complex settlement systems emerged between 5000 cal. B.P. and 3900 cal. B.P.—larger residential bases (such as SBR-75, the Aerophysics site) were occupied for long periods of time every year, and smaller, short-term camps were interspersed over the landscape. Between 3900 cal. B.P. and 2000 cal. B.P., the coast witnessed a further increase in population and was marked by an increase in maritime orientation (fishing and regional exchange with the islands) (Glassow et al. 2007). Important technological and social developments occurred between 2000 cal. B.P. and 950 cal. B.P., including the introduction of the plank canoe and the bow and arrow. Many scholars have argued for the development of social complexity during this time (e.g., Arnold 1992b, 1992c; Gamble 2005; Glassow et al. 2007; King 1990). Chumash and Tongva cultural systems were in place by 650 cal. B.P., and according to Arnold (1992a, 1992b, 2001), a ranked society emerged between 750 cal. B.P. and 650 cal. B.P. These cultural developments have been the subject of considerable debate, particularly in terms of whether social complexity was a response to climatic changes or not (see Gamble [2005], Johnson [2000], and others).

The next lagoon immediately to the south is the Mugu Lagoon, which also has considerable evidence of human occupation. In prehistoric times, the Santa Barbara Channel, as well as the Hueneme and Mugu submarine canyons (Warme 1971), would have provided productive fisheries. Furthermore, the tidal flats and estuaries supported numerous local and seasonal waterfowl and other riparian species. The span of coastline that includes Port Hueneme is part of an environmental montage that forms the central California coastline. It is a region composed of mountainous terrain with stretches of rugged coast and rocky headlands punctuated by bays, lagoons, tidal flats, estuaries, and relatively narrow coastal plains (Erlandson 1994). Offshore, the topography is relatively steep, dropping off rapidly into many basins and submarine canyons formed by relict river channels that once flowed across a wider coastal plain exposed when the sea level was much lower, prior to the end of the Pleistocene era. The post-Pleistocene, or Holocene, era was dominated by a steady but gradual increase in sea level and a series of environmental perturbations that triggered sporadic periods of drought and periods of heavy rainfall (Pisias 1978). Climate fluctuations that ranged from one extreme to another, from drought to heavy rainfall, are visible in dendrochronological and historical streamflow records compiled by Martz et al. (1995:4–5, Table 20). At least one sustained period of drought, between about 850 cal. B.P. and 700 cal. B.P., is said to have been the stimulus that altered the course and nature of Chumash social and political organization (Arnold 1987, 1992a; Gamble 2002, 2005; Kennett and Conlee 2002; Raab 1994; Raab and Larson 1997; Raab, Porcasi, et al. 1995).

Mugu Lagoon, characterized by tidal flats, lies just onshore from the coastal fringe of the Oxnard Plain, a large, flat alluvial basin bounded by the Santa Clara River on the north, the Calleguas Creek on the south, and a series of mountains on the other sides. Calleguas Creek flows into Mugu Lagoon and creates more than 3,000 acres of coastal wetlands (Swanson 1994). Martz et al. (1995) conducted an extensive paleoenvironmental study of the lagoon, including its formation and change over the last 5,000 years. The lagoon was formed about 3,000 years ago, when the sea level stabilized at its present level. Beginning about 2,400 years ago, at least three prehistoric villages were established around the lagoon, with several smaller camps scattered around them (Martz et al. 1995; Raab 1994). Interestingly, according to Martz et al. (1995:5–10), long-term dry and wet periods triggered fluctuating salinity in the marshes, which, in turn, contracted or expanded the natural resources. There was, however, no real change in the biome. In other words, the environmental changes were never very intense or extreme, compared to the historical-period and modern human-induced changes (Sigman and Boyle 2000; Tudhope et al. 2001).

In summary, the paleoenvironmental reconstructions of lagoonal and estuarine settings along the central California coast are distinct from those of coastal southern California. There are comparatively fewer lagoons along the central coast, and most of the studies and projects did not include intense paleoenvironment reconstructions. When included, the focus of these reconstructions was on paleoclimatic conditions and not on paleogeography and lagoon evolution, with the exception of the work done at Mugu Lagoon by Martz et al. (1995).

The Southern California Bight

Paleoenvironmental and human-occupation studies have been conducted at several lagoons along the coastline of the Southern California Bight. Unfortunately, the research is not uniform down the coast; in other words, the studies done in coastal Orange County are more limited than those in San Diego County. Two lagoons at Bolsa Chica and Newport Bay have been subject to some paleoenvironmental research (Davis 1992, 1996, 1998; Grenda et al. 1998; Harrowby 1989; Mason et al. 1991, 1992). Newport Bay is a large, estuary lagoon system comprising a drowned valley and is not very deep (3.5 m in depth). Major studies of the paleoenvironment of Newport Bay include those by Davis (1990, 1992) on pollen and by Palacios-Fest (1996) on ostracodes. Data from three cores taken from the eastern margin of Newport Bay were analyzed by Davis (1990, 1992) and Palacios-Fest (1996). They argued that rapid sea-level rise during the early Holocene had significant marine influences on the estuary, resulting in the replacement of the freshwater estuary by a marine lagoon between 8300 and 8000 cal B.P. Their research identified increased sedimentation between 8000 and 7500 cal B.P., which resulted in changes in resource exploitation by human populations (as supported by archaeological data) (Mason and Peterson 1994). This brackish estuary was, however, short-lived, because an open lagoon was in place a few hundred years later and continued until about 5,000 years ago (Davis 1990, 1992; Palacios-Fest 1996). Salinity of the lagoon increased again by 4500 cal B.P., as freshwater input decreased. Around 3500 cal. B.P., the character of Newport Bay changed as a result of the rerouting of the Santa Ana River (Hurd and Macko 1989). Pollen studies of samples from the San Joaquin Marsh within the upper bay by Davis (1992) indicated that the period between 850 cal. B.P. and

650 cal. B.P. (Medieval Climatic Anomaly) was a time of very low moisture and prolonged drought. Although marine influences dominated the bay between 2000 and 1000 cal B.P., in general, Newport Bay fluctuated between a saltwater marsh and a brackish-water estuary during this period.

This fluctuation had a direct impact on human occupation and exploitation strategies. Until about 5800 cal. B.P., ORA-64 may have been a large residential settlement with smaller camps focused on exploitation of particular terrestrial and lagoonal resources. When Newport Bay was significantly affected by the rerouting of the Santa Ana River to the north, human populations moved north to Bolsa Chica, between 3000 and 1350 cal B.P. Newport Bay had very few settlements. This changed around 1350 cal B.P. (600 A.D.), when residential sites were slowly established in the Newport Bay area.

The paleogeography and settlement history of lagoons and estuaries of the San Diego coastline are much better documented than are those of the other areas of the southern California coastline. As a result, demographic and land-use histories of this region have focused more on their relationship to the evolution of these lagoons and estuaries than have those of other regions of the southern California coast (Figure 27). In fact, understanding the paleogeography of these lagoons and estuaries has been considered by some to be crucial to interpreting the history of human occupation in the region (Byrd 2004, 2005; Byrd and Reddy 2002:42; Byrd et al. 2004; Reddy 2005; Reddy et al. 1996). According to the most widely accepted reconstruction, large, semisedentary populations focused on resource-rich bays and estuaries during the Millingstone and Intermediate periods (Gallegos 1985, 1992; Warren 1968). Shellfish were believed to have been a dietary staple, although nuts and grasses were important components of the diet, and hunting and fishing were much less important. This adaptive strategy persisted largely unchanged for several thousand years, as long as shellfish were plentiful in the coastal lagoons. A major abandonment or depopulation of the coast occurred after 4000 cal B.P. as a result of extensive infilling of local lagoons and estuaries that caused a decline in shellfish populations. Occupation is believed to have shifted inland to river valleys, where populations intensified the exploitation of small, terrestrial animals and plant resources. Coastal occupation was limited to seasonal or short-term occupations, with a possible slight increase between 1200 and 1600 cal B.P. (Byrd and Reddy 1999, 2002:41, 44). More-recent evidence from the northern San Diego coast, however, suggests that occupation flourished throughout the Late period. According to Byrd and Reddy (2002:42),

> [a]long the northern San Diego coast, beginning around A.D. 700 . . . and becoming more highly developed after A.D. 1200, site density increased, the distance between major residential sites decreased, and numerous specialized short-term occupation sites appeared. At the same time that this strong logistically organized coastal settlement pattern developed, there was a shift toward increased reliance on smaller, less "optimal" resources . . . and a more thorough exploitation of the littoral zone. . . . These settlement and subsistence patterns in northern San Diego imply potentially profound changes in hunter-gatherer communities and may be correlated with population pressure, increased territoriality, and greater settlement permanence.

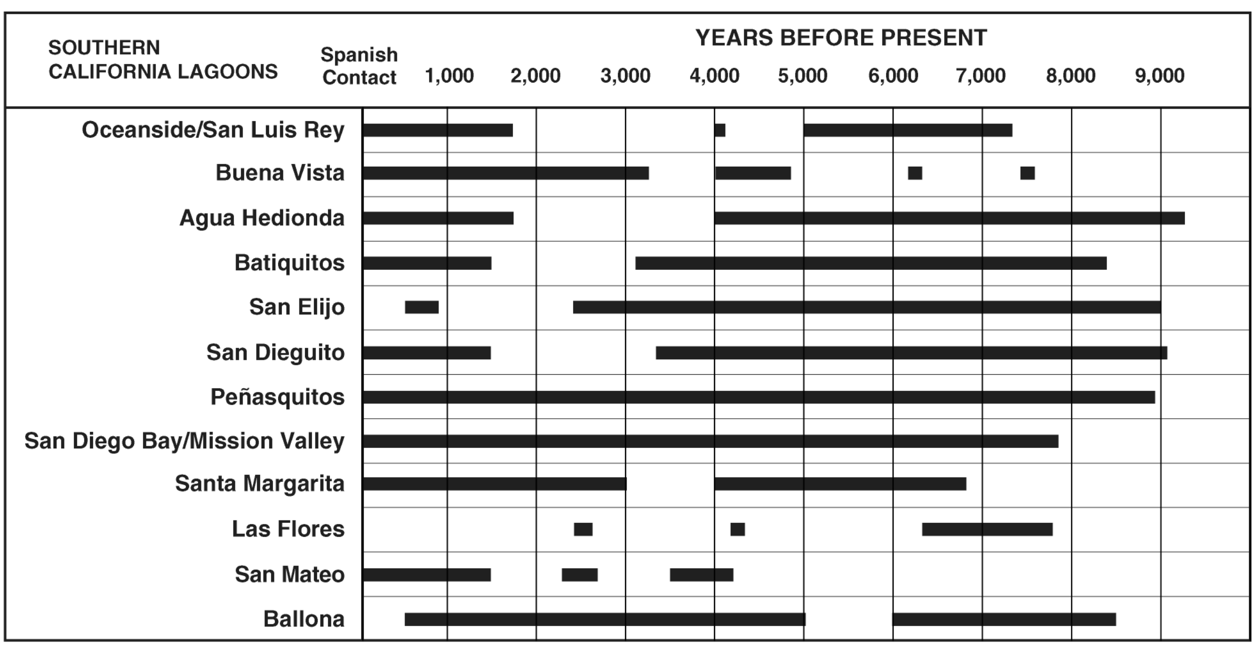

Figure 27. Human occupation along select lagoons in southern California.

Paraphrasing Byrd and Reddy (1999, 2002:42), these cultural changes were associated with the evolving landscapes of the San Diego coastline. As happened elsewhere along the California coast, fast-paced sea-level rise at the beginning of the Holocene shifted the shoreline eastward, inundating river-valley floors and creating narrow bays (Inman 1983). As this marine transgression slowed between 6000 and 3000 cal B.P., complex, low-energy environments began to develop in the drowned river valleys: bays developed into lagoons, and estuaries and sandy beaches replaced rocky shorelines (Nardin et al. 1981). Although sea level rose another 1–2 m in the last 3,000 years, these estuaries continued to aggrade, and some were completely infilled with sediment, becoming freshwater alluvial environments. At the same time, extensive sandy beaches developed initially in the north and eventually spread south to form the extensive Oceanside littoral cell (Inman 1983).

Although all the lagoons and estuaries of the San Diego coastline were characterized by this general pattern, these are transient geological features that are extremely sensitive to localized, short-term environmental change. Thus, detailed local reconstructions are needed to model the relationships between environmental change and human adaptation (Byrd 2004, 2005; Byrd and Reddy 2002:42). It is important to note that different lagoons have different histories, and coring and archaeological data are important to understanding these histories. Lagoon histories vary by the sizes of drainage systems; tectonic activity; the rise, fall, and stabilization of sea level; and cobble or sand bars that can form across the mouths of lagoons, blocking or restricting tidal flow and trapping sediment and freshwater within the lagoon basins (Byrd et al. 2004). There are, however, no high-resolution records for individual estuaries; shifts in local paleovegetation are uncertain, and differences in the developmental histories of estuaries are not well known (Byrd and Reddy 2002:42; Byrd et al. 2004). Substantial paleoenvironmental research integrated with archaeological investigations has been conducted at five lagoons—San Mateo (Byrd et al. 1995; Reddy et al. 1996; Waters et al. 1999), Las Flores (Byrd 1996, 2003; Reddy 2005), Santa Margarita (Byrd 2005; Davis 2005), Batiquitos (Gallegos 1985, 1987), and San Elijo (Byrd et al. 2004)—all of which are located along the northern coast of San Diego County.

Batiquitos Lagoon, located in the middle of the San Diego coastline, formed more than 9,000 years ago with the rise in sea level flooding the mouth of a river valley and closed about 3,500 years ago with the stabilization of sea level and the formation of a cobble barrier bar across the mouth of the lagoon. From about 8,000 years ago to the time of the lagoon's closure, nearby archaeological sites produced large amounts of primarily *Chione* sp. and *Argopecten* sp. To test contrasting hypotheses regarding the time of this closure, Miller (1966) extracted a single core that provided a 6,500-year sedimentary sequence for Batiquitos Lagoon. A series of ^{14}C dates on marine shell revealed a uniform rate of sedimentation from about 6,400 to 4,000 years ago, but the rate increased dramatically about 3,000–1,000 years ago. Based on the presence or absence of shellfish and the estimated sea level at various depths of the core, Miller suggested that the lagoon was closed during the period of peak sedimentation in the Intermediate period, between 3,000 and 1,000 years ago, but reopened at the end of that period.

This reconstruction should be considered preliminary, given the limited data available from a single core and the possible problems with sample integrity (Byrd and Reddy 2002:43; Miller 1966:245–246). Miller's reconstruction, however, is supported by archaeological evidence. The closure of the lagoon and the loss of habitat from about 3,500 to 1,500 years ago are indicated by the general absence of adjacent archaeological sites radiocarbon-dated to this period. Of the 20 Late Holocene (Intermediate and Late period) sites in this area, only 4 have produced dates between 3500 and 1500 cal B.P. (Gallegos 2002). The reopening of Batiquitos Lagoon about 1,500 years ago is indicated by radiocarbon-dated sites adjacent to the lagoon containing mudflat species of primarily *Chione* sp. and *Ostrea* sp. Late Holocene sites in the Batiquitos Lagoon occasionally contain thick midden deposits, but most are best characterized as special-function or limited-use processing and consumption locations, indicating that the lagoon supported economically viable shellfish populations even during this period of presumed closure (Byrd and Reddy 2002:53, 57).

Foster's (1993) pilot sediment-coring study in the San Elijo Lagoon, located just south of Batiquitos, also provides support for Miller's reconstruction at Batiquitos. The San Elijo study revealed a sequence of estuary deposits up to 8,000 years ago. Sedimentation peaked about 4,000 years ago at San Elijo and tapered off thereafter. Prior to the 1880s, San Elijo was once again a fully tidal estuary system.

Byrd and Reddy (1999, 2002) argued that the Late Holocene sites attest to a much more extensive use of the San Diego coastline than indicated by previous studies, a pattern well demonstrated along the northern part of the San Diego coastline. More recently, a series of detailed paleoenvironmental studies (including geomorphology, palynology, and ostracode analyses) at various-sized drainage systems has provided a more-robust data set with which to examine trans-Holocene environmental change in the San Diego region. Research in the Las Flores estuary has yielded a well-dated and continuous sequence of Holocene deposits that extends more than 9,000 years and has revealed the complex paleogeographic history of this drainage system (Byrd 1996, 2003; Reddy 2005). Prior to 8,100 years ago, a freshwater lagoon existed in this area and was buried by a long and varied alluvial sequence separated by a series of buried paleosols. Reddy and Pope (2005) refined the chronology of the infilling of the Las Flores estuary to 7000 cal. B.P. By 4000 cal. B.P., the lagoon associated with this small drainage system had virtually shut down. Similar to Las Flores, the Ysidora Basin (situated several kilometers upstream from the mouth of the Santa Margarita River) began to fill in after 6700 cal. B.P., and a brackish-water marsh developed by 6000 cal. B.P. (Byrd 2005).

The timing and nature of changes further downstream have not been well documented by paleoenvironmental research. Even so, it is clear that the infilling of the Las Flores and the Ysidora Basin lagoons was largely a result of the slowdown in the rate of sea-level rise to below the sedimentation rate.

Byrd et al. (2004:32–33) offered a finer-scale reconstruction of the Late Holocene period at San Elijo Lagoon resulting from a larger number of cores and augers. The earliest marine indicators are dated to 11,000 cal. B.P. Subsequently, lagoonal conditions fluctuated, and a second phase of lagoonal formation occurred between 7750 and 7150 cal. B.P. (5800–5200 cal. B.C.). Open lagoon conditions continued to exist between 6250 and 4950 cal. B.P. (4300 B.C.–3000 cal. B.C.). None of the cores or augers recorded open lagoon conditions between 3450 and 1050 cal. B.P. (1500 B.C. and cal. A.D. 900). During that time, tidal open-water conditions may have prevailed in the southwestern portion of the system, given the presence of tidal shellfish (*Tegula* and *Cerithidea*). Based on auger tests, the southeastern arm of the lagoon was characterized by open lagoon conditions from 950 to 650 cal. B.P. (cal A.D. 1000 to as late as cal. A.D. 1300).

Overall, the paleoenvironmental data from San Elijo Lagoon, Santa Margarita drainage, and Las Flores lagoon all indicated that the formation, infilling, and opening of these lagoons occurred in response to postglacial marine transgressions and short-lived regressions. Rapid aggradation resulting in a shift to estuarine sedimentation occurred around 10,250 cal. B.P. (8300 B.C.) in the Ysidora Basin, and the formation of a freshwater lagoon occurred around 10,550 cal. B.P. (8600 B.C.) in the Las Flores drainage, at a time of marine regression. A brackish- to marine-water open lagoon emerged between 9450 and 8650 cal. B.P. (7500–6700 B.C.) at San Elijo Lagoon and between 9850 and 9450 cal. B.P. (7900–7500 B.C.) in the Ysidora Basin. A second transgression around 8350 cal. B.P. (6400 B.C.) produced lagoons at San Elijo and Ysidora Basin. The dynamic nature of these lagoons was directly related to marine transgressions and regressions, along with the sizes of the drainage catchment areas.

Archaeological sites with dated shellfish often serve as crude proxies for environmental conditions, because different shellfish species are associated with specific habitats. These data were used by Byrd and Reddy (1999, 2002) to argue that occupation of the San Diego coastal area persisted throughout the Late Holocene and that prehistoric hunter-gatherers regularly exploited lagoonal or rocky-shoreline shellfish in some localities and, in others, concentrated on sandy-shoreline species. Contrary to the Batiquitos reconstruction, occupation along the northern San Diego coast appears to have peaked in the Late Holocene and included major residential bases and numerous specialized sites (Byrd and Reddy 1999, 2002:47). Only 2 of the 39 dated sites lacked Late Holocene components, whereas only 11 sites contained earlier components. Of the Late Holocene dates, the vast majority dated to the Late period, after 1250 cal. B.P. (A.D. 700), and most of those dated to after 750 cal. B.P. (A.D. 1200). Characteristics of the Late period include increased site density, shorter distances between major residential sites, and greater numbers and types of specialized, short-term occupations. Byrd and Reddy (1999, 2002:53) interpreted this pattern as indicative of the emergence of a more-complex settlement pattern that included major residential bases surrounded by clusters of specialized sites along key drainages. Byrd and Reddy suggested that these trends represent greater settlement permanence, a decline in territorial range, and a more-thorough exploitation of the littoral zone. They suggested that the paucity of older sites may have been due, in part, to burial by alluvium in the valley floors, although testing of buried sites along the Santa Margarita River has revealed a range of Late Holocene sites (Byrd and Reddy 2002:53).

Limited data from sites in the San Luis Rey, Buena Vista, and Agua Hedionda drainages located between the Batiquitos and Las Flores drainages provided supporting evidence for Byrd and Reddy's (1999, 2002) reconstruction. These drainages contained major settlements as well as special-function and limited-use sites dating to after the presumed decline of estuaries 4,000 years ago. Shell middens at these sites were dominated by lagoon species, such as *Chione* and *Argopecten,* indicating that lagoons remained open and that coastal occupation and marine- or estuarine-resource exploitation continued throughout the Late Holocene (Byrd 2003; Byrd and Reddy 2002:53, 57; Reddy 2004). Other San Diego lagoons (Los Peñasquitos Lagoon and Tijuana lagoon) and San Diego Bay also demonstrated continuous occupation from 8,000–10,000 years ago to historical-period contact.

Subsistence patterns, particularly the procurement of different species, varied considerably over time and with location along the San Diego coastline. In the Camp Pendleton area, on the northern part of the coast, local patterns focused on the most abundant nearby resources, and smaller and more labor-intensive (in terms of collection and processing) shellfish became key elements by the Late period (Byrd 1996, 1998, 2003; Byrd and Reddy 1999, 2002:57; Reddy 2004). Quantities and varieties of shellfish remains in middens along the northern coast varied significantly between drainages. The last 2,000 years of occupation along the central coast of Camp Pendleton were characterized by the almost exclusive exploitation of the small *Donax* clam, found on sand beaches. By contrast, *Protothaca, Tegula,* and (to a lesser degree) *Mytilus* prevailed in middens along the northern coast of Camp Pendleton. The continued exploitation of *Argopecten* and *Chione* along the Santa Margarita River suggests the presence of a local estuary in the Late Holocene, and the dominance of *Argopecten* and *Ostrea* at some sites indicates optimal estuary conditions (York et al. 1999). Vertebrate exploitation during the Late Holocene was dominated by small land mammals and nearshore fish and included lower frequencies of elasmobranch fish, birds, and large land and marine mammals (Byrd and Reddy 2002:58; Wake 1999). Offshore fish were more common at earlier sites, along with elasmobranch fish. The fish assemblages suggested a shift to open-coast, sandy-beach species and a change in procurement strategies from fishing with hooks and lines to the use of nets to capture surf and schooling fish.

Overall, early sites on the northern coast had a higher taxonomic diversity and a greater density of vertebrate remains (Byrd and Reddy 2002:59; Wake 1999). This included greater numbers and diversity of fish species and greater frequencies of ducks and other waterfowl. Invertebrates were dominated by *Chione* and *Argopecten*, and *Ostrea* was most frequent in the earliest occupations. These taxa suggest that early occupation focused on estuaries and their contact zones with the ocean and terrestrial habitats. Over time, however, diet breadth increased toward greater reliance on smaller, lower-ranked resources, such as fish, shellfish, birds, terrestrial mammals, and possibly plants. Shellfish remained important as harvesting strategies shifted toward smaller species that involved greater investment in labor. The dietary importance of large mammals and birds decreased, and small mammals increasingly came to dominate the terrestrial diet. Fish also decreased in diversity and, possibly, in dietary importance over time.

Considerable variability in resource procurement is also evident along other portions of the San Diego coastline. For example, shellfish use was highly situational; where sufficient data are available, each drainage and portion of the coastline appears to have had its own distinct history (Byrd and Reddy 2002:60; Reddy 1999). Shellfish gathering, often of very different species, clearly persisted as a viable economic strategy at many sites. *Argopecten* and *Chione* usually dominated shellfish assemblages, although the times of their use varied widely. These two bay and lagoon species were present in the Buena Vista and Los Peñasquitos Lagoons throughout much of the Holocene, in Mission Bay and the San Elijo Lagoon from 2,500 years ago to the modern era, and in Batiquitos Lagoon from 1,500 years ago (Byrd and Reddy 2002:60). By contrast, the sandy-shore *Donax* was the predominant shellfish along the central coast of Camp Pendleton, the San Luis Rey River, and Agua Hedionda after 2,000 years ago, although lagoon species were also present in the last area. In addition, a shift to a greater use of rocky-shore species was documented along San Diego Bay (Byrd and Reddy 2002:60).

The exploitation of marine invertebrates was also highly variable and, like shellfish, reflected emphases on different local habitats. For example, lagoon and open-water fish were emphasized at Buena Vista Lagoon, nearshore fish at Agua Hedionda and Camp Pendleton, kelp beds and the open-ocean habitat near Mission Bay, and rocky and soft substrates along San Diego Bay. The more-maritime adaptation—involving an emphasis on marine mammals and pelagic fish—that characterized the Santa Barbara Channel area was not common anywhere along the San Diego coastline, except at single sites along San Mateo Creek (marine mammals) and San Diego Bay (pelagic fish) (Byrd and Reddy 2002:60). Terrestrial resources were important throughout the region, although the emphasis during the Late Holocene was on small species.

A Summary of the Paleogeography of the Ballona

The previous sections summarize archaeological interpretations of human adaptation to southern California wetlands. By and large, these interpretations are based on archaeological data of various strengths; some wetlands are well researched, with numerous site excavations and analytical studies, but are placed into a much weaker environmental context. The result is that we have a relatively good understanding of trends in settlement and subsistence as they relate to slow-moving, major environmental change. These trends are important to document, but they are only part of the story. Wetlands, by definition, are dynamic environments that change in response to shifts in climate, tectonics, sea levels, and other environmental factors. Some of these factors, such as temperature and rainfall, change frequently, whereas others, such as sedimentation, change more gradually. To examine how humans responded to these challenges requires a much finer resolution of environmental and culture history, which can only be accomplished through integrating a variety of environmental and cultural proxies with strong chronometric control. Here, we briefly summarize the results of our paleogeographic and previous cultural studies of the Ballona Lagoon, leaving it to the synthetic volume (Volume 5 of this series) to integrate the results of our data recovery efforts into this study of human adaptation to this coastal wetland.

Nichols and Biggs (1985) noted the importance of unifying models of deposition and of matching modern and ancient deposits. By following their lead, we were able to reconstruct the long-term evolution of the Ballona Lagoon from the late Pleistocene through the Holocene. Stratigraphic reconstruction of the Ballona Lagoon indicates a system that was probably in static equilibrium with sea-level rise after about 7000 cal B.P.; pollen and other microfossil indicators from Core 8 (see Chapter 7 of this volume) were largely consistent with the stratigraphic evidence, confirming that sea level stabilized about 6,000 years ago. Thereafter, the lagoon's evolution was driven primarily by sediment infilling rather than sea-level change. Sedimentation rates were higher near the mouths of Ballona and Centinela Creeks and in the marshes along these creeks. These higher rates indicated that sediment deposition from overland drainage systems was largely responsible for lagoon infilling.

The barrier across the Ballona Lagoon stayed in a relatively constant position during most of the last 7,000 years; the only noteworthy changes were shifts in the locations and configurations of outlet channels. Likewise, a shoreline was present approximately at the location of Core 209 (which is near the present intersection of Lincoln and Jefferson Boulevards) (see Figure 25) from around 7000 cal. B.P. until Centinela Creek moved westward past that position (about 0.5 km or so), between 2000 and 3000 cal. B.P., depositing a large volume of sediment that filled in the lagoon in that area. Both of these observations are indicative of a dynamic equilibrium between local tectonic uplift and sea-level rise after about 7000 cal. B.P., perhaps creating a situation similar to that observed by Kraft et al. (1980, 1982) on the Turkish coast over the last 3,500 years. The Core 8 ostracode and pollen data, as well as an associated radiocarbon date from oyster, suggested that the marine transgression in our study area ceased by about 6200 cal. B.P. Equilibrium between uplift and sea-level rise probably prolonged the persistence of the Ballona Lagoon, because the lagoon was neither inundated by seawater nor drained.

Water in the Ballona Lagoon varied in salinity throughout its history, alternating between marine and freshwater inputs. Sometimes the lagoon was dominated by marine inputs or evaporation, which caused high salinity. At other times, discharge from Ballona and Centinela Creeks dominated; the result was greater freshwater input into the lagoon. Ostracodes, pollen, foraminifera, and siliceous microfossils provide additional information on the paleoenvironmental conditions that were dominant at various stages of the lagoonal history. Each fossil group shows that salinity levels fluctuated in the lagoon. In general, the paleoenvironmental studies showed that marine conditions prevailed before 6200 cal. B.P. in the Ballona Lagoon. Between 6200 and 4000 cal. B.P., marine influence persisted, interrupted by several freshwater pulses. A freshwater environment dominated after about 4000 cal. B.P., and the tidal channels were probably frequently blocked or filled in above sea level. As a result, freshwater from Ballona and Centinela Creeks was blocked behind the barrier and diluted the salinity.

A relatively stable shoreline existed in the vicinity of Core 209 for several millennia. This stable shoreline, combined with a hypothesized midbay bar north of LAN-62, offered prehistoric human populations a strategic location for exploiting lagoonal resources, such as plants, shellfish, and fish. Several sandy areas of higher ground existed in the marshes surrounding the Ballona Lagoon, some of which were identified during this study; others were identified in our archaeological excavations. These sandy islands were better drained than the surrounding wetlands; therefore, these landforms were available for human occupation on at least a seasonal basis from after 4000 cal. B.P. to the historical period.

By 3000 cal B.P., the inner bay that formed in response to the initial transgression was largely erased beneath intertidal deposits of sand and mud, thereby restricting open water to the former outer bay, with a more-expansive coastal plain to the north. By 2000 cal B.P., the coastal plain continued to encroach on the salt marsh along the northern margin. The salt marsh was somewhat more extensive, extending over much of the bay beyond the north shore and at the creek mouths. The barrier and bluff shoreline on the open coast was probably still about 50 m seaward of the present location. An extensive intertidal, unvegetated mudflat developed in the bay (lagoon). The configuration of the Ballona was mapped in the 1863 U.S. Coast Survey, showing that sediment had largely filled the lagoon, which was surrounded by a complex of sandy islands and extensive saltwater and freshwater marshes.

Paleogeography and Human Settlement in the Ballona

The dynamic changes in the aquatic and terrestrial environments in and around the Ballona Lagoon and neighboring wetlands documented in this paleogeographic study had a dramatic effect on human populations during the late Quaternary. Estuarine, riparian, and coastal chaparral/prairie habitats were the primary areas used by Native Americans to obtain food and other resources. Temporal variations in the composition, distribution, and extent of plant and animal resources were vital in affecting human lifeways and seasonal activities. Throughout much of prehistory, occupations were concentrated on the southeastern side of the lagoon, on alluvial fans that dotted the landscape below the bluff. These transitional areas were ideally situated, because there was ready access to a variety of habitats and there were streams nearby that provided routes for rapid and easy movement between resource areas. The cultural periods represented at archaeological sites in the Ballona are summarized in Table 12, sorted by landscape position: on the bluff top, on alluvial fans along the base of the bluff, or on elevated landforms within the wetlands. The locations of these and other archaeological sites in the region are shown in Figure 2. The following discussion briefly reviews the archaeological sites associated with these cultural periods. Altschul et al. (2005) provided a detailed discussion of these trends, a refinement of the earlier models presented by Altschul et al. (1992); Altschul et al. (1993); and Grenda et al. (1994).

No Paleoindian sites have been identified in the Ballona, although projectile points that could have been created at that time have been found in the middens of latter-period sites on top of the bluffs (Lambert 1983). The reason for the lack of Paleoindian sites, in all likelihood, is that these occupations were concentrated along the coast, which is now submerged below sea level or buried deeply in alluvial and estuarine deposits. At about 10,000 cal B.P., sea level was about 20 m lower than at present, and sea level did not approach its current elevation until about 6000 cal. B.P. Consequently, most archaeological sites in the Ballona area older than 6,000 years are probably inundated by Santa Monica Bay and concentrated 1–4 km offshore from the modern coastline.

The earliest securely dated archaeological components in the Ballona are campsites occupied in the early Millingstone period. Millingstone components were identified at LAN-64 and LAN-206, on top of the bluff west of Lincoln Boulevard; both dated to about 7000 cal. B.P. and possibly as early as 8000 cal. B.P. (see Table 12). These camps had ready access to terrestrial and vernal-pool resources on top of the bluff as well as estuarine resources below, in the Ballona. Similar campsites may have been present at some of the Millingstone period sites recorded in the nearby Baldwin Hills by Malcolm Farmer but destroyed by urban development before they could be investigated (see

Table 12. Distribution of Archaeological Sites in the Ballona Area, by Landscape Position and Cultural Period

Cultural Period	Age Span	Bluff Top					Alluvial Fans						Wetlands		
		59	61	63	64	206	60	62A	62C and 62D	193	211	2768	47	54	62G[a]
Millingstone period															
Early	8500–6000 cal B.P.		X		X	X		X							X
Middle	6000–5000 cal B.P.														
Late	5000–3000 cal B.P.		X?					X	X	X				X	
Intermediate period															
Early	3000–1600 cal B.P.		X	X	X	X	X	X		X	X	X		X	X
Late	1600–1000 cal B.P.	X	X					X	X	X	X				X
Late period	1000 cal B.P.–A.D. 1542			X				X	X		X		X		X
Protohistoric period	A.D. 1540–1770			X?				X	X		X				X
Mission period	A.D. 1770–1830		X?	X?				X	X		X				
Rancho period	A.D. 1834–1848									X		X			

[a] LAN-62G is located at the fan-marsh juncture north of LAN-62A.

Chapter 4 of this volume). Available data suggest that the first early Millingstone period settlements on the bluff expanded onto alluvial fans in favorable locales where the lagoon and surrounding marshes could be exploited for food resources. LAN-62, for example, straddles a prominent, broad alluvial fan and the wetlands to the north. The earliest occupation at this site dated to about 6200–6600 cal. B.P., slightly later than those at LAN-64 and LAN-206. With the exception of a 1,000-year hiatus between 5000 and 6000 cal. B.P., this site was occupied almost continuously until the late Mission period. LAN-62 is near the hypothesized midbay bar (see Chapter 7 of this volume). This location, combined with the large size of the alluvial fan and the proximity to Centinela Creek, a permanent source of freshwater, may explain why occupation at this site was so intensive and long-lived and why we have hypothesized that this was a persistent site (see Chapter 5 of this volume). No archaeological sites or components dating to the middle Millingstone period (6000–5000 cal. B.P.) have been found in the Ballona area, suggesting that the entire area may have been abandoned.

Occupation of the Ballona became both more intensive and more extensive during the Late Millingstone period (5000–3000 cal B.P.). Four sites (LAN-61 on the bluff, LAN-62 and LAN-193 on alluvial fans, and LAN-54 in the wetlands) have components dating to the Late Millingstone period. The bluff and alluvial fan continued to be favorable locales for settlement, but occupation at LAN-54 on a sandy "island" in the wetlands indicated that sedimentation in the marsh was sufficient to create landforms suited to at least seasonal settlement by 4000 cal. B.P. or slightly earlier.

Prehistoric occupation continued to intensify during the Intermediate period (3000–1000 cal B.P.). Radiocarbon dates, which supply a proxy measure of the intensity of human settlement, suggested that there were two major peaks in occupation at this time, one during the early Intermediate period (3000–1600 cal. B.P.) and one during the late Intermediate period (1600–1000 cal. B.P.) (see Chapter 3, Volume 2 of this series, for discussion of radiocarbon dates). With the exception of LAN-47, a single-component Late period site, all known sites in the Ballona for which we have chronometric data were occupied during the Intermediate period, and occupation was especially intensive and widespread during the early Intermediate period. Intermediate period occupations are also spread across the bluff, alluvial fans, and wetlands in the Ballona area. At that time, the Ballona probably reached its peak biotic productivity, in terms of food resources that could be exploited. The pickleweed marsh became extensive in the western portion of the Ballona Lagoon between 2750 and 750 cal. B.P., a time span when freshwater marshes still predominated in the eastern part of the Ballona. Human-population growth in the Ballona Lagoon corresponded to expansion of the salt-marsh habitat during the Intermediate period. Freshwater sources probably increased dramatically, as well, because groundwater recharged springs to maintain reliable flows throughout this period. Vernal pools on the bluff tops would have increased in extent and may have held water well into the summer dry season. Using regional pollen data, Wigand (2005) documented a brief period of unusually high precipitation during the Intermediate period. Sites located on the bluff top immediately south of the Ballona Lagoon were ideally situated for procuring resources from two distinct environments: the Ballona wetlands to the north and the extensive Los Angeles Coastal Prairie to the south, which contained numerous vernal pools (Altschul et al. 2005; Wigand 2005). Macrobotanical evidence from West Bluffs suggested that its inhabitants took advantage of this ecotone, collecting seeds from plants growing around vernal pools to the south and marsh plants from the Ballona Lagoon to the north (Wigand 2005). Because of the dramatic increase in rainfall during this brief period, resources in both the Ballona wetlands and the coastal prairie would have been at their peak, making the area especially attractive to settlement. The Intermediate period also corresponds with the beginning of significantly drier conditions east of the Sierra Nevada in the Great Basin and the northern Mojave Desert, conditions that probably promoted settlement concentrations on the coast.

Relative to the Intermediate period, archaeological occupation appears to have declined dramatically in the Ballona during the Late period (1000 cal. B.P.–A.D. 1542) and increased again during the Protohistoric (A.D. 1540–1770) and Mission (A.D. 1770–1830) periods and was finally abandoned by Native Americans in the Rancho period (A.D. 1834–1848) (see Table 12). Occupation during the Late period extended across a variety of landforms, but occupations tended to be small and dispersed (a small component at LAN-63 on the bluff, LAN-62 Locus A and LAN-211 on the alluvial fans, and LAN-47 and LAN-62 Locus G in the wetlands). There was also a paucity of radiocarbon dates, especially during the Medieval Climatic Anomaly (about A.D. 800–1350 [600–1150 cal. B.P.]). It is unclear whether this was a period of sufficient drought to explain the apparent reduction in occupation, but that is a distinct possibility in need of further exploration with pertinent tree-ring records. Although the Ballona had declined in biological productivity, Late period and historical-period occupations were able to take advantage of a variety of habitats to obtain food resources. As in the Late period, historical-period occupations were spread across a variety of landforms and were represented by two major occupations on alluvial fans (LAN-62 Locus A and LAN-211) and by minor components at one site on the bluff (LAN-61), two sites on alluvial fans (LAN-193 and LAN-2768), and one site in the wetlands (LAN-62 Locus G).

Conclusions

One of the lasting contributions of the PVAHP is the depth and scope of the paleogeographic reconstruction and land-use history of the Ballona, which is currently unmatched anywhere along the southern California and Baja California coast. We hope future researchers can use the Ballona data in a wide array of environmental and cultural studies, because detailed comparison of environmental and cultural trends of the Ballona and those of other coastal estuaries of the region is difficult at present. For example, in the greater Los Angeles Basin, there is little comprehensive data available about the paleogeography and land-use histories of other lagoons and estuaries, such as San Pedro Bay, Bolsa Chica, and Newport Bay.

Paleoenvironmental and archaeological data indicated that both biological productivity and human occupation in the Ballona reached a peak between about 3000 and 2000 cal B.P. and slowly but steadily declined after that time. This pattern seems to be replicated from the central coast of California to Baja California, although the peak in the Ballona occurred about 500–1,500 years later than in most of the other lagoons and estuaries in this broad region. The peak occupation within the Ballona Lagoon, as indicated by radiocarbon dates from archaeological sites, corresponds with one of the most dramatic wet episodes during the last 8,000 years, that of the early Intermediate period, when the wetland and terrestrial resources of the Ballona would have been most productive. A dramatic spurt in local population within the Ballona between 3000 and 2000 cal B.P. seems to have been related to both climate and an increase in biological productivity in the lagoon and surrounding wetlands. Prior to that time, the Ballona was occupied on a short-term basis by small groups of people who occupied the bluff tops and adjacent alluvial fans surrounding the lagoon and wetlands.

In contrast to most of the other lagoons and estuaries of the region, the Millingstone occupation of the Ballona was intermittent, with a marked hiatus between 5,000 and 6,000 years ago, a time when occupation of Newport Bay was at a peak. When Newport Bay and other estuaries along the California coastline were being depopulated in the Late Millingstone and early Intermediate periods, however, large and semipermanent residential sites were being established on the bluff tops and alluvial fans near Lincoln Gap, and more specialized sites were located along the edges of the creeks draining into the Ballona Lagoon (Altschul et al. 2005). This settlement pattern foreshadowed the Late period occupation of the Camp Pendleton area and other sections of the San Diego coastline.

Like the Santa Barbara Channel area, however, the Ballona witnessed a decline in settlement at the beginning of the Late period that may be related to the Medieval Climatic Anomaly or a combination of local climatic fluctuations and shifts in the course of the Los Angeles River. A resurgence of occupation occurred at the end of that period and into the early historical period, when settlement was concentrated at the edge of the wetlands, near the outlet of Centinela Creek (Altschul et al. 2005). This concentration of population was quite distinct from the complex pattern described by Byrd and Reddy (2002) for the Late period along the San Diego coastline, where a similar resurgence of occupation occurred at that time. In contrast to the San Diego region, most of the locations settled in earlier times were abandoned, and small, specialized sites were absent from the Ballona during the early Historical period. Furthermore, the exploited taxa—shellfish, land mammals, birds, and fish—increased in diversity in the Ballona during the early historical period (Van Galder et al. 2007), and large mammals increased in importance (Reddy and Lev-Tov 2009).

When coupled with the paleoecological studies based on the microfossil and mollusk records, the stratigraphic and paleogeographic reconstruction of the Ballona provides a powerful tool for interpreting landscape evolution and the changing patterns of prehistoric human utilization of the Ballona Lagoon. Sea-level rise, formation of a coastal barrier and lagoon, sedimentation, subsidence, and tectonic activity shaped the Ballona landscape, which, in turn, profoundly affected the distribution of landforms available for settlement and the subsistence resources available for human use.

On geologic time scales, coastal lagoons, such as the Ballona Lagoon, are short-lived geomorphic features. Once a lagoon forms, sediment is deposited, and the lagoon begins to fill in quickly, typically within a few millennia. As the lagoon continues to fill, the surrounding marsh expands, and the lagoon becomes shallower and shrinks in size. Paralleling the evolution of lagoon systems over time are changes in biomass. Biomass, a measure of biological productivity, increases in a coastal lagoon as it ages, reaches a peak, and then declines as the lagoon and its associated wetlands are reduced in size. Such changes have a direct effect on the carrying capacity for human populations reliant on such estuarine environments. It is therefore not surprising that human occupation of the Ballona appears to have started at the time the lagoon was first created, and the peak human population of 2000–3000 cal B.P., as estimated from archaeological sites in the Ballona, is strongly correlated with the peak biological productivity of the Ballona, as reconstructed based on the proxy measures (pollen, ostracodes, foraminifers, diatoms, and shellfish). The decline in settlement in the early Late period also appears to relate to a period of increasing aridity during the Medieval Climatic Anomaly. Overall, we interpret Holocene changes in biological productivity as good predictors of changes in carrying capacity, and therefore of changes in human-population size, in the Ballona. There are significant exceptions, however. The absence of radiocarbon dates for the period 5000–6000 cal B.P. points to a hiatus in human settlement in the Ballona. There is no environmental explanation for this apparent hiatus; the Ballona would have been a productive environment for human exploitation at that time, though less so than during the Intermediate period. Furthermore, a resurgence of population and an intensification of settlement at the end of the Late period and in the Protohistoric and Mission periods appear counterintuitive, because it was a time of continued decline and infilling of the wetlands. Finding causes that relate to cultural and/or environmental factors exogenous to the Ballona would be necessary to explain these settlement changes.

Although our research has highlighted the evolution of the wetlands and the associated changing resource base and how these may have effected prehistoric human occupation, we want to emphasize that we do not propose that all cultural changes documented in the Ballona were direct responses to changing environmental conditions. Rather, we consider social factors, such as decision making, technology, and paleodemographic movements, to have been equally important, and we focus on the environment as the context within which culture changed or remained stable.

In the chapters of this volume, we have presented a detailed model of environmental change within the Ballona based on a variety of paleoenvironmental data. In this final chapter, we compared this model with archaeological data on human settlement derived from earlier archaeological studies and the results of archaeological testing conducted as part of the PVAHP. At present, the temporal scale of the paleogeographic component of this integrated model is much more refined than that of the archaeological data. Therefore, only general comparisons between paleoenvironmental and settlement changes can be made at this time. A much more refined cultural chronology, however, is developed in Volume 2 of this series, based on archaeological data recovered during the PVAHP. Volumes 2 and 3 of this series also present detailed analyses of settlement and subsistence data recovered during the PVAHP. In Volume 5, we will explore the relationship between the environment of the Ballona and human adaptation in much greater detail, using the results of the analyses carried out as part of the PVAHP.

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