SAN FRANCISCO BAY-DELTA REGIONAL CONTEXT AND RESEARCH DESIGN FOR NATIVE AMERICAN ARCHAEOLOGICAL RESOURCES, CALTRANS DISTRICT 4



San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

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MANAGEMENT SUMMARY

The California Department of Transportation (Caltrans) contracted with Far Western Anthropological Research Group, Inc., to provide a framework for Native American archaeological site assessment using a common chronological sequence, comparable data sets, and relevant research issues for the San Francisco Bay-Delta Area. The document focuses on eligibility for the National Register of Historic Places (National Register) under Criterion D—sites that have yielded, or may be likely to yield, information important in prehistory or history.

This document is made up of five sections. SECTION 1 provides a regulatory and historical context within which Caltrans staff and consultants can evaluate the National Register significance of Native American archaeological sites under National Register Criterion D. It also presents information on site identification, focusing on geoarchaeological studies in an urban environment. SECTION 2 provides research issues, questions, and data requirements so practitioners can easily develop testing and evaluation proposals and reports or data recovery plans consistent with Attachment 6 of the Caltrans 2014 First Amended Programmatic Agreement. SECTION 3 covers recommended best practices for recovering, evaluating, and realizing the potential of archaeological data as they relate to research issues, site significance, and data recovery. It also includes ideas for public outreach which should be a part of all substantial projects. SECTION 4 is an extensive reference section, and SECTION 5 has supplementary data, expanding on such topics as the ethnographic Community Distribution Model, substantive archaeological sites in the study area, radiocarbon dates by sites, and field forms for documentation of study area excavations, among others.

Any questions or comments on this study should be directed to the Chief, Office of Cultural Resources Studies, Caltrans District 4, 111 Grand Ave., Oakland, CA 94612.

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ACKNOWLEDGEMENTS

An undertaking such as this was both exciting and challenging. It aimed to: (1) synthesize data contained in numerous reports generated during more than 100 years of archaeological research by a myriad of academic institutions and private companies; (2) identify important research perspectives and questions that have relevance for future archaeological investigations on Native American sites in the San Francisco Bay-Delta Area region; and (3) present relevant field and analytical methods to address these perspectives, all in a coherent document readily usable for other scholars.

The document was produced by Caltrans. It was envisioned as a tool that Caltrans archaeologists and contractors working in the Bay-Delta Area could use as a framework for future investigations. The primary authors did an exceptional job, with extensive research on regional archaeology and contemporary research issues, and offering straight-forward ways to operationalize the recovery, analysis and documentation of archaeological data; their efforts are very much appreciated. Contributing authors were tapped for their expertise, offering critical data and interpretations—Eric Wohlgemuth for plant remains; Philip Kaijankoski, Jack Meyer for paleoenvironment and geoarchaeolgy; and Randy Milliken for mission record studies.

Initial funding came through the Transportation Enhancement Act as part of a broader contract (04A4147) to update the Caltrans Cultural Resource Database (CCRD). Some content was developed as part of other District 4 Transportation Enhancement contracts, and coalesced in this document. The initial draft was reviewed by the Cultural Resources staff at Caltrans District 4, including myself, Brett Rushing, Kathryn Rose, Christopher Caputo, Emily Castano, Jennifer Blake, Benjamin Harris, Lindsay Hartman, Kristina Montgomery, and Karen Reichardt. Funding for additional review and revisions was supported by Jody Brown and approved by Glenn Gmoser, Caltrans Cultural Studies Office, under Contract 43A0313; Mike Lerch, SRI, served as Project Manager. Peer reviewers included John Fagan, Glenn Farris, Glenn Gmoser, Mark Hylkema, Tsim Schneider, and Dwight Simons. The document also benefited from a formal review of the draft by Bill Hildebrandt, and informal discussions with Kim Carpenter, Philip Kaijankoski, Nathan Stevens, and Drew Ugan. Their unique perspectives and detailed knowledge of the record are appreciated.

The archaeological review staff at the Office of Historic Preservation offered comments that greatly enhanced the document's usability, encouraging a linkage between abstract research issues and specific data types and special studies. The review team was led by Alicia Perez, with Anmarie Medin, Brendan Greenaway, Jeanette Schulz, Koren Tippett, and Jessica Tudor contributing helpful suggestions. The final version reflects the perspectives of Caltrans District 4 and the authors, who are solely responsible for the content.

A number of archaeologists kindly provided copies of their reports and publications: Eric Bartelink, Alex DeGeorgey, Jelmer Eerkens, Sally Evans, Richard Fitzgerald, John Holson, Mark Hylkema, Linda Hylkema, Kent Lightfoot, and Sally Morgan.

Far Western personnel were integral to this endeavor. Cassy Brainard, Stephanie Bennett, and Jennifer Thomas helped manage reports and references; Kaely Colligan and Stephanie Bennett compiled obsidian, radiocarbon, and faunal data from dozens of cultural resources management reports. Laura Leach-Palm aided with accessing the CCRD. Paul Brandy and Shannon DeArmond managed and edited geospatial data sets (including the CCRD) used to generate the regional analysis and synthesis of the archaeological record, and ran many of the GIS-based analyses that appear in various research issue discussions. Shannon DeArmond also created most of the beautiful maps, assisted by Jill Bradeen, Darla Rice, and Ruth Zipfel. Laura Harold and Lucas Martindale Johnson provided up-to-date lab analyses for Appendix I. Production Department staff— Nicole Birney, Michael Pardee, Sorana Bucur, Kathleen Montgomery, Margo Meyer, and Molly Starr patiently and expertly produced this final document. Thank you to all.

Todd Jaffke

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1. INTRODUCTION

This report presents an extensive regional contextual discussion and research design for Native American archaeological resources in the San Francisco Bay-Delta region of California Department of Transportation (Caltrans) District 4 within central California. These data can be used as starting points for future Caltrans District 4 archaeological investigations (including survey, testing, and data recovery projects). It is anticipated that this document will need to be updated periodically to reflect subsequent advances in archaeological data accumulation, perspectives, and methods.

The topical focus of this study is the archaeological record of Native Americans from initial occupation until AD 1847 (the end of the Mexican Period). As such, it does not specifically address the historical-era archaeological record of non-Native Americans. The areal focus of the report is the central portion of Caltrans District 4 (Figure 1). Oriented around the San Francisco Bay and the western portion of the Sacramento-San Joaquin Delta (generally defined as within 20 kilometers [~12 miles] of the circa AD 1800 historical-era bay margin), the study area covers 1.98 million acres (8,027 square kilometers [3,100 square miles]) and encompasses 41% of the District. This area—referred to here as the San Francisco Bay-Delta—is a fairly well-defined geo-topographic and archaeological region, and encompasses large segments of the region's major highways.

Presented in this document are key studies, datasets, topics, and methods to provide a structure for archaeological research designs, archaeological evaluations, and data recovery plans for Bay-Delta Area sites. Included are: (a) references to peer-reviewed, published research in the region; (b) discussions of major excavations that provide data valuable to research topics of interest; (c) highlighted topical research themes currently germane to archaeological investigations in the region; and (d) best-practices for archaeological studies, including public outreach.

The report consists of five sections:

- SECTION 1 BACKGROUND
 - Chapter 2 Regulatory contexts, including federal and state laws and Caltrans protocols.
 - Chapter 3 Environmental setting, paleoenvironmental changes, Native communities at historic contact, and a detailed summary of the Native American archaeological record. The Caltrans Cultural Resources Database (CCRD)—an electronic inventory of archeological investigations and resources along the right-of-ways of Caltrans highways—was an important source of information.
 - Chapter 4 Methods for discovering buried sites through geoarchaeological approaches and predictive modeling.
- SECTION 2 RESEARCH ISSUES
 - Chapter 5 A series of abstracts for each of the nine detailed research domains presented in the following chapters; the abstracts highlight key points and data requirements and can be inserted into work proposals, as applicable.
 - Chapters 6–14 Detailed research domains and issues which can be used to guide the determination of site eligibility and the direction of archaeological investigations in Native American occupation of the Bay-Delta Area. Each larger research domain has a series of salient research issues and associated data needs pertinent to local, regional, and theory-driven archaeology:
 - Chapter 6 Site Age and Occupation History, focusing on chronology and component identification.

- Chapter 7 *Temporal Trends in Pre-Contact Occupation*, including discussions of radiocarbon sampling and interpretation, obsidian hydration, and use of Scheme D for chronological refinement.
- Chapter 8 *Settlements in Spatial Context*, presenting ideas on San Francisco estuary adaptations, reconstructing settlement trends and seasonality, Bay-Delta Area mounds, and causal factors of sedentism.
- Chapter 9 *Exploring Changes in Diet and Health,* including resource intensification, fishing trajectories, species-specific animal exploitation, shellfish and plant gathering, diet and health discerned from human remains, and anthropogenic landscapes.
- Chapter 10 *The Importance of Technological Change,* focusing on changing form, function, and style of two major artifact categories—milling tools and the bow and arrow—as indicators of social, economic, and cultural transitions.
- Chapter 11 *Human Demography and Population Movement* relates to population movement and demographic transitions, and violence-related activities.
- Chapter 12 *Tracking Trends in Social Interaction* deals with socio-political complexity, gender roles, animal interments, and social patterning.
- Chapter 13 *Reconstructing Regional Interaction Spheres* is explored through studies of obsidian, *Olivella* beads, and abalone ornaments.
- Chapter 14 *Indigenous Assimilation and Persistence* reconstructs the tribal landscape, tracks Native American assimilation, and presents data on indigenous resistance, refuge, and autonomy.

SECTION 3 – OPERATIONALIZING EVALUATION AND MITIGATION

- Chapter 15 After emphasizing the importance of temporal component identification for significance evaluation, best-practices are then covered for field sampling techniques, laboratory methods, and documentation for each artifact class as they relate to research issues, site significance, and data recovery.
- Chapter 16 An array of public outreach mitigation measures is presented. Then each is rated by scaling cost, utility, effectiveness, and distribution.
- SECTION 4 REFERENCES
 - A complete and up-to-date bibliography of relevant research and investigations undertaken in the Bay-Delta Area and California (includes references for Appendix D).

• SECTION 5 – SUPPORTING DOCUMENTATION

• A series of appendices includes maps, models, codes, tabulated summaries, radiocarbon data and calibration, plant and animal scores for Ideal Free Distribution, examples of field forms, and common analytical methods for flaked and ground stone.

WHAT THIS REPORT IS NOT

As it stands, this document is more than 500 pages and exceeds 124,000 words in length. Even with this much information and discussion, some archaeologists and cultural resources managers working in the San Francisco Bay-Delta Area will find things missing. Many of these omissions are intentional, and the data can be found elsewhere in numerous, well-researched and well-presented documents. In addition, research issues don't touch on every possible avenue of study. While hundreds of reports and published articles were reviewed, the references used were directly pertinent to the various arguments. Not included herein are

details on: (1) comprehensive regulatory guidance; (2) Native American consultation; (3) site significance evaluation under Criteria A, B, and C; and (4) the history of San Francisco Bay-Delta Area archaeology.

Regulatory Guidance

Chapter 2 provides an overview of Caltrans, state, and federal regulations as they relate to evaluating resources under Section 106 of the National Historic Preservation Act (NHPA), California Environmental Quality Act (CEQA), and the Programmatic Agreement. The information provided in Chapter 2, however, is meant to highlight those portions of the regulatory process that are important to the evaluation of Native American archaeological sites in the project area. No attempt was made to replicate the exhaustive guides to cultural resources compliance that already exist. Those interested in these details are referred to the Caltrans Standard Environmental Reference (SER), Volume 2¹, the California Office of Historic Preservation², and National Parks Service National Register of Historic Places Bulletins³.

Native American Consultation

Caltrans has extensive guidelines for Native American consultation⁴, and each District has a Native American Coordinator on staff who manages all communication with interested Native Americans. Native American consultation is an integral part of any project, particularly those that have potential to affect cultural resources, and as such, concerted efforts will be made to consult with interested Native American parties for every stage of every project.

Some research issues and methods rely on the analysis of human remains and other objects (e.g., beads) that can be, or often are, found with human interments. These analyses (e.g., ancient DNA and stable isotope analysis) should only be undertaken after consultation with and approval by the Most Likely Descendant (MLD), and following the guidelines of the California Health and Safety Code (Sections 7050.5(b) and 70505(c)) and the California Public Resources Code (Section 5097.98(a)). This point will be assumed for all following discussions and will not be repeated.

Evaluation of Resources under Criteria A, B, and C

This document does not directly address the potential eligibility of sites under Criteria A, B, and C (see page 2-3). However, these criteria should be considered for every site, in consultation with Caltrans and Native Americans, to identify sites of traditional importance. This research design explicitly focuses on the **evaluation of archaeological sites under Criterion D**—their potential to contribute to important regional research issues—as directed by Caltrans.

History of San Francisco Bay-Delta Area Archaeology

With over a century of archaeological investigations in the San Francisco Bay-Delta Area, it would be an onerous task to delve into every temporal scheme, every study, and every excavation project and site. Such a complete history of investigations and intellectual thought in the Bay-Delta Area, or even in one of the six regions discussed in this document, is beyond the scope of this study. As a starting point to gain further appreciation of the rich archaeological history of the Bay-Delta Area, we recommend the reader turn to Milliken et al. (2007), as well as other references presented in our archaeological context.

¹ http://www.dot.ca.gov/ser/vol2/vol2.htm

² http://ohp.parks.ca.gov/

³ https://www.nps.gov/Nr/publications/index.htm#bulletins

⁴ http://www.dot.ca.gov/ser/vol2/ch3.pdf; http://www.dot.ca.gov/hq/tpp/offices/ocp/nalb/index_files/nalb_intro.pdf

Further, in designing and highlighting key regional research issues, we felt that the history of archaeological excavations in the region was ancillary to our immediate goals. Similarly, we have not attempted to synthesize the extensive archaeological record, as this would have required detailed analyses of countless reports, and would have yielded information germane to only a narrow range of archaeological research topics. We therefore apologize in advance for those authors, theories, and reports, we have not included in this study.

All-Inclusive Research Issues

As we describe in the section entitled *Research Orientation* (see page 5-1), we fully acknowledge that this research design reflects our own particular views on important topics that can be addressed with the San Francisco Bay-Delta Area archaeological record. That being said, we have attempted to fully address as many research issues of interest to the broader community as we could identify, and have presented topics that reflect the current state of archaeological research in the Bay-Delta Area. There are certainly research issues, both broad and specific to a particular area and time period, that we do not focus on.

Also, archaeological research is organic on an international scale. Technological and theoretical advances are constantly changing the questions we ask, the questions we can answer, and the methods we use to better understand the archaeological record. Just 20 years ago we would not have been able to imagine the types of data from which we can gain new insights—e.g., stable isotope and ancient DNA analysis—or, for example, the dynamic relationships between indigenous people and Spanish missions that can be identified in the record. We anticipate that many of the questions outlined in this document will be answered in the next five, 10, or 20 years, while many others that we cannot yet imagine will be posed, probably in rapid fashion. As such, this document should be revised regularly, and archaeological studies should routinely look beyond the topics presented here when the situation or data demand it.

Reference Material

There is an extensive bibliography for this document (Section 4), that touches on key sites in the region and important studies done for each research issue. On developing this Bay-Delta Area research design, we primarily focused on studies that present substantive data, particularly radiocarbon dates, as well as those that identify discrete time periods. There are, of course, many more archaeological projects that have yielded excavation results (with varying levels of excavation, analytical presentation, and reporting); most, however, lack substantive results from clear temporal components, making the results less useful in our efforts to highlight major studies and results in the region. These projects, however, have the potential to contribute to our understanding of the archaeological record in a particular locality and should be assessed on a case-by-case basis.



Figure 1. San Francisco Bay-Delta Study Area in Regional Context.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

SECTION 1 – CONTEXT

This section presents Federal and State laws and Caltrans protocols; the environmental setting of the project area circa AD 1800; a consideration of the scale and nature of paleoenvironmental changes during the Holocene; the prehistoric and historic-era Native American archaeological record documented by prior studies; and geoarchaeological studies focused on the Bay Area.



2. CALTRANS REGULATORY CONTEXT (with Todd Jaffke)

This chapter presents a brief overview of Caltrans' regulatory context for archaeological resources in the environmental planning process. It is not intended to negate or supersede any of the Caltrans guidance found in the SER maintained by Caltrans Headquarters Division of Environmental Analysis. Rather, it provides a Caltrans District 4 Office of Cultural Resources Studies perspective and practice for compliance with applicable cultural resources regulations and policies for transportation projects. This includes compliance with State of California laws conducted in tandem with compliance driven by federal legislation. The information is not exhaustive, but focuses on compliance for the identification, evaluation, and mitigation of archaeological resources related to Native American presence in the San Francisco Bay-Delta Area. The SER Volume 2 offers a complete recitation of the Caltrans cultural resources compliance process, along with templates and format and content guidance for cultural resources compliance documents⁵.

FEDERAL CULTURAL RESOURCES COMPLIANCE

Caltrans Federal-Aid Highway program is subject to compliance with both the NHPA and the National Environmental Policy Act (NEPA). Caltrans has historically used the process and outcomes of compliance with Section 106 of the NHPA, as codified in 36 CFR Part 800, as the basis for compliance with NEPA. Caltrans currently complies with 36 CFR Part 800 through the 2014 *First Amended Programmatic Agreement among the Federal Highway Administration, the Advisory Council on Historic Preservation, the California State Historic Preservation Officer and California Department of Transportation regarding compliance with Section 106 of the National Historic Preservation Act as it pertains to the administration of the Federal-aid Highway Program in California (PA). Caltrans coordinates its PA compliance with NEPA to avoid duplication of effort, while giving appropriate consideration to cultural resources under both laws. Caltrans uses studies, determinations, and findings made in compliance with the PA to support compliance decisions under NEPA.*

Caltrans Section 106 First Amended Programmatic Agreement

Under the authority of 23 U.S.C. 326 and 327, Caltrans is deemed a Federal Agency and takes on all responsibilities for compliance with NEPA and NHPA for almost all Federal-Aid Highway undertakings in California. This authority is detailed in the PA, along with extensive delegations of authority to Caltrans for the few undertakings for which the Federal Highway Administration has retained Lead Agency status. Caltrans Division of Environmental Analysis and Cultural Studies Office (CSO) at Headquarters assumes the role of Federal Highways and ultimate responsibility for determinations and findings under the PA. The PA also delegates many important responsibilities to Caltrans Districts and their Professionally Qualified Staff (PQS).

FIRST AMENDED PROGRAMMATIC AGREEMENT – 2014

Refer to PA for:

- APE delineation
- Exempt resources
- Native American consultation
- Phased approach
- Resource identification and evaluation
- Assessment of effects
- Resolution of adverse effects
- Post-review discoveries
- Curation
- Data recovery plans
- Documentation

⁵ http://www.dot.ca.gov/hq/env/

Identification of Archaeological Resources

Caltrans uses the "reasonable and good faith effort" standard prescribed in 36 CFR Part 800 to identify properties eligible for the National Register of Historic Places (National Register). While the PA (§VIII.B) does little to amplify this standard, the SER, Volume 2, Chapter 5, provides step-by-step guidance for Caltrans projects. The Advisory Council on Historic Preservation has also published a brief explanation of the reasonable and good faith effort standard. The Secretary of the Interior's Standards and Guidelines also provide a common baseline for conducting a reasonable and good faith effort, though they have not been updated since 1995.

Area of Potential Effects

The Area of Potential Effects (APE) needs to include both the horizontal and vertical extent of construction, as well as all locations of possible ground disturbance, including staging areas, and even locations away from the immediate project area where soils might be taken. The final APE must also encompass the entire boundary of any site that partially extends into the project design APE.

While consideration of both the horizontal and vertical aspects of the APE is noted by the Advisory Council on Historic Preservation, Caltrans guidance specifically acknowledges the need to assess the potential for archaeological sites to be present beneath the constructed and natural land surfaces. Caltrans has made a concerted effort to develop and refine regional models of buried site sensitivity to inform the level of effort when considering the vertical APE (see Chapter 4, *Discovering Sites*, page 4-1). Caltrans District 4 maintains detailed GIS-based models of surface and buried site sensitivity used to support an assessment of level-of-effort. The models employ weighted geospatial data regarding slope, historical location of water courses (prior to modern channelization and realignment), and age of landforms (based on quaternary geologic mapping and thousands of radiocarbon dates from cultural and natural contexts). A model of submerged site sensitivity is also being introduced for Bay margins, indicating areas that were available for habitation prior to inundation by rising sea water (see Chapter 4, *Discovering Sites*, page 4-1). Archaeological consultants working on Caltrans projects should contact Caltrans Office of Cultural Resources Studies PQS when assessing buried site sensitivity and level of effort to identify archaeological resources on projects where substantive vertical effects are anticipated.

Extended Phase I Investigations

Where ground surface visibility is largely obscured by modern or historical land use and/or when there is a high probability for encountering buried archaeological deposits, Caltrans typically conducts an Extended Phase I subsurface identification study to meet the reasonable-and-good-faith effort standard. The effort should be guided by the extent and location of planned and reasonably foreseeable ground disturbance related to the project. An Extended Phase I Proposal is prepared and must be approved by Caltrans PQS prior to commencement of any excavation (see SER, Chapter 5, Volume 2, Exhibits 5.2 and 5.3 for format and content). The Extended Phase I report should also include documentation and data sufficient to provide feedback for informing and improving the buried site sensitivity model (e.g., detailed profiles and identifying soil horizons and associated radiocarbon dates). These reports are prepared in addition to, but may be combined with, the Archaeological Survey Report (SER, Volume 2, Exhibit 5.1).

National Register Evaluation

The 36 CFR Part 800 regulations and Caltrans PA require evaluation of the historic significance of identified resources against the National Register Criteria published in 36 CFR Part 63 and described in National Register Bulletin 15. While a National Register Eligible Property (Historic Property) can be a district, site, building, structure, or object, this document focuses on providing a historical context and

research issues for evaluation of Native American archaeological sites in the San Francisco Bay-Delta Area under Criterion D—have yielded, or may be likely to yield, information important in prehistory or history. In this context, an archaeological site is generally defined as a location that contains the physical evidence of past human behavior that allows for its interpretation.

National Register Bulletin 36

Caltrans acknowledges that consideration of the applicability of all four National Register Criteria (A, B, C, and D) should be given to archaeological sites as part of the evaluation and consultation process; however, consistent with *National Register Bulletin 36: Guidelines for Evaluating and Registering Archaeological Properties*:

The use of Criteria A, B, and C for archaeological sites is appropriate in limited circumstances and has never been supported as a universal application of the criteria. However, it is important to consider the applicability of criteria other than D when evaluating archaeological properties. The preparer should consider as well whether, in addition to research significance, a site or district has traditional, social or religious significance to a particular group or community. It is important to note that under Criteria A, B, and C the archaeological property must have ability to convey its demonstrated its significance, as opposed to sites eligible under Criterion D, where only the potential to yield information is required [National Park Service 2000:221.

NATIONAL REGISTER CRITERIA (36 CFR 60.4)

- (A) Associated with events that have made a significant contribution to the broad patterns of our history; or
- (B) Associated with the lives of persons significant in our past; or
- (C) Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- (D) Have yielded, or may be likely to yield, information important in prehistory or history

This document does not detail consultation with regional Native American Tribes regarding any traditional, social, or religious significance that sites in the region may or may not possess for them. However, Caltrans will ensure that consultation with interested Native American Tribes and groups occurs on individual undertakings, to assess whether or not any identified archaeological sites possess significance applicable to criteria other than, or in addition to, Criterion D.

Caltrans also recognizes that groups of archaeological properties may be considered a *District*, which possesses a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development. However, as the Caltrans right-of-way is comprised of narrow, linear strips of land, Caltrans rarely has the opportunity to formally evaluate such an entity. This document presents a regional context that may provide the basis for determining linkages between archaeological sites that may be eligible as a district, but there has been no concerted effort to define such entities. As above, the presence or absence of an archaeological district will be considered as part of the good-faith-effort to identify Historic Properties for individual undertakings.

Evaluation Process under the PA

The Caltrans PA provides for some flexibility in 36 CFR Part 800 evaluation requirements for archaeological sites, and identifies the parties who are empowered to exercise or authorize such flexibility. Caltrans PQS are responsible for determining if resources meet the criteria for eligibility for the National Register. Qualified consultants may apply the criteria and make eligibility recommendations,

but Caltrans PQS make the determination on behalf of Caltrans and conduct the consultation with the State Historic Preservation Office (SHPO) on all eligibility determinations. This Research Design is intended to provide a context within which the eligibility of archaeological sites in the region can be evaluated under Criterion D.

Exempt Resources

Attachment 4 of the PA includes property types that are exempt from evaluation as they typically have no potential to be eligible for the National Register. The list includes only one Native American archaeological property type: "Isolated prehistoric finds consisting of fewer than three items per 100 square meters." In practice, Caltrans does not generally exempt locations of sparse archaeological finds without some sort of controlled test excavations, unless the finds are situated in non-depositional or clearly secondary contexts. Items found in contexts that are "disturbed" are not summarily dismissed without clear demonstration that they are isolated. The concept of "disturbance" is part of the assessment of integrity when evaluating a resource, not an attribute of potential significance that would qualify a resource to be exempt from evaluation under the PA. Caltrans PQS and appropriately qualified consultants may exempt properties listed in Attachment 4. Caltrans PQS, however, have the responsibility and authority to determine that all terms and conditions in Attachment 4 are satisfactorily met.

Eligible for Purposes of the Project – Environmentally Sensitive Area

Under Stipulation VIII.C.3 of the PA, Caltrans PQS may consider (assume) an archaeological site eligible for the National Register if the resource can be protected from any potential effects by establishment and effective enforcement of an Environmentally Sensitive Area (ESA). This consideration of eligibility does not require any documentation of evaluation effort or consultation with the SHPO, and does not extend to other undertakings. Consultation with interested Indian tribes is required to determine if all values of the archaeological site can be protected through an ESA designation.

Eligible without Formal Evaluation

The PA also has a provision (§VIII.C.4) giving PQS authority in determining if there exist special circumstances where a property not subject to protection as an ESA may also be considered eligible for the National Register without formal evaluation. This consideration of eligibility must be approved by Caltrans CSO, but consultation with the SHPO is not required. Restricted access to perform effective evaluation and limited potential to affect the site are the most common reasons for considering a site eligible. Large property size coupled with limited potential for effect may also provide justification for considering a property eligible. Insufficient time and/or insufficient funding are not acceptable reasons for considering a property eligible. District PQS should be consulted early in the process to determine if resources can be considered eligible under this stipulation. As with archaeological sites protected by ESAs, the consideration of eligibility is only for the purposes of that specific undertaking.

Archaeological Evaluation

If a site is not considered eligible using the procedures described above, Caltrans typically will authorize archaeological testing, and/or rely on previous archaeological excavations of the site to evaluate its eligibility. Preparation of an Archaeological Evaluation Proposal, with review and approval by Caltrans PQS, is a required element of Caltrans evaluation process. As noted in Exhibit 5.4 of the SER, the research design portion is the core of the proposal. Similarly, the Archaeological Evaluation Report (Exhibit 5.5) depends heavily on the archeological research design and context. The Research Design presented herein is intended to provide the substantive and consistent archaeological context necessary to

complete these key elements of Caltrans evaluation process for this region. It provides the framework within which the information potential of archaeological sites can be assessed in relation to relevant research issues, a common chronological sequence, and comparable data sets.

Assessment of Effects

When formally or considered eligible archaeological sites are located within an undertaking's APE, there are four possible effect findings under the PA that will conclude the process:

- No Historic Properties Affected
- No Adverse Effect with Standard Conditions
- No Adverse Effect
- Adverse Effect

Consultation with interested Native American Tribes and notification of any assessment of effects is required.

No Historic Properties Affected

A *No Historic Properties Affected* finding (§IX.A) with an eligible archaeological site in the APE is extremely rare and must be approved by a Caltrans PQS at the Principal Investigator level. Typically, if a site is potentially affected within the APE, then it should be protected by designation as an ESA. There may be a few scenarios where an eligible site is included in the APE because a portion of it extends into the Caltrans right-of-way, but there is sufficient vertical separation between the location of work and the site, or there is an existing physical barrier between the proposed impact areas and the site to justify a No Historic Properties Affected finding.

No Adverse Effect with Standard Conditions – Environmentally Sensitive Area

A *No Adverse Effect with Standard Conditions (ESA)* finding (§X.B.1) is appropriate when all eligible or considered eligible archaeological sites can be protected through ESA designation. Consistent with the requirements of Attachment 5 of the PA, adequate information to accurately delineate site boundaries in relation to the proposed effects must be obtained prior to concluding that a Standard Conditions finding is appropriate. For archaeological sites, an Extended Phase I effort is often necessary to accurately delineate site boundaries. Observation of the distribution of surface materials may be sufficient if there are also natural or introduced boundaries (e.g., deep-cut watercourse or retaining wall) that would preclude subsurface extension of the site. A generous buffer delineated around the observed surface distribution of site materials may also be considered sufficient in some circumstances.

No Adverse Effect

A *No Adverse Effect* finding (§X.B.2; sometimes referred to as *No Adverse Effect without Standard Conditions*) is appropriate when application of the Criteria of Adverse Effect (36 CFR 800.5(a)(1)) is not met or conditions other than Standard Conditions are imposed to avoid all adverse effects.

Caltrans has adopted a relatively recent change in perspective from the SHPO that has resulted in a change of procedure for Caltrans related to the consideration (assumption) of a property's eligibility and effect findings for those properties. In the past, when Caltrans evaluated a site,

NO ADVERSE EFFECTS WITHOUT STANDARD CONDITIONS

Use appropriate language:

"As the site could not be formally evaluated as a whole, it is therefore considered eligible to the National Register for purposes of this project. However, project impacts to site deposits within the Area of Direct Impacts (ADI) <u>will not alter the</u> <u>characteristics that might make the site eligible</u> for the National Register under Criterion D, the potential to contribute to prehistory. The site outside the direct impact area will be protected as an ESA." it was common practice to determine that portions of a site were not contributing to the eligibility of the site as a whole. With SHPO concurrence on the determination, Caltrans could then make a No Adverse Effect with Standard Conditions finding if only a non-contributing portion was affected; the remaining portion was considered eligible and protected by ESA designation to conform to the Standard Conditions finding. Now, the whole site is assumed eligible, with a finding of No Adverse Effect. This perspective acknowledges that the site as a whole is being affected, but effects to the marginal portion of the site would not meet the Criteria of Adverse Effect.

Adverse Effect

An Adverse Effect finding (§X.C) is appropriate when effects to portions of a site that have the potential to yield important information cannot be avoided. This is a relatively low bar as the deposit only needs to have the **potential** to yield important information. This is especially pertinent in cases where a site has been considered eligible and there is no substantive information to demonstrate a lack of potential. Caltrans PQS Principal Investigator-Prehistoric Archaeology makes the determination of whether or not an effect is adverse. For adverse effects to properties eligible exclusively under Criterion D, the Caltrans District may concurrently submit the Finding of Effect to Caltrans CSO, SHPO, and consulting parties (§X.C.2). This applies only to the Finding of Effect. Consultation with the SHPO on resolution of adverse effects via a Memorandum of Agreement and Data Recovery Plan must be conducted by the Caltrans CSO.

For archaeological sites eligible under Criterion D, data recovery is the standard treatment for resolution of adverse effects. Attachment 6 of the PA lists the agreed-upon elements that should be included in a Data Recovery Plan. The Research Design presented herein is intended to provide the basis for many of the substantive portions listed, including, research questions, public interest, results of previous research, field methods and techniques, laboratory processing and analysis, methods and techniques for artifact, data and record management, and public involvement and education.

CONSIDERATIONS UNDER STATE CULTURAL RESOURCES LEGISLATION

Caltrans conducts federal cultural resources compliance in tandem with State of California laws similar to the coordination between Section 106 and NEPA compliance. Studies, determinations, and findings made in compliance with the PA are also used to support decisions made in compliance with the California Public Resources Code (PRC) 5024 and CEQA. Caltrans projects without federal involvement follow a similar process but with slightly different terminology and guidelines. Compliance for CEQA projects—i.e., no federal funds or permits—mirrors the Section 106 2014 First Amended Programmatic Agreement and requires that state-owned resources be evaluated under both National Register and California Register criteria.

Public Resources Code 5024

Taking effect on January 1, 2015, Caltrans has entered into a Memorandum of Understanding with the SHPO for compliance with Public Resources Code 5024⁶. The procedures generally mirror those of the Section 106 Programmatic Agreement, and state-owned resources considered under PRC 5024 must additionally be subjected to National Register eligibility criteria. The context and research design presented herein are applicable to the evaluation and mitigation of Native American archaeological resources in compliance with PRC 5024.

⁶ http://www.dot.ca.gov/ser/vol2/5024mou_15.pdf

California Environmental Quality Act

Under the CEQA, archaeological resources, including those considered to be tribal cultural resources, meeting the criteria for inclusion in the California Register of Historical Resources (California Register) as established in PRC 5024.1 are subject to consideration from project impacts. CEQA is encoded in Sections 21000 et seq. of the Public Resources Code, with guidelines for implementation codified in the California Code of Regulations (CCR), Title 14, Chapter 3, Sections 15000 et seq. State-owned properties are subject to the provisions of Public Resources Code Section 5024 and 5024.5. The California Register criteria are extremely similar to those for the National Register, although the California Register encompasses a broader range of resource types that may meet its criteria. The context and research design presented herein are applicable to the evaluation and mitigation of Native American archaeological resources in compliance with CEQA.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4
3. REGIONAL RESEARCH CONTEXT

This section describes the research area (study area), which constitutes a portion of Caltrans District 4, incorporating all or parts of the counties of Alameda, Contra Costa, Marin, Napa, San Francisco, Santa Clara, San Mateo, Solano, and Sonoma. It then describes the modern and paleoenvironment, followed by a discussion of archaeological, ethnographic, and historical contexts. Finally, an in-depth discussion of the local archaeological record is given, focusing on substantive excavation data.

STUDY AREA

The project study area is centered on the San Francisco Bay-Delta and is a fairly well-defined geotopographic and archaeological region. Its boundary is primarily defined as 20 kilometers (~12 miles) from the historic-era shoreline of San Francisco Bay (EcoAtlas Information System 2012). Two exceptions were made to make the study area a more coherent archaeological area while maximizing management objectives. It expands farther into the interior valleys along the east side of the Bay, effectively incorporating a greater portion of the Interstate 580 corridor eastward to the city of Livermore and the Interstate 680 corridor immediately to the north. The northern edge of the study area was decreased to just north of State Routes 116 and 12 to maintain a more coherent archaeological context focused around adaptations to San Francisco Bay and the lower, western portion of the Sacramento-San Joaquin Delta.

The study area covers 8,027 square kilometers (3,099 square miles; 1,983,455 acres). It encompasses 41% of Caltrans District 4, and includes large segments of major highways in the central portion of the District (Figure 2). Overall, 98.4% of the study area falls within District 4, along with 32,107 acres of District 3 (the southeast end of Sacramento County) on the northeast, and 34 acres of District 5 (the northern edge of Santa Cruz County) on the south. As such, the study area includes all of San Francisco County, as well as significant portions of Alameda, Contra Costa, Marin, Napa, Santa Clara, San Mateo, Solano, and Sonoma Counties; it also falls within 70 USGS 7.5-minute quadrangles (Appendix A).

Given the large size of the study area, it is also subdivided into variously sized regions to facilitate more refined discussion and to have a consistent set of terms to make spatial distinctions. The six named regions are based on geo-topographic drainage and drainage catchments parameters—Northwest Bay, Southwest Bay, South Bay, and East Bay (the Bay regions), and South Delta and North Delta (the Delta regions); the San Francisco, San Pablo, and Suisun Bays can be considered a seventh region (the Water region). Each subdivision represents from 9 to 18% of the total study area, and from 10 to 21% of the landmass of the study area (Figure 3; Table 1).

Region	Total	Area	TOTAL LANDMASS (Excluding Water		
	ACRES	Percent	ACRES	Percent	
Northwest Bay	329,098	16.6	329,236	19.3	
North Delta	239,754	12.1	240,530	14.1	
South Delta	308,149	15.5	308,776	18.1	
East Bay	362,235	18.3	361,648	21.2	
South Bay	292,444	14.7	291,707	17.1	
Southwest Bay	174,206	8.8	174,000	10.2	
Water (San Francisco Bay)	277,568	14.0	-	-	
Total	1,983,454	100.0	1,705,897	100.0	

Table 1.	Extent of	of San	Francisco	Bay-Delta	Study .	Area Regions.
				1	1	0



Figure 2. San Francisco Bay-Delta Study Area.



Figure 3. San Francisco Bay-Delta Study Area Subdivisions.

The Northwest Bay region (portions of Marin, Napa, Solano, and Sonoma Counties) includes the Marin Peninsula on the west (incorporating its high point of Mount Tamalpais at 784 meters [2,572 feet]) and extends along San Pablo Bay to the eastern edge of the Napa River drainage catchment. On the west in this region, small drainages and catchments dominate moderately steep terrain, while on the north the gently sloping terminus of the Petaluma, Sonoma, and Napa Rivers fall within this area. The Southwest Bay region (San Francisco and part of San Mateo Counties) is represented by the San Francisco Peninsula, bounded on the south by the northern edge of the San Francisquito Creek drainage catchment. These two western-most regions are separated by the narrow, one-quarter-mile-wide Golden Gate opening between the bay and the Pacific Ocean. Each also contains a portion of the open Pacific Coast that includes Bolinas Bay on the north and Half Moon Bay on the south. The South Bay region (parts of Alameda, Santa Clara, and San Mateo Counties) begins with the San Francisquito Creek drainage catchment and extends eastward to the edge of the large Alameda Creek drainage catchment, incorporating Guadalupe River and Coyote Creek at the north end of the Santa Clara Valley. The East Bay region (parts of Alameda and Contra Costa Counties) begins on the south with the extensive Alameda Creek drainage catchment, extending over the East Bay Hills into the interior, incorporating a portion of the Amador-Livermore Valley. It also extends northward along the bay to the Carquinez Strait. To the northeast is the South Delta region (Contra Costa County and a small portion of Alameda County), centered on Mount Diablo (the highest peak in the study area at 1,173 meters [3,848 feet]), and bounded by Suisun Bay and the Sacramento River on the north. Finally, the North Delta region (Solano County and a part of Sacramento County) extends from east of the Napa catchment to the eastern edge of the study area, and encompasses the Potrero Hills and the Montezuma Hills. Both the North and South Delta regions include portions of the Suisun Bay and San Joaquin delta catchments.

ENVIRONMENTAL CONTEXT

Modern and Recent Setting

The study area's 1.98 million acres is centered on San Francisco Bay, but also includes the distal end of the Sacramento-San Joaquin Delta (defined using drainage catchments as the portion of the study area beginning at Sherman Island and extending west). The greater San Francisco Bay is actually comprised of three bodies of water—Suisun Bay on the east; San Pablo Bay to the north, separated by Carquinez Strait; and finally the larger San Francisco Bay proper, south of the strait formed by San Pablo Point and Point San Pedro.

The area's climate is typically Mediterranean, with cool, wet winters and warm, dry summers. The region has warmer temperatures than more-northern coastal regions and is relatively frost-free. The majority of rainfall occurs December through March, decreasing from north to south. Along the immediate coast, the climate is cool and without extreme fluctuations.

Annual precipitation within the general region varies widely, from fewer than 380 millimeters (15 inches) to more than 1,650 millimeters (65 inches) per year (Figure 4). Rainfall within the study area is highest in upper elevations, particularly in the northwest and at Mount Tamalpais. Maximum rainfall in the uplands of the Southwest region is somewhat lower than in the Northwest region, while it is considerably lower in the East Bay Hills and on Mount Diablo in the South Delta. The study area's lowest rainfall occurs in lowlands of the South Bay and eastern portions of the North and South Delta (which are situated in localized rainfall shadows).

Ten main vegetation zones are present within the study area (see Küchler 1976 for summary descriptions of the composition of the communities portrayed), with mixed hardwood forest (28.8%) and coastal prairie scrub (19.7%) most pervasive, followed by California prairie (14.6%) and blue oak-gray pine forest (11.1%; Figure 5). Owing to variation in topography and rainfall, there is significant



Figure 4. Rainfall Variation in the San Francisco Bay-Delta Study Area.



Figure 5. Plant Communities within the San Francisco Bay-Delta Study Area.

variation in the distribution of major vegetation zones (Table 2). Notably, blue oak-gray pine is most prevalent in the South Delta and Northwest Bay. Mixed hardwood forest and coast prairies-scrub mosaic are both in the four bay regions, and infrequent in the two delta regions. In contrast, the delta regions are dominated by California prairie and tule marsh (the latter is particularly pervasive in the North Delta). Other notable differences between regions include an extensive coastal saltmarsh in the Northwest Bay and abundant valley oak savanna in the South Bay. These strong differences in the nature of upland and lowland terrestrial vegetation, as well as wetland zones, have strong implications for significant variation in the potential Native food resources within the study area.

Küchler (1976) Vegetation Zones	Northwest Bay (%)	North Delta (%)	South Delta (%)	East Bay (%)	South Bay (%)	Southwest Bay (%)	Total (%)
Blue Oak-Gray Pine Forest	16.0	2.2	29.5	4.7	7.5	1.0	11.1
California Prairie	-	37.4	40.7	12.5	-	-	15.1
Chaparral	1.2	-	-	-	-	-	0.2
Coastal Prairie-Scrub Mosaic	28.4	5.7	1.2	20.2	33.4	30.0	19.7
Coastal Saltmarsh	26.0	-	-	7.5	7.7	9.3	8.9
Mixed Hardwood Forest	19.6	9.8	11.5	54.3	30.6	45.1	28.8
Northern Seashore Communities	-	-	-	-	-	6.8	0.7
Redwood Forest	8.6	-	-	0.7	6.1	0.9	3.0
Tule Marsh	-	44.8	11.0	-	-	-	8.1
Valley Oak Savanna	0.2	-	6.1	-	14.7	7.0	4.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 2. Distribution of Major Vegetation Zones by Regions within the San Francisco Bay	v-Delta
Study Area.	

The reconstructed natural setting of the region circa AD 1800 highlights the primacy of wetland and estuary settings within the study area. Extensive coastal marsh lands, tidal marshes and flats, coastal prairie, and willow groves vary considerably within the study area (Figure 6). Notably, the Northwest Bay and the North Delta have the most extensive salt water and fresh water marshes, respectively. In addition to the Sacramento and San Joaquin Rivers, a series of moderate-sized water courses drained into the Bay. In the northern part of the bay, prominent drainages include the Petaluma River, Sonoma Creek, and Napa River, while on the south, notable drainages are San Francisquito Creek, the Guadalupe River, Coyote Creek, and Alameda Creek.

The area contained varied animal resources such as fish, shellfish, and terrestrial and marine mammals, as well as a range of plant resources. Detailed discussions of regional fauna and flora, including consideration of economically important ones, are provided in the following sources: Anderson (2005), Hickman (1993), Jameson and Peeters (2004), Munz (1968), Lightfoot and Parish (2009), and Rickets et al. (1985). The dominant vegetation along creek edges included yellow willow (*Salix lasiandra*), arroyo willow (*Salix lasiolepis*), broadleaf cattail (*Typha latifolia*), common tule (*Schoenoplectus acutus* var. *occidentalis*), and California bulrush (*Schoenoplectus californicus*). Pickleweed (*Salicornia pacifica*), Pacific cordgrass (*Spartina foliosa*), and salt grass (*Distichlis spicata*) are common species in coastal salt marshes. Native grasses along the coastal prairie include Pacific reed grass (*Calamagrostis nutkaensis*), Pacific hairgrass (*Deschampsia cespitosa* subsp. *holciformis*), and California bentgrass (*Agrostis densiflora*). Anadromous fish were present in the creeks that drained into the Bay, and notable large terrestrial mammals included tule elk (*Cervus elaphus nannodes*), pronghorn (*Antilocapra americana*), and grizzly bear (*Ursus arctos*).



Figure 6. Historical Wetlands (ca. 1800) within the San Francisco Bay-Delta Study Area.

Paleoenvironment (by Jack Meyer and Philip Kaijankoski)

In discussing the paleoenvironment, we employ Walker et al.'s (2012) proposal to formally subdivide the Holocene based on an emerging consensus drawn from geological investigations. As such, we use the following terms and time spans: Terminal Pleistocene (circa 25,000–11,700 cal BP), Early Holocene (11,700–8200 cal BP), Middle Holocene (8200–4200 cal BP), and Late Holocene (4200–0 cal BP) in discussing the paleoenvironment and in broadly structuring our subsequent discussion of the archaeological record (Figure 7). It should be noted that all dates used in this report refer to calibrated ages.

The Bay-Delta Area has undergone a series of significant large-scale environmental changes since the Terminal Pleistocene, when Native Americans may have first entered and inhabited the region (Meyer and Rosenthal 2007; Meyer et al. 2013). These changes included shifts in temperature and vegetation, rising sea levels, widespread sediment deposition, and corresponding fluctuations in the distribution and availability of important natural resources (Figures 8 through 10). As a result, the archaeological record, and the potential for archaeological deposits in the study area environs, are better understood when viewed within the history of Bay-Delta Area environmental and landscape changes.

Terminal Pleistocene (25,000–11,700 cal BP)

During the last glacial maximum some 22,000 years ago, vast ice sheets covered the northern part of the continent, and the climate in central California was considerably cooler than at any time since. Worldwide sea levels were at least 100 meters (~330 feet) lower than today, and the California coastline was located some 25 to 50 kilometers (15 to 30 miles) west of its current position (Atwater et al. 1977; Bard et al. 1996; Helley et al. 1979; Yokoyama et al. 2000). At that time, the combined runoff from the Sacramento and San Joaquin Rivers merged to form the "California River" (Howard 1979), which passed through the Carquinez Strait and into the "Franciscan Valley" (Axelrod 1981), now occupied by San Francisco Bay (Figure 11). The smaller streams and rivers draining the Bay also joined this massive drainage as it flowed west through the Golden Gate and across the continental shelf, where it eventually emptied into the Pacific Ocean near the modern-day Farallon Islands (Atwater et al. 1977; Axelrod 1981). Thus, instead of a "bay," there was a broad inland valley that supported grassland and riparian plant and animal communities.

Floral assemblages from throughout coastal central California indicate that Terminal Pleistocene climate was more seasonal than today, with cooler temperatures, greater effective precipitation, and a longer rainy season (West 2000). Axelrod (1981) documents a near continuous distribution of coniferous forest extending from the northern California coast as far south as the Channel Islands and Los Angeles. In the San Francisco Bay-Delta Area, the Tomales Flora, dated at 29,000 BP, included wood of Douglas fir, cypress, and Sitka spruce (Picea sitchensis), as well as a variety of shrubs and forbs (Johnson 1977). Johnson (1977:165) suggests that the occurrence of Sitka spruce and Monterey pine some 160 kilometers (99 miles) south and 120 kilometers (75 miles) north, respectively, of their modern distribution indicates a much more uniformly moist and cooler environment. A similar assemblage of cedar, cypress, pine, juniper, and fir macrofossils and pollen are found at Mountain View in clay deposits currently six to seven meters (19.7 to 23 feet) below sea level, dated between 23,000 and 20,000 years old. In the absence of redwood and oak, which are common in the region today, the Mountain View flora also implies a colderwetter climate. As Axelrod (1981:850) points out, the nearest modern analog now occurs in the mountains some 175 kilometers (108 miles) to the north, where the mean annual temperature is 3–4 °C (5.4–7.2 °F) cooler than at Mountain View and winter snowfall is common. The Douglas fir-dominated San Bruno Flora, dated around 10,000 BP, suggests that cooler-wetter conditions prevailed on the east-facing slopes of the San Francisco peninsula until the very end of the Pleistocene (Axelrod 1981; Potbury 1932). The closest modern analog occurs at Inverness Ridge, near Tomales Bay, where rainfall is currently 300 millimeters (12 inches) greater than at San Bruno (Johnson 1977; Potbury 1932).

EPOCH (MYA/cal BP)	ERA (cal BP)	LANDFORM MAP UNIT (cal BP)	CLIMATIC STAGE (cal BP)	
Modern <0 (<ad 1950)<="" td=""><td>Modern <0 (<ad 1950)<="" td=""><td>Historical Modern <100 (<ad 1850)–present<="" td=""><td>Historical Modern <100 (<ad 1850)–present<="" td=""><td>cal BP _0</td></ad></td></ad></td></ad></td></ad>	Modern <0 (<ad 1950)<="" td=""><td>Historical Modern <100 (<ad 1850)–present<="" td=""><td>Historical Modern <100 (<ad 1850)–present<="" td=""><td>cal BP _0</td></ad></td></ad></td></ad>	Historical Modern <100 (<ad 1850)–present<="" td=""><td>Historical Modern <100 (<ad 1850)–present<="" td=""><td>cal BP _0</td></ad></td></ad>	Historical Modern <100 (<ad 1850)–present<="" td=""><td>cal BP _0</td></ad>	cal BP _0
	Historical 100–0 (AD 1850-1950)	Recent Holocene 600–100	Little Ice Age (LIA) 600–100	150 = 100
		Medieval Climatic Anomaly (MCA) 1150–600	Medieval Climatic Anomaly (MCA) 1150–600	1150
	Late Holocene	Latest Holocene 2200–1150		22000
	4200–100	Late Holocene 4200–2200	Late Holocene 4200–2200 (cooler/wetter)	4200 - 4400
				5000 5000
Holocene 11,700-0	Middle Holocene 8200–4200	Middle Holocene 8200–4200	Holocene Climatic Optimum (HCO) 8200–5000 Cooling Event	- 6000 - 7000 - 8000
	Early Holocene 11,700–8200	Early Holocene 11,700–8200	8200	9000 - 10,000 - 11,000
				11 700
Pleistocene 2.58 MYA–11,700	Terminal Pleistocene 25,000–11,700	Youger Dryas (YD) 12,900–11,700	Youger Dryas (YD) 12,900–11,700	12,001
	Older Pleistocene	Terminal Pleistocene	Recess Peaks Glacial (RPG)	12,900 = 13,00
	2.58 MYA–25,000	25,000–12,900	Last Glacial Maximum (LGM) 22,000–18,000	

Note: MYA – million years ago.





Figure 8. Evolution of San Francisco Bay (after Meyer et al. 2013).



Figure 9. San Francisco Bay-Delta Area Sea Level Curve (after Meyer et al. 2013).



Figure 10. Geological Cross-Section at the San Mateo Bridge in the Southern San Francisco Bay (after Atwater et al. 1977).



Figure 11. Paleoshoreline Reconstructions for San Francisco Bay-Delta Area (after Meyer et al. 2013).

As the continental ice sheets began to melt some 16,000 years ago, the world's oceans rose rapidly, causing the Pacific shoreline to migrate eastward (Bard et al. 1996). For instance, between 13,500 and 11,000 cal BP, sea levels rose about 40 meters (130 feet), at an astounding average rate of about 16 meters (~50 feet) every 1,000 years. This time segment coincides with the earliest known evidence for human occupation in the California region. West (2000:19) points out that "the transition from the late Glacial Maximum (22,000 years ago) of the Pleistocene to the Holocene appears to have occurred in a step-like manner but with several reversals, the most significant being the period called the Younger Dryas." The Younger Dryas is a worldwide interval of colder climate that began around 12,900 years ago, lasting until 11,700 cal BP. Evidence of this brief reversal in the general warming trend leading to the Holocene comes from marine sediments along the California coast (Kennett and Ingram 1995), fossil pollen records from Clear Lake (Adam 1988; West 2000, 2001, 2002), midge fly remains in high elevation Sierra Lakes (Porinchu et al. 2003), and from pluvial lake basins in eastern California and Western Nevada (Benson et al. 1997).

Early Holocene (11,700-8200 cal BP)

The onset of the Holocene is marked by an abrupt warming event at around 11,700 cal BP. Between 11,000 and 8000 cal BP, sea level rose by 25 meters (82.02 feet; see Figure 9) causing ocean waters to move up the channel trenched by the California River, enter the Golden Gate, and spread across the exposed floodplain of the Franciscan Valley (see Figure 8; Axelrod 1981; Helley et al. 1979). By 10,000 years ago, 50% of the area formerly covered by glacial ice was exposed (Bloom 1983) and sea-level rise was progressing at an average rate of about 8.3 meters (27.23 feet) every 1,000 years (Stewart et al. 2002). At the same time, numerous other canyons and valleys along the central California coast were flooded, forming bays and estuaries. The sea continued to rise at an average rate of about 6.7 meters (~22 feet) per 1,000 years (9000–7000 cal BP, submerging much of the western continental shelf. Over the next 2,000 years (9000–7000 cal BP), sea level rose about 10 meters (~33 feet) at a more modest rate of roughly five meters (~16 feet) per 1,000 years. Thus, there was a cumulative ~70-meter (230-foot) rise in sea level during the Latest Pleistocene and Early Holocene. As the waters rose, freshwater marshes began to form, and sediments carried by the California River accumulated on the floor of the Franciscan Valley, marking the transition from valley to bay; by 8,000 years ago, a smaller version of San Francisco Bay existed (see Figures 8 and 11b).

The transition to the Holocene is reflected in a number of paleoenvironmental records marked by significant increases in temperature and decreases in precipitation (Adam and West 1983; West 2002). In the Clear Lake Basin, and elsewhere in the interior North Coast Ranges, the onset of the Holocene is marked by high oak and chaparral values, beginning about 9,500 years ago, reflecting an increase in drought-tolerant species (West 1993, 2001). Redwood appears to have responded rapidly to a changing environment along the coast, overtaking pine in the pollen profile at Laguna De Las Trancas, in Santa Cruz County, after 12,000 years ago (Adam et al. 1981). A core recovered near the mouth of the Russian River shows a similar florescence of redwood pollen at the beginning of the Holocene, reaching a maximum at around 6200 cal BP (Gardner et al. 1988; West 2000). An increase in coastal redwood peaking in the middle Holocene is likely a response to longer and warmer summers:

As a result of greater oceanic-continental temperature contrasts, a stronger sea-to-land atmospheric gradient developed, which generated upwelling winds. Under these conditions of greater upwelling, the extent of maritime summer fog was probably greater in middle Holocene times than today [West 2000:23].

As redwood is heavily dependent upon precipitation derived from fog drip, warmer interior temperatures would have been beneficial. In contrast, species such as Douglas fir, which are not as well adapted to summer drought, would have been restricted to more northern and upland localities.

Axelrod (1981) has shown that a number of plant species from arid and semi-arid regions to the south and east of San Francisco were able to colonize the valleys and uplands of the central North Coast Ranges during the early to middle Holocene as a result of increased temperatures and more severe summer droughts. Likewise, many taxa favoring cooler and moister conditions retreated from the central Coast Ranges, leaving only isolated remnants in the most favorable microclimates. A number of semi-desert to desert plant taxa reached their northern extent in the Diablo Ranges near Mt. Diablo, and isolated stands of other south coast plant species in the uplands of Sonoma, Napa, and Solano Counties, suggest a continuous distribution of xeric taxa from the central to southern North Coast Ranges during the early to middle Holocene (Axelrod 1981).

Middle Holocene (8200-4200 cal BP)

Sea level continued to rise during the Middle Holocene, but between 7000 and 6000 cal BP, there was a dramatic decrease in the rate of sea level rise worldwide (Stanley and Warne 1994). During this time, the sea inundated the Franciscan Valley at a more gradual rate of about 1.3 meters (four feet) every 1,000 years, for a total of 8.0 meters (26 feet) over the past 6,000 years. This allowed sedimentation to keep pace with inundation, which permitted the formation of extensive tidal-marsh deposits during the Middle Holocene (Atwater et al. 1979). As base levels rose, the lower reaches of the stream and river channels became choked with sediments that spilled onto the surface of existing fans and floodplains, forming large alluvial floodplains (Helley et al. 1979). As a result, bay and marsh deposits now cover many formerly stable Holocene-age land surfaces, such as those documented beneath Yerba Buena Cove (Lee and Praszker 1969:60–63), and the San Francisco-Oakland Bay Bridge (Atwater et al. 1977:Plate 1; Louderback 1951:90; Treasher 1963:Figure 5).

It was not until about 6,200 years ago that salt waters of San Francisco Bay reached Browns Island at the mouth of what is now the Sacramento-San Joaquin Delta, and formed the brackish-tidal marsh found there today (Goman and Wells 2000; contra Shlemon and Begg 1975). Between 6200 and 5550 cal BP, an incipient tidal marsh formed and drowned intermittently at Browns Island (Goman and Wells 2000). After 5500 cal BP, inundation was less frequent and the brackish-water marsh matured, likely in concert with the maturation of the larger Delta-Estuary. This feature dominated the central California landscape from that time on, ultimately encompassing some 494,000 acres in a roughly triangular-shaped zone that expanded eastward from a constriction point at the Coast Ranges (Atwater 1980; West 1977). Basal peat deposits from 15.2 meters (49.8 feet) below Sherman Island, located just east of Browns Island, have been dated to 7700 cal BP, indicating that a freshwater marsh was established in the western Delta region prior to inundation by rising ocean waters (cf. Goman and Wells 2000; Shlemon and Begg 1975; West 1977). The extent of an earlier freshwater marsh remains unclear, but appears to have been confined to a narrow strip immediately surrounding the confluence of the Sacramento and San Joaquin Rivers (Shlemon and Begg 1975:Figure 5). Overall, the San Francisco Bay-Delta began to take on much of its ultimate form and extent by 5,000 years ago (see Figure 11c).

A number of studies from the Coast Ranges suggest peak Holocene warming likely occurred prior to 5000 cal BP. Oak and chaparral pollen reached highest frequencies in the North Coast Ranges and Santa Barbara region at this time, along with peak amounts of redwood pollen in more maritime settings (e.g., Adam 1988; Adam and West 1983; Adam et al. 1981; Heusser 1978; Jones and Waugh 1997; West 1993). Axelrod (1981) estimates that July temperatures during the middle Holocene in central California were about 1 °C (1.8 °F) warmer than today, corresponding to the 1.4 °C (2.5 °F) increase suggested by Adam and West (1983; West 1993).

Late Holocene (4200–170 cal BP)

During the Late Holocene, pollen records from central and northern California suggest a return to more mesic conditions, with increased precipitation and less pronounced seasonal temperature variations, more characteristic of modern climate (West 2000). At higher elevations in the North Coast Ranges, Douglas fir begins to expand between 3800 and 2300 cal BP, and most pollen records studied by West (1993) show an increase in pine and a decrease in oak. Study of plant macrofossils in stratified tidal marsh deposits in Suisun Bay indicates a shift from brackish to fresh water conditions between about 3800 and 2000 cal BP, reflecting a period of increased summer flow from the Sacramento and San Joaquin Rivers (Goman and Wells 2000; Malamud-Roam et al. 2006; Wells and Goman 1994). Similarly, Davis (1999) reports a significant high stand at Tulare Lake between 3775 and 2560 cal BP. This roughly correlates with a significant flood event identified at 3600 cal BP in the Sacramento-San Joaquin Delta (Goman and Wells 2000).

Marshlands may not have extended to the eastern and southern Delta until the late Holocene, reaching a maximum extent perhaps only within the last 1,000 to 2,000 years. During the Late Holocene (4200 cal BP onward), the Bay grew in size as marshlands expanded in response to higher sea levels and the decomposition, compaction, and subsidence of intertidal deposits (see Figure 11d). These processes resulted in the formation of large tidal mudflats and peat marshes, which further promoted the deposition of sediment around the margins of the Bay and in the eastern and southern Delta (Atwater 1980; Shlemon and Begg 1975). Radiocarbon dates from Palo Alto Marsh in the South Bay indicate that these deposits were generally formed during the past 2,000 years (Atwater et al. 1979:349). Dates of 1665 and 1520 cal BP have been obtained from layers of organic clay from marsh deposits buried at depths of 6.1 to 6.5 meters (20 to 21 feet) along lower Colma Creek near San Bruno (Price 1981).

Late Holocene salinity profiles recorded in marsh deposits from Suisun and San Pablo Bays are quite variable, reflecting local conditions and estuary-wide fluctuations in freshwater flow. Several, often contradictory, records of high and low salinity levels are recorded in the estuary (cf. Byrne et al. 2001; Ingram and DePaolo 1993; Ingram et al. 1996; Malamud-Roam et al. 2006). For example, lower freshwater flows and high salinity in the Sacramento-San Joaquin Estuary between about 3000 and 2500 cal BP are indicated by the carbon isotope composition and high frequency of pollen from salt-tolerant plants in marsh deposits at Rush Ranch in northern Suisun Bay (Byrne et al. 2001). However, several other records from the estuary suggest relatively low salinity levels during this period (Ingram and DePaolo 1993; Malamud-Roam et al. 2006). The latter is more in line with regional pollen evidence for comparatively wet-conditions in the Sacramento watershed after 3800 cal BP. Studies of marsh deposits and analysis of oxygen isotopes in baydwelling shellfish deposits reveal significant high flow events in the Sacramento watershed between 1900 and 1600 cal BP (Ingram et al. 1996) 750 cal BP (Byrne et al. 2001) and about 500 and 350 cal BP (Ingram et al. 1996; Wells and Goman 1994). These latter two intervals correspond to other records from the bay-estuary, showing low salinity levels (Malamud-Roam and Ingram 2004; Malamud-Roam et al. 2006), and match high stands at Mono Lake (Stine 1990) at 550-465 and 375-290 cal BP. Tree-ring studies document additional high-flow events in the Sacramento River watershed at 825 and 600 years ago, which closely match Mono Lake high stands around 866 and 680 to 605 cal BP (Meko et al. 2001; Stine 1990).

Pollen profiles from Pearson's Pond in San Mateo County reflect a dry period in central California between 1950 and 1550 cal BP (Adam 1975). This corresponds to a drought interval recorded in giant sequoia tree rings from the southern Sierra at 1714 to 1773 cal BP (Hughes and Brown 1992), and partially overlaps with a period of high salinity at Rush Ranch in Suisun Bay between 1750 and 750 BP (Byrne et al. 2001). The wet period identified by Adam (1975) between 2300 and 1950 cal BP corresponds to freshwater conditions at Rush Ranch between 2500 and 1750 cal BP (Byrne et al. 2001); however, a dry interval from 1950 to 1550 cal BP contradicts the Rush Ranch record and other isotope studies from the estuary (Ingram et al. 1996). The latter indicate higher freshwater flows during this period (Ingram and

Byrne 1998; Ingram et al. 1996). As Goman and Wells (2000) point out, however, there are significant problems in the temporal resolution of the isotope data. In contrast, the Mono Basin record is largely consistent with the findings of Adam (1975), as a coeval low stand is recorded about 1800 cal BP and a high stand at 1370 cal BP (Stine 1990).

Two periods of drought are recognized by low stands of Mono Lake between 1100 and 890 cal BP and 790 and 650 cal BP, generally referred to as the Medieval Climatic Anomaly (Stine 1994; see Figure 7). This Late Holocene climatic perturbation is considered by some to be evident across the west (Jones et al. 1999), roughly coinciding with "an extreme hydrological event" (Ingram et al. 1996) in the Delta sometime between 1670 and 750 cal BP, and high salinity levels in the bay-estuary between 1000 and 800 cal BP (Byrne et al. 2001; Malamud-Roam and Ingram 2004; Malamud-Roam et al. 2006). This is consistent with reconstructed Sacramento River flows using tree-ring data, which suggest droughts occurred about 1,020 and 700 years ago (Meko et al. 2001). Meko et al. (2001), however, indicate the most severe drought in the last 1,100 years occurred in the Sacramento watershed 420 years ago. This drought interval is also recorded in the southern Sierra between 482 and 370 cal BP by growth rings in giant sequoia (Hughes and Brown 1992).

By about 650 cal BP, warm, dry conditions of medieval times began to give way to the Little Ice Age in the Sierra Nevada, also known as the Matthes glaciation (Matthes 1939). This neo-glacial period reached its peak about AD 1850 and declined thereafter, ending about AD 1900 (Guyton 1998; Stine 1998). It is generally thought that this climatic shift was triggered by reduced solar activity which changed the atmospheric circulation of the winter storm track over the northern Pacific (Graham 2004). Increased precipitation and lower temperatures (1.0–2.0 °C cooler than today) led to greater snowfall and the expansion of glaciers during this interval. These changes are reflected in isotopic, lake sediment, macrofossil, pollen, and tree-ring records from throughout California (Stine 1998), along with a decrease in the frequency of fires as monitored by reduced quantities of charcoal (Swetnam and Baisan 2003). The Little Ice Age is the only widely recognized period of glacial growth in the Sierra during the Holocene, and the coldest period in at least the past 11,000 years.

Historic-era Changes

More recent changes in the region include the introduction of non-native plant species, which generally coincides with the arrival of the Spanish and later Euro-American settlers during the late 1700s and 1800s (West 1989). These vegetation changes have been documented in part by pollen studies at the Presidio in San Francisco (Reidy 2001) and at other locations in the Bay-Delta Area (Duncan 1992; Mudie and Byrne 1980; Russell 1983). During the late 1800s, intense drought and livestock grazing and other activities associated with historic-era settlement greatly reduced the protective cover of vegetation, which made the landscape particularly susceptible to erosion (Burcham 1957:171). Around this same time, huge amounts of sediment were deposited within the Bay, largely because of hydraulic-mining for gold in the Sierra Nevada (Gilbert 1917). Lasting evidence of these changes is found in estuarine deposits (Mudie and Byrne 1980) and along many stream channels, where the lowest terraces are often composed of historic-era sediments (Knudsen et al. 2000). Finally, thick deposits of artificial fill were placed around the margins of the Bay to reclaim the marshes and wetlands for human development (Lee and Praszker 1969), including the former Yerba Buena Cove east of the study area (Schlocker 1974:Plate 1).

ARCHAEOLOGICAL CONTEXT

This section is a discussion of the San Francisco Bay-Delta Area regional cultural sequence, followed by a summary of archaeological research in the study area.

San Francisco Bay Region Temporal Framework

The initial cultural sequence for central California was defined largely on the basis of stylistic variation in artifacts from graves excavated in the lower Sacramento Valley (Lillard et al. 1939). Beardsley (1948) later extended this sequence to include the Bay-Delta Area, subsequently labeled the Central California Taxonomic System by Gerow (1968; Hughes 1994). Although three primary time segments continue to be recognized—Early, Middle, and Late—the timing, extent, and cultural-historical implications of each have changed greatly over the years (see in particular Bennyhoff and Fredrickson 1994; Bennyhoff and Hughes 1987; Fredrickson 1974a; Heizer 1958). Radiocarbon dating, widely used since the 1980s, has demonstrated that distinct culture-historical traditions coexisted in different geographic regions of central California, falsifying earlier evidence for a single culture-historical sequence, and making the "Central California Taxonomic System" no longer relevant over most of this region (contra Beardsley 1954; Bennyhoff and Fredrickson 1994).

Today, our understanding of the temporal sequence of Native American occupation is primarily built upon radiocarbon dating of archaeological site components. Rigorous dating allows sites to be accurately placed in time, and then, for comparative purposes, sites can be grouped within time intervals to track regional trends and differences. The most recent and refined chronology for the Bay-Delta Area, referred to as Scheme D (Groza 2002; Groza et al. 2011; Milliken et al. 2007), continues to employ a three-

part sequence—Early, Middle, and Late Periods—with transitional Early/Middle and Middle/Late Periods (Table 3). Preliminary versions of Scheme D were presented in Groza (2002), Milliken et al. (2007), Hughes and Milliken (2007), and Milliken and Schwitalla (2012). All have been superseded by Groza et al. (2011) which is a more complete summary of radiocarbon results. The current Scheme D, based on stylistic temporal variation in well-dated and widely traded shell bead types, is primarily a Late Holocene sequence (post-4200 cal BP), although the onset of the Early Period is generally considered to have its origins in the Middle Holocene (>4200 cal BP; Lightfoot 1997; Ragir 1972).

CHRONOLOGICAL SEQUENCE SCHEME D						
Period	cal BP					
Historic/Mission	180–115					
Late 1-2	685–180					
Middle/Late Transition	930–685					
Middle 1-4	2150–930					
Early/Middle Transition	2550-2150					
Early	+4050–2550					

Unfortunately, some researchers in the San Francisco Bay-Delta Area continue to use an older and inaccurate chronology, often referred to as Scheme B (Bennyhoff and Hughes 1987). The use of this outdated chronology greatly hinders efforts to advance our understanding of a suite of key research topics (see discussions in Groza et al. 2011 and Milliken et al. 2007) since fine-grained Late Holocene temporal changes are muddled (see Hughes and Milliken 2007:Figure 17-2 for a graphical depiction of the temporal differences between the two chronologies). There is also considerable spatial variation in cultural patterns at any point in time between regions, and discerning distinct cultural traditions requires that measures of time (particularly changes in artifact style horizons [e.g., Groza et al. 2011]) be independent of local culture-historical sequences and adaptive patterns (e.g., Fredrickson 1973; Hughes 1994; Milliken et al. 2007). The continued use of outdated chronological frameworks makes such efforts impossible.

Owing to a dearth of evidence for earlier occupation in the Bay-Delta Area, additional terms are lacking to refer to the Terminal Pleistocene through Middle Holocene archaeological record (13,500–4200

			DA			
CAL BP (YEARS)		CALENDAR YEARS	TEMPORAL PERIODS ^a	Array of Diagnostic <i>Olivella</i> Bead Types ^b	PATTERN ^C	
180–115	65	AD 1770–1835	Historic/Mission (H)	Needle drilled (H)	na	
430-180	250	AD 1520-1770	Late 2 (L2)	Lipped (Class E)		
				Normal sequin (M1a)		
(PE 420	255	AD 12(5, 1520	$I_{-1} = 1 (I_{-1})$	Pendant (M2)		
685-430	255	AD 1265-1520	Late I (LI)	Callus cupped (K1)		
				End-ground (B2)		
				Normal sequin (M1a)	Augustine	
				Split drilled/oval (C2/3)		
020 (95	245	AD 1000 10/F	Middle/Late	Split punched (Class D)		
930-685	245	AD 1020-1265	Transition (MLT)	Split amorphous (C7)		
				Tiny saucer (G1)		
			Wide sequin, occasional (M1d)			
				Normal narrow saddle (F3a)		
1200–930	270	AD 750-1020	Middle 4 (M4)	Rectanguloid/Oval saddle-smooth edges (F4c/d)		
				Full saddle-smooth edges (F4a/b)		
				Small narrow saddle (F3b)		
1365–1200	165	AD 585–750	Middle 3 (M3)	Normal narrow saddle (F3a)		
				Irregular saucer (occasional; G5)		
				Normal narrow saddle (F3a)	Uppor	
1520 1265	165	AD 420 585	Middle 2 (M2) 6	Rectanguloid/Oval saddle-chipped edges (F2c/d)	Berkelev	
1550-1565	165	AD 420-385		Full/Round saddle-chipped edges (F2a/b)		
				Full saddle-smooth edges (F4)		
				Saucer (Class G)		
2150-1530	620	200 BC-AD 420	Middle 1 (M1)	Split-drilled/oval (C2/3)		
				Oval saddle (F1)		
2550-2150	400	600–200 BC	Early/Middle Transition (EMT)	Split beveled (?) – no wall beads? (C1)		
+4050-2550	1,500+	+2100–600 BC	Early (E)	Thick rectangle (Class L)	Lower Berkeley	

Table 3.1	Late Holocene	Scheme D C	Chronological	Sequence for	r the San Fra	ncisco Bay-I	Delta Area.
			0			1	

Notes: ^a Periods are based on temporal duration of diagnostic shell bead styles; abbreviations in parentheses; ^b Listed by relative predominance; ^c Fredrickson (1994). Groza et al. (2011:Figure 3) has inconsistent start dates for EMT and Late 2 (but see page 7-15 and Figure 37 for revised start date for EMT)

cal BP), although some researchers have opted to extend the label "Early Period" farther and farther back in time. Others, however, employ the pre-contact periods defined by Fredrickson (1974a, 1984, 1994) to track broad socio-economic and technological trends in central California and the North Coast area. As originally conceived, these include: Paleo-Indian (10,000–6000 BC), Lower Archaic (6000–3000 BC), Middle Archaic (3000–1000 BC), Upper Archaic (1000 BC–AD 500), Lower Emergent (AD 500–1500), and Upper Emergent (AD 1500–1800). This temporal scheme no longer bears a relationship to welldocumented changes presented in the Scheme D chronology, but the socio-economic and technological trends it encapsulates may remain relevant, particularly for earlier periods (>4500 cal BP).

The following summary draws on insights gained from surrounding regions and recent overviews by Hylkema (2002), Lightfoot (1997), Lightfoot and Luby (2002), Milliken et al. (2007), and Rosenthal and Meyer (2004; see also Elsasser 1978; Fredrickson 1974b; Gerow 1968; and Moratto 1984). It is organized by geologic time segments and includes sections on the Terminal Pleistocene (13,500–11,700

cal BP), Early Holocene (11,700–8200 cal BP), Middle Holocene (8200–4200 cal BP), and Late Holocene (4200 cal BP, onward). The Late Holocene is further divided into shorter periods using Groza et al.'s (2011) Scheme D dating results.

Terminal Pleistocene (13,500–11,700 cal BP)

Currently, there is growing agreement that humans entered the Americas via multiple migrations using both coastal and inland routes (Erlandson et al. 2007a; Goebel et al. 2008). Most scholars view this as a post-glacial maximum process (after 21,000 cal BP), although some have argued for pre-glacial maximum incursions (Madsen 2004). The coastal route, referred to by Erlandson et al. (2007b) as "the Kelp highway," entailed travel by boat exploiting this corridor's highly productive marine resources. This reconstruction has been bolstered by a growing body of evidence from coastal southern California, particularly the Channel Islands (Erlandson et al. 2001; Rick et al. 2013), demonstrating that humans were living along the California coast at the end of the Pleistocene.

The Terminal Pleistocene is largely contemporaneous with the Clovis and Folsom periods of the Great Plains and the Southwest and is generally considered to be represented by wide-ranging, mobile hunters and gatherers who periodically exploited large game (Haynes 2002). Throughout California, Terminal Pleistocene occupation is infrequently encountered and poorly understood, and most often represented by isolated fluted points (Erlandson et al. 2007a; Rondeau et al. 2007; Rosenthal and Fitzgerald 2012).

No fluted points or archaeological deposits dated to the Terminal Pleistocene have been documented in the Bay-Delta Area. The Borax Lake site (CA-LAK-36), situated near Clear Lake in the North Coast Ranges, is the nearest locality where fluted points are reported (Meighan and Haynes 1970; Moratto 1984:82–85). Isolated fluted points have also been documented at Tracey Lake in the Delta (Heizer 1938), and at the Wolfsen mound (MER-215), a major Late Holocene residential site along the middle San Joaquin River (Peak and Weber 1978). The latter find appears to be intrusive to the site.

The absence of Terminal Pleistocene archaeological remains is undoubtedly the result of several factors, most notably the likelihood that initial human populations were small, highly mobile, and traveled rapidly across the continent. Therefore, their archeological signature on the landscape was generally faint and wide-spaced. For coastal areas, sea level rise, coastal erosion, and, localized subsidence have further reduced the likelihood of documenting initial occupation of the region, and some sites may be preserved under water (see *Paleoenvironment*, page 3-9). On the interior of central California, widespread landscape evolution and floodplain development during the Holocene has also obscured the earliest records of human colonization (e.g., Rosenthal and Meyer 2004).

Early Holocene (11,700-8200 cal BP)

It is typically thought that evidence for Early Holocene human occupation in central California is the product of semi-mobile hunter-gatherers exploiting a wide range of plant and animal foods from marine, lacustrine, and terrestrial contexts (Erlandson et al. 2007a; Jones et al. 2002; Meyer and Rosenthal 1995; Moratto 2002). Early Holocene assemblages often include stemmed points, crescents, and steepedged formed flake tools that share many attributes with contemporaneous material in the Great Basin and southern North Coast Ranges (Rosenthal et al. 2007). However, milling tools (handstones and millingslabs) are ubiquitous in these early deposits, a characteristic which distinguishes Early Holocene occupations in California from those in the Great Basin (Rosenthal and Fitzgerald 2012).

There are only four Early Holocene deposits archaeologically documented in the Bay-Delta Area, resulting in few and poorly established patterns. These include two at Los Vaqueros Reservoir (CCO-696 and CCO-637) in the East Bay region (Meyer and Rosenthal 1997, 1998), the Laguna Creek site (P-48-

000897) near Lagoon Valley on the western margin of the North Delta region (Hildebrandt et al. 2012), and the Fremont Site (P-01-011556) in the city of Fremont in the South Bay region (Meyer 2015). Two nearby Early Holocene sites include the Blood Alley site (SCL-178) in the Coyote Narrows of the Santa Clara Valley (Hildebrandt 1983), and SCR-177 at Scott's Valley in the Santa Cruz Mountains (Cartier 1993). All six sites were identified in buried terrestrial contexts (Hildebrandt et al. 2012; Meyer 2015; Rosenthal and Meyer 2004:30–32). No sites from this time span have been documented as yet in paleo-bay or paleo-outer coast settings, in part because these contexts are now submerged making them difficult to discover.

Diverse resource exploitation is indicated by artifact and ecofact assemblages from these sites. They include handstones and millingslabs (but not mortars and pestles), large flaked cores and cobble tools, flake tools, well-made bifaces, and a single flaked stone crescent. Obsidian from the closest sources in the southern North Coast Ranges (particularly the Napa Valley) predominates, although eastern Sierra obsidian (Bodie Hills) is also represented at Los Vaqueros (Meyer and Rosenthal 1997). Trace amounts of marine shellfish have been recovered from some inland sites, while faunal assemblages are varied and include deer, elk, rabbit, ground squirrel, coyote, and grizzly bear. Carbonized plant remains from CCO-696 are dominated by acorn, indicative of fall-winter occupation, while those from the Laguna Creek site and the Fremont site are primarily summer-ripening seeds, consistent with the idea that these early foragers moved seasonally. Each Los Vaqueros site also included a single human burial. These Early Holocene deposits demonstrate that the general region was occupied throughout this time segment, but a better understanding of the nature of early occupation will require much more information.

Middle Holocene (8200-4200 cal BP)

Evidence for Middle Holocene occupation is much more ubiquitous than for earlier time segments. More than 60 Bay-Delta Area archaeological sites have produced radiocarbon dates indicating occupation during the Middle Holocene. Both surface and buried deposits are present, including a number of substantial residential settlements. Notably, the Middle Holocene includes a series of buried sites with diverse cultural assemblages and occasional burials, such as East Bay region sites ALA-483 in the Amador-Livermore Valley, the Marsh Creek Site (CCO-18/548) and the Los Vaqueros Dam site (CCO-637) in the northern Diablo Range, and Northwest Bay site MRN-17 on De Silva Island in Richardson Bay (Meyer 2005; Meyer and Rosenthal 1998; Pohl 2003; Rosenthal and Meyer 2004; Wiberg 1996). In addition, several isolated human burials have been found in buried contexts, including several in the northern Santa Clara Valley of the South Bay (such as SCL-33, -484, -674, and -832) and along the edge of the bay in the Southwest region—in the Mission Bay/Yerba Buena Cove area (SFR-28, BART Skeleton, the Transbay Skeleton) and near Coyote Point (SMA-273; Henn et al. 1972; Leventhal 1987; Meyer 2008, 2015; Scher and Meyer 2014).

Artifact assemblages are varied and include ground stone (some only with millingslabs and handstones, some with mortars and pestles, and some with both); side-notched dart points; cobble-based chopping, scraping, and pounding implements; and shell beads and ornaments (Fitzgerald 1993; Meyer and Rosenthal 1998). Notably, Type N grooved rectangular *Olivella* beads are present at San Bruno Mountain mound (SMA-40), Yñigo mound (SCL-12/H) and CCO-474/H along the eastern edge of San Pablo Bay (Arrigoni et al. 2008; Clark 1998; Estes et al. 2002). These beads are well-dated to the Middle Holocene across a large region, from the northwestern Great Basin to San Clemente Island, and indicate the presence of an extensive regional interaction sphere by at least 5200 cal BP (Byrd and Raab 2007:220–221; Vellanoweth 2001; Vellanoweth et al. 2014). Obsidian from the Napa Valley and eastern Sierra Nevada, including Casa Diablo and Bodie Hills sources, make up a significant amount of the toolstone in some Middle Holocene sites (e.g., Meyer and Rosenthal 1997; Rosenthal 2010), beginning a pattern of extensive inter-regional obsidian exchange that would continue through the Late Holocene (e.g., Hughes 2011).

Current evidence suggests that the mortar and pestle were in use by 6000 cal BP, primarily at sites in the Amador-Livermore, Kellogg Creek, and San Ramon Valleys (ALA-574, CCO-308, CCO-637) in

the East Bay region. Mortars and pestles were the predominant milling tools used thereafter throughout the East and South Bay regions (Fredrickson 1966; Gerow 1968; Hylkema 2007; Meyer and Rosenthal 1997; Price et al. 2006; Rosenthal and Byrd 2005; Wiberg 2010).The first evidence for extensive use of estuarine resources occurs during the middle Holocene with the expansion of San Francisco Bay's mud flats, and tidal marshes. Estuarine shell midden deposits are present at MRN-17 on De Silva Island, CCO-474/H near Hercules, and at the San Bruno Mountain mound (SMA-40) between 6300 and 5000 cal BP, and somewhat later (4900 cal BP) in the East Bay at ALA-307 (Clark 1998; Ingram 1998; Meyer n.d.). Shellfish exploitation included bay oyster (*Ostrea*) and mussel (*Mytilus*), while inland East Bay sites include freshwater shellfish (Meyer and Rosenthal 1998; Waechter 1993). Faunal remains reveal diverse, local, niche-based exploitation strategies that included hunting seasonal waterfowl and capture of estuary, anadromous, and freshwater fish. Archaeobotanical assemblages from Middle Holocene contexts are varied; for example CCO-18/H features produced a varied assemblage of nutshell, small seeds, and fruit pits, including acorn, gray pine, bay, buckeye, red maids, goosefoot, farewell-to-spring, juniper, and manzanita berry pits (Wohlgemuth 2010). These remains suggest that a wide range of habitats was exploited throughout the year, consistent with either semi-permanent occupation or multi-season visits.

Evidence for long-distance exchange, greater investment in processing technologies (e.g., mortar and pestle), and extensively occupied habitation sites, including the basal layers of many bay shore shell mounds, suggest higher population levels, more complex adaptive strategies, and longer seasonal occupation than took place during the Early Holocene (Lightfoot et al. 2011). Along with burial by alluviation, undoubtedly pre-6000 cal BP sites situated along the bay margin would have been inundated by subsequent sea level rise. In part, this may explain why habitation sites from between about 8000 and 7000 cal BP are extremely rare in the wider Bay-Delta Area.

Late Holocene (4200–180 cal BP)

The Late Holocene is generally divided into the following five main time periods: Early (4200–2550 cal BP), Early/Middle Transition (2550–2150 cal BP), Middle (2150–930 cal BP), Middle/Late Transition (930–685 cal BP), and Late (685–180 cal BP; see Table 3). The Middle and Late Periods can be further subdivided (into four and two subdivisions, respectively), based largely on the seriation of specific types of shell beads (Groza et al. 2011). The temporal abbreviations included under the Shell Bead Period column in Table 3 are commonly used throughout the report to refer to time segments.

The Late Holocene is very well-documented in the Bay-Delta Area, with more than 240 radiocarbon-dated sites reflecting widespread occupation (Milliken et al. 2007). Over the last 4,000 years it is generally thought that regional human population increased and there was an upward trend in social, political, and economic complexity, in part reflected by distinct, geographically specific cultural traditions. Concurrently, a number of studies indicate that there was an increasing reliance on lower-ranked and more costly foods (including particular species of marine mammals, terrestrial mammals, birds, fish, plants, and possibly dogs) indicative of resource intensification (Broughton 1999, 2002; Broughton et al. 2007; Byrd et al. 2013; Whitaker and Byrd 2014; Wohlgemuth 1996, 2002). Territorial circumscription, active landscape management (e.g., burning), and periodic upswings in inter-group violence are also indicated (Andrushko et al. 2010; Bartelink et al. 2013; Lightfoot et al. 2013a, 2013b; Milliken 2006; Schwitalla et al. 2014). Drawing largely on mortuary remains, a number of scholars have argued that community organization entailed non-egalitarian social structure and status ascription (Bellifemine 1997; Fredrickson 1974b; Hylkema 2002:258–261; King 1974; Luby 2004; Milliken et al. 2007). Most suggest that these changes took place near the beginning of the Late Period, although King (1974:38) and Luby (2004:18) argue that they developed earlier, during the Middle Period.

The Early Period (+4050–2550 cal BP) marks the establishment or expansion of a number of large shell mounds. Prominent sites near the bay margins dating to the Early Period include University Village

(SMA-77), Ellis Landing (CCO-295), San Bruno Mountain mound (SMA-40), Stege mound (CCO-298), West Berkley mound (ALA-307), MRN-67, and ALA-17 (Banks and Orlins 1981; Clark 1989; Gerow 1968; Jones and Darcangelo 2007; Pahl 2003; Schwitalla and Powell 2014; Wallace and Lathrap 1975).

Lightfoot (1997:138) states that the earliest shell mound artifact assemblages consisted of:

stemmed and short, broad leaf projectile points; square-based knife blades; mortars (both unshaped and cylindrical), pestles (short and sturdy, cylindrical); crescentric stones; perforated charmstones; bone awls; polished ribs; notched and grooved net sinkers; rectangular and spire lopped *Olivella* beads; rectangular abalone (*Haliotis* sp.) beads and various pendant types; antler wedge; and stone bars or "pencils."

Bay margin sites reveal a strong emphasis on marine shellfish, marine fishes, and marine mammals. Recent research reveals that localized variation in shellfish exploitation is pervasive, oysters, mussels, and horn snail often dominating (Byrd et al. 2013; Whitaker and Byrd 2014). In contrast, interior sites emphasized freshwater fish and shellfish along with terrestrial mammals. Nuts, berries, and small seeds appear to have been particularly important plant foods.

Very large cemeteries first occur in the Late Holocene, and graves are common at most sites. Burials are almost exclusively found in a loose to tightly flexed position in Bay margin and Santa Clara Valley sites, and the regular occurrence of grave offerings, including shell beads and ornaments, bone objects, and charmstones, suggests well-developed mortuary practices. In the valleys of the east Bay and watersheds connected to the San Joaquin Valley, extended burials are common in the same cemeteries as flexed burials. This pattern reflects either a distinct cultural tradition (e.g., an early expression of the intrusive Meganos culture [Bennyhoff 1994a, 1994b]) or possibly cosmopolitan communities with members from the Central Valley or Bay-Delta Area where these contrasting burial postures predominate. Artifacts recovered mostly from burial contexts reflect extensive trade networks, providing access to finely crafted implements made of obsidian originating east of the Sierra Nevada and from Napa County (Hughes and Milliken 2007). *Haliotis* (abalone) and *Olivella* (olive snail) beads and ornaments also represent trade items, since manufacturing sites are undocumented in the local region. Multi-season plant and animal foods (e.g., Byrd and Berg 2009; Price et al. 2006; Wiberg 2010), residential structures (Price et al. 2006; Wiberg 2010), cemeteries, mortars and pestles, and evidence for regular exchange, all suggest to Byrd and Berg (2009) that relatively sedentary communities had emerged by the Early Period.

The Middle Period (2150-930 cal BP) is often considered to have witnessed greater settlement permanence-characterized by either sedentary or multi-season occupation (Hylkema 2002; Milliken et al. 2007). This time interval is also often considered to have been the heyday of mound building (as many of the bay margin shell mounds have dates within this time span) and correlated with greater social complexity and ritual elaboration (Lightfoot 1997; Lightfoot and Luby 2002, 2012). A series of changes in artifact types has been documented, including barbless and single-barbed bone fishing spears; large, shaped mortars and equally large pestles; and ear spools and varied forms of Haliotis and Olivella beads and ornaments. Mortuary practices were often highly ritualized, and some individuals, typically males, were buried with thousands of shell beads. Terrestrial resources appear to have been more heavily exploited than previously, based on food remains and isotopic analysis of human bone (Bartelink 2006, 2009; Beasley 2008). Shifts in resource emphasis included greater use of deer; less reliance on oysters and more on mussels, clams or horn snail; and increased acorn exploitation (Bickel 1978; Byrd et al. 2013; Simons 1992; Whitaker and Byrd 2014; Wohlgemuth 2004). During the Middle Period there are also indications that people originating in the San Joaquin Valley moved into the East Bay through Amador-Livermore Valley and the San Ramon and Walnut Creek Valleys, ultimately reaching the bay plain near Fremont. Referred to as the Meganos Intrusion, settlements associated with this distinctive cultural tradition are characterized by a high frequency of extended burials, and primarily date between about 1530 and 930 cal BP (Middle 2–Middle 4 Period) in the East Bay region. Earlier Meganos settlements from the Early Period (+4050–2550 cal BP) and Early/Middle Transition (2550–2150 cal BP) occur on the eastern side of the Diablo Range and in the sand mounds of the Delta, generally considered to be the cultural home land (Bennyhoff 1994a, 1994b).

The Late Period (685–180 cal BP) is the best-documented era, and current evidence suggests that Bay-Delta Area populations grew in size (Lightfoot and Luby 2012; Milliken et al. 2007), sedentary villages flourished (Eerkens et al. 2013b), and material signatures of ritual activity increased (Buonasera 2013; Byrd et al. 2013). Milliken et al. (2007:99) note that artifact assemblages at the end of this period included "clamshell disk beads, distinctive *Haliotis* pendants, flanged steatite pipes, chevron-etched bone whistles and tubes, elaborately finished stone "flower pot" mortars, and needle-sharp coiled basketry awls." The bow and arrow also are first documented in the region circa 700 cal BP, near the start of the Late Period (Groza et al. 2011; Kennett et al. 2013). The technological development is represented by a regionally distinctive arrow point style, the Stockton Serrate, with its distinctive square serrations and almost exclusive manufacture from Napa Valley and Annadel obsidian, the point style represents a local invention, rather than the adoption of existing arrow types from neighboring groups in central and northern California. This *in situ* point style development suggests that ethnic continuity was present across the Bay region from the Middle/Late Transition (930–685 cal BP) through Late 1 Period (685–430 cal BP).

Late Period archaeobotanical remains reveal greater reliance on small-seeds, further supplementing the earlier use of acorns and other nuts. This may suggest surplus production and storage for use in the fall and winter. Likewise, faunal evidence indicates a wide range of species was used, notably sea otters, rabbits and deer from estuary and terrestrial habitats. Clams (*Macoma*) and horn snails (*Cerithidea*) also were important to the diet, the latter used almost exclusively in the South Bay. Funerary rituals were strongly patterned and included flexed interments and intentionally broken grave offerings, along with occasional cremations. Extensive trade relations also appear to have flourished with neighboring groups during this period, although the long-range acquisition of eastern Sierra obsidian declined. In parts of the East Bay, Napa Valley obsidian makes up between 70 and 100% of all flaked stone debitage. Acquired as large flake blanks or small un-worked pebbles and cobbles, manufacturing costs were transferred to consumers, perhaps reflecting a deflation of value from earlier periods. Clam shell disk beads, manufactured north of the Bay, were traded southward as well as to the east into the Central Valley and beyond (Rosenthal 2011a). However, clam shell beads are rare in the South Bay region during Late 2 (Milliken et al. 2007), indicating different regional interaction spheres within the Bay-Delta Area.

Subsequently, early Spanish colonizers documented exceedingly high population densities in the San Francisco Bay and Delta area, equaled in California only by the Santa Barbara-area Chumash (Cook and Heizer 1968; Kroeber 1939; Milliken 2006, 2010). Sketchy and sometimes anecdotal ethno-historical information reinforces the perspective of elaborate ceremonialism (including the secret *Kuksu* society; Kroeber 1932; Loeb 1932, 1933), and suggests the presence of a standardized system of exchange based on clam shell beads (Chagnon 1970; King 1978; Rosenthal 2011a), and indicates that some families held hereditary authority (e.g., Loeb 1933).

ETHNOHISTORICAL NATIVE AMERICAN CONTEXT

The Bay-Delta study area, based on ethnohistorical reconstructions, falls within the aboriginal territory of several distinct Native American groups (Figure 12). These include the Ohlone in the southern and central portion of the bay; Coast Miwok in the northwest portion of the bay; and Bay Miwok, Plains Miwok, and Patwin in the eastern bay-delta area (Johnson 1978; Kelly 1978; Kroeber 1925; Levy 1978a, 1978b). Each of these Native groups were hunter-gatherers, lived in villages with well-defined tribal



Figure 12. Full Extent of Ethnographic Groups Present in the San Francisco Bay-Delta Study Area (after Milliken 2010).

territories, interacted and traded extensively with neighboring groups, and spoke unique languages. These languages were, however, all part of the Penutian-speaking phylum, with the Ohlone and Miwok languages more closely related to each other (both within the Utian language group) than to the Patwin (part of the Wintuan language family; Golla 2011). Moreover, "Some San Francisco Bay Costanoan-speaking local tribes had overlapping social and marriage networks with neighboring Coast Miwok, Bay Miwok, and Delta Yokuts-speaking groups, and thus shared genetic relationships with them, and probably some cultural relationships as well" (Milliken et al. 2009).

In the study area, traditional Native lifeways were disrupted first by the influx of European explorers, and then profoundly altered by the establishment of Spanish missions in the late eighteenth century (e.g., Lightfoot and Simmons 1998; Milliken 1995). Colonization and occupation quickly reduced Native populations, displaced them, and dramatically altered their traditional way of life. As a result, these groups are not as well-known ethnographically compared to groups in some other regions of California. Much of what we know comes from early European accounts—both explorers and mission staff—along with a few twentieth-century interviews by anthropologists who gathered information on remembered lifeways (e.g., Bean 1994; Galvin 1971; Harrington 1921–1929; Kroeber 1925).

As such, any discussion of Native lifeways at contact is a reconstruction based on incomplete data and level of effort invested by early ethnographers, and subject to varying perspectives and analytical efforts, particularly with respect to group size and territorial extent. Recent interpretations of Native populations, sometimes contradictory with earlier studies, are largely based on detailed research using mission records, particularly those carried out by Milliken (Milliken 1995, 2006, 2008, 2009, 2010; Milliken and Johnson 2005). Notably, we rely upon Milliken's most recent research results—referred to as the Community Distribution Model (CDM) for estimating populations and their density, and distinguishing tribelets and their spatial extent (identified as "regions," see Appendix B). As clearly stated by Milliken (2008:20–21), however:

It must be emphasized that the mapped regional boundaries of the CDM are not intended to represent actual ethnographic group boundaries...Where fixed boundaries did exist, they were not documented by ethnographers. This study attempts to reconstruct the general placement of ethnographic groups on the landscape. Such inferential reconstruction is hampered because territorial groups did not consistently follow simple rules of boundary definition.

With respect to reconstructing population estimates at Spanish contact, Milliken's approach placed more emphasis on the impact of post-contact diseases on Native populations than previous reconstructions (e.g., Cook 1976; Kroeber 1925). The basic premise is that tribelets recruited into the missions later in time (typically those further from a mission) have lower mission baptismal numbers due to the greater impact of Euro-American diseases. To correct for these impacts and obtain the most accurate estimate of individual tribelet's population at contact, three steps were taken by Milliken (2010). First, only adults (15 and above) were used to calculate population estimates, since children, especially infants, were most likely to have been impacted by disease vectors. Second, a time-transgressive mortality factor was used to estimate the impact of diseases on the total population (Milliken 2010:Table B-1). This entailed calculating the average date of all baptisms in a tribelet and dividing it by the temporally derived tribal mortality factor. Finally, the estimated adult population was doubled to obtain an estimate of total population (Acsádi and Nemeskéri 1970; Milliken 2008:22). The results yield finer-grained and more accurate population estimates, undoubtedly represent the most accurate reconstruction to date, and are the results used in this study.

Each of the five groups that inhabited the study area in the late eighteenth century is discussed below.

Ohlone

Ohlone (also referred to as *Costanos*, Spanish for "coastal people") is a linguistic subfamily of the Penutian language stock (Bean 1994; Kroeber 1925; Levy 1978a; Teixeria 1997). Western Miwok (such as that spoken by the Coast Miwok north of Golden Gate) is the closest related language. According to early linguists, there were eight branches of the Costanoan language, each associated with a geographic location and the tribelet(s) that inhabited the locality. Four of these—the Ramaytush, Chochenyo, Tamyen, and Karkin—fall within the project study area. Whether these were distinct languages (Levy 1978a) or dialects (Milliken 1995:26) is uncertain, but Golla (2011) suggests that they were most likely dialects.

The territory of the Ohlone covered around 17,350 square kilometers (6,700 square miles), extending 177 kilometers (110 miles) along the Pacific Coast from south of Monterey Bay all the way up the San Francisco Peninsula and inland some 32–72 kilometers (20–45 miles) into the Coast Ranges, running along the east side of San Francisco Bay to the Carquinez Strait. At the time of Spanish contact, the Bay-Delta Area and Coast Range valleys were dotted with Ohlone villages. Kroeber (1925:464) estimates an aboriginal population of 7,000, while Cook (1943) suggests it may have been as high 10,000. Based on mission records, Milliken (2010), in contrast, estimates that the Ohlone population was much larger, around 16,000, with an average population density of 2.4 per mile (Table 4; Figure 13).

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GROUP	TOTAL GROUP AREA (SQUARE MILES)	TOTAL GROUP POPULATION	POPULATION DENSITY (PER SQUARE MILE)	Total Tribelets	Tribelets in Study Area ^a	STUDY AREA POPULATION DENSITY
Ohlone	6,701	16,130	2.4	59	20	4.3
Coast Miwok	996	7,387	7.4	15	7	8.9
Bay Miwok	507	1,764	3.5	6	6	3.5
Plains Miwok	1,693	10,282	6.1	16	1	6.0
Patwin	3,223	13,955	4.3	25	1	6.4

Note: ^a Includes only those with at least 50% within the study area.

For the Ohlone as a whole, the basic unit of political organization was a territory-holding group of one or more associated villages and smaller temporary encampments. Often referred to as a tribe or tribelet (Kroeber 1962), these groups were generally considered independent, multi-family, landholding groups. Each regional community was a largely autonomous polity numbering typically between 150 and 400 people falling under the jurisdiction of a headman and council of elders who served as advisors to the villagers (Levy 1978a:487). Permanent villages were established near the coast, the bay, and along river drainages, while temporary camps were located in prime resource-processing areas. Some tribes occupied a central village, while others had several villages within a few miles of each other. Milliken (2010) has identified 59 Ohlone tribelets, of which 20 have more than half their territory within the project study area (Figure 14). Notably, the tribelets within the study area, especially along the eastern and southern margins of the bay, had a considerably larger population density (4.3 per square mile for the study area) than the Ohlone as a whole.

Tribelet organization included a chief, which could be a man or women, although the office was generally inherited via patrilineal descent (Levy 1978a:487). The chief represented a tribal council of elders, and took a leadership role in such important tasks as hosting visitors and leading food procurement expeditions. War leaders and shaman also played key roles in each community. The Ohlone had clans and moieties, and households appear to have been large, with 10–15 individuals per family. Patrilineal extended households were common (Harrington 1942:12), sororal polygymous households (where wives are sisters) were also present (Palóu 1926:404–405), and patrilocal lineages played an important role in group interaction.



Figure 13. Study Area Showing Population Density Estimates by Territorial Tribelet Community (after Milliken 2010).



Figure 14. San Francisco Bay-Delta Study Area showing Ethnographic Groups and Regions, and Spanish Missions (after Milliken 2010).

The most common type of housing consisted of hemispherical huts thatched with grasses and rushes (Kroeber 1925:219). Although village organization is poorly documented, other types of village structures included sweathouses, dance enclosures or plazas, and assembly houses. A variety of stone tools were used, including knives, arrow and spear points, handstones and millingslabs, mortars and pestles, net sinkers, anchors, and pipes. Chert was obtained from local quarries, and obsidian was acquired in trade. Many perishable items were made from tule (e.g., canoes, mats, and baskets), plant fibers (e.g., cordage, nets, and baskets), and animal skins (e.g., sea otter, rabbit, and duck skin blankets). Pottery was not made. Mortars, both bedrock and portable, were important components of acorn-processing technology. Tule balsas were used for transportation, fishing, and duck hunting. Shell beads were gaming and trading commodities as well as ornamental items. Trade relations with neighboring villages and groups were well-established. According to Davis (1961:23), bows, arrows, basketry materials, paints, and feather blankets were procured from the east, while the Ohlone traded mussels, dried abalone, salt, and abalone shells to the neighboring Yokut groups and provided the Sierra Miwok with *Olivella* and abalone shell beads.

Prior to European contact, the Ohlone and other Native people of the Bay-Delta Area were hunters, gatherers, and fisherfolk. Subsistence activities centered around the seasonal availability of gathered resources, such as acorns, nuts, seeds, greens and bulbs; hunting deer, pronghorn, tule elk, smaller animals, sea mammals, and waterfowl; fishing; and collecting shellfish (clams, oysters, mussels, and abalone). Notably, the Ohlone territory included the open coast, the littoral zone of the bay, and a variety of inland settings, each with a varied range of resources available within the territorial extent of a tribelet. Although they did not cultivate crops, the Ohlone practiced burning on an annual basis to ensure an abundance of seed-bearing annuals and forage for large game, and to facilitate gathering fall-ripening acorns (Crespí 1927; Levy 1978a:491). Their only domesticate was the dog (Harrington 1942), which presumably served as a companion and camp protector, and may have played an important dietary role (a "walking larder") when times were bad (Byrd et al. 2013; Levy 1978a:491).

Coast Miwok

The northwestern portion of the study area falls within aboriginal territory of the Coast Miwok (Barrett 1908; Collier and Thalman 1996; Goerke 2007; Kelly 1978; Kroeber 1925:272–278; Milliken 2009). Centered in Marin County, the Coast Miwok spoke one of the California Penutian languages, most closely related linguistically to the nearby Lake Miwok; together they are often referred to as the Western Miwok languages (Golla 2011). Coast Miwok territory at historical contact extended from the northern edge of the bay to near Duncans Point, and from the coast to beyond Sonoma River. This area, covering around 2,600 square kilometers (1,000 square miles), included both open coast and bay littoral settings (see Table 4).

Their settlement system consisted of a primary village located along a principal stream, with satellite communities or special-use sites, usually seasonally occupied, in the surrounding countryside. The study area covers about half of the 15 Coast Miwok tribelet territories present at contact (Kelly 1978:415; Milliken 2010). Overall population estimates at contact vary greatly. Kroeber (1925:275) estimates 1,500, Cook (1943:181–183) suggest a slightly higher figure of 2,000, while Milliken (2009, 2010) argues for a population of approximately 7,400 individuals. Comparatively, the Coast Miwok had very high population densities, particularly along the bay margins, and Milliken (2010), based on Mission records, estimates there was a mean of 7.4 individuals per square mile, with tribelets along the bay margin encompassed by the study area having a higher density of 8.9 per square mile (see Figure 13).

Although relatively little is known of Coast Miwok social organization, moieties and secret societies existed, and tribelet leaders were non-hereditary (Kelly 1978:418). These chiefs were men or women who played key roles in leading subsistence procurement events, ceremonies, and dances. The basic social unit appears to have been the patrilineal extended family (Slaymaker 1982:19). Social ranking may have existed, and clam shell disk beads appeared to have played an important role as a medium of exchange.

Coast Miwok domestic structures were conical in shape with a central hearth, built of perishable wood, grass, rushes, and tule around a frame fashioned of two forked poles. It is uncertain whether they were built above or below ground (Kelly 1978:417; Kroeber 1925:276 quoting Drake), although Meighan (1953) reports on archaeological evidence of semi-subterranean bark houses at MRN-115. The buildings were the residences of nuclear families and typically contained approximately six to 10 inhabitants (Cook and Heizer 1968:91). At larger settlements, two special-function buildings – a sweathouse and ceremonial building—were often present. The sweathouse was "circular, dug four or five feet into the ground" (Kelly 1978:417). Superstructure construction included a central post and a series of smaller posts set around the basal margins of the pit. Primary roofing beams were set on the forked tops of the perimeter posts and the central post. These beams, flush with the exterior surface, were then covered sequentially with secondary sticks, brush, grass, and earth. "The entrance was gallery-like, with a drop" (Kelly 1978:417). Sweathouses were considered the domain of men. Ceremonial buildings, often referred to as dance houses, were larger (around 4.5 meters [14.8 feet] in diameter) and shallower (0.6 meters [2.0 feet]) than sweathouses but similar in construction style. Their use was restricted to members of secret societies; male and female gathering took place in the main building, while female-only meetings took place in an adjacent, smaller structure that lacked an earth covering.

Bay Miwok and Plains Miwok

The Bay and Plains Miwok have often been discussed together since their territories abut each other and they are the most closely related languages within the Eastern Miwok language group (which also includes the adjacent Sierran Miwok languages; Barrett 1908; Bennyhoff 1977; Golla 2011; Kroeber 1925:442–463; Levy 1978b; Powers 1877). At contact, the Bay Miwok occupied a territory of some 500 square miles in the upper reaches of the San Francisco Bay-Delta, mainly situated south of the Sacramento River, including Mount Diablo. As such, the Bay Miwok tribal area is entirely within the current study area. Milliken (2010) distinguishes six Bay Miwok tribelets, and estimates a total population of around 1,750 at contact for a population density of 3.5 per square mile (see Table 4). The adjacent Plains Miwok occupied a much larger area—circa 4,400 square kilometers (1,700 square miles)—extending to the northeast along the Sacramento River and from north of the Cosumnes River to south of the Mokelumne River. Milliken (2010) distinguishes 16 Plains Miwok tribelets, for a total contact period population of 10,000 and population density of 6.1 per square mile. Only the southwestern-most of the 16 Plains Miwok tribelets falls within the study area.

Social organization of the Eastern Miwok groups included moieties, as well as lineages defined by patrilineal descent. Bay and Plains Miwok tribelets were comprised of one or more villages. Strong territoriality existed, and violations of group territories were the primary source of conflict between neighboring groups. Unlike groups to the west, the Bay and Plains Miwok homeland was concentrated along the Sacramento River delta, adjacent plains, and major tributary rivers. As such, it encompassed a wide range of micro-environments, including delta wetlands and marshes, lakes and sloughs, riparian forest, prairie grassland, and oak woodland/savanna.

The Miwok constructed conical residential structures that were either semi-subterranean or above ground. Residential dwellings contained a central fire pit along with an earth oven. Houses were typically a thatch of brush, grass, or tule laid over a framework of poles that was sometimes covered with earth. Major villages typically included assembly or dance houses, sweat-houses, ceremonial structures (circular or rectangular), grinding booths, and acorn granaries. The superstructure of large semisubterranean dance houses typically had a roof of substantial, heavy beams supported with four center posts and eight side posts. These structures were covered with earth and thatch, had a single entrance, and contained a central fire pit.

Patwin

Patwin is a distinct Penutian language within the Wintuan language family, which also includes the Nomlaki and Wintu farther to the north (Golla 2011:140). Only a small portion along the northeast edge of the study area was occupied by the Patwin at Spanish contact (Bennyhoff 1977; Johnson 1978; Kroeber 1925, 1932; Maloney 1943, 1944; McKern 1922, 1923; Powers 1877). Overall, the Patwin occupied an area some 145 kilometers (90 miles) north-south by 65 kilometers (40 miles) east-west (totaling more than 8,280 square kilometers [3,200 square miles]), north of Suisun Bay along the west side of Sacramento Valley (see Table 4).

Total Patwin population at European contact has been variously estimated to be between 3,500 (Cook 1955) and 13,600 (Milliken 2010). Similar to nearby Native population groups, the tribelet was the primary organization structure of the Patwin, of which 25 have been distinguished. Based on Milliken's (2010) research, only the southern-most Patwin tribelet (Suisun/Malaca) fall within the project study area. Tribelets included a main village and smaller affiliated villages, each led by a hereditary chief, defined by patrilineal descent, who was responsible for organizing community-wide economic and ceremonial activities (McKern 1922:244).

The Patwin lived in large communities along the Sacramento River and major tributaries of the Coast Ranges. These permanent winter villages typically had a centrally located chief's house, and other residential structures distributed in no formal patterning (McKern 1923). Large villages also included three non-residential structures. A dance house and sweat house were situated at the northern or the southern edge of each village, while a menstrual hut was generally situated at the opposite end of the village.

McKern (1922), in discussing Patwin social organization, stressed the importance of the extended patrilineal family, the family social group, and the household. The latter co-residence group included a couple, their unmarried offspring, married daughters with their husbands, and children (McKern 1922:239–240). Residential structures were semi-subterranean, with each household of the extended family occupying a certain portion of the dwelling (McKern 1923). At least six meters (20 feet) in diameter, these dwellings had one door facing either east or west. A centrally located fire pit and smoke hole were generally situated between the two main support beams of the structure. In general, subsistence was more riverine and terrestrial-oriented than was the case for groups centered around the bay or that had access to the coast where heavy exploitation of littoral and marine resources took place.

HISTORIC-ERA CONTEXT OF NATIVE AMERICAN OCCUPATION

For the study area, the historic-era is generally considered to have formally begun in June AD 1776 (hereafter, AD is omitted), when the Juan Bautista de Anza expedition traveled into the area of modern San Francisco in the search for a suitable location for a Spanish settlement (Milliken 1995; Milliken et al. 2009). This resulted in the late June founding of the San Francisco Presidio along the northern edge of the peninsula and Mission San Francisco de Assisi at Dolores (generally referred to as Mission Dolores) some four kilometers (2.5 miles) to the south, just west of Mission Bay (Beck and Haase 1974).

However, contact between Native groups in the Bay-Delta Area began considerably earlier, initially with contact between the Coast Miwok and sea-going Europeans. This time span has been referred to by some as the protohistoric era, broadly consistent with Late 2 Period in the region. This included landings by Francis Drake in 1579 and Sebastian Rodriquez Cermeño in 1595. These explorers were the first to document the activities of native Californians in the region. Between 1769 and 1776, the pace of Spanish explorations of San Francisco Bay-Delta Area increased in intensity, with an expedition almost every year, often staged from Monterrey where the Presidio and Mission San Carlos Borromeo were founded in 1770 (Milliken 1995:31–59). These expeditions began with José de Ortega's discovery of the entrance to the Golden Gate (under command of Gaspar de Portolá) in 1769, and also include Juan Manuel de Ayala's pioneering passage into the Bay in 1775. Accounts of these early explorers provide

vivid insight into a vibrant and rich set of indigenous adaptations that characterized the study area (e.g., Anza 1776; Crespi 1769; Fages 1770; Palou 1774).

Spanish political and military control of the central California coastal region began with the founding of the missions in Monterey in 1770 and San Francisco in 1776. Although both missions were in Ohlone homelands, they recruited widely from Ohlone, Coast Miwok, Bay Miwok, Wappo, and other communities. Their establishment resulted in immediate and well-documented negative impacts to lives and traditional lifeways. Then in 1777, Mission Santa Clara and the San Jose Pueblo were founded at the south end of the bay. Subsequently, a series of additional missions was founded both between these three missions and also farther to the north. Initially, Mission Santa Cruz was established in 1791 less than 30 kilometers (20 miles) south of the study area. Then in 1797, Mission San Jose was founded to the north of Mission Santa Clara, and Mission San Juan Bautista was established northeast of Monterey (outside the study area). All of these missions were situated within the traditional lands of the Ohlone. Finally, two missions were established in Coast Miwok territory—Mission San Rafael near the northwest margin of the bay in 1817, followed in 1823 by Mission Solano farther to the northeast, along the Solano River (just outside the study area). Overall, four of these Spanish missions are within the study area (see Figure 14).

Spanish colonial policy throughout the late 1700s and early 1800s was directed toward establishing outposts in all lands claimed by Spain. Similar to other Spanish settlements in Alta California, colonial San Francisco (known as Yerba Buena, from the plant native to the original pueblo) was organized around three frontier institutions: the fortified military garrison or presidio; the mission, the religious component founded by Franciscan padres; and the pueblo, the civilian village. With the founding of the missions, Euro-Asian domesticated plants were introduced to California as gardens, orchards, and grain fields were planted (some invasive Euro-Asian weeds may also have preceded establishment of the missions). Euro-Asian domesticated animals were also introduced in large numbers. The Native inhabitants were then enlisted as laborers.

As such, Spanish occupation of Alta California was the driving force behind tribal disintegration, with Native people leaving their villages for the missions where padres then sought to control their daily lifestyles, work, diet, and religious expression. The Native groups in the region suffered numerous hardships during the Spanish colonization of the Bay-Delta Area. Missionization—enlisting Native Americans, often by force, to work for the Spanish (initially constructing Mission Dolores and the Presidio)—heavily impacted traditional subsistence practices, suppressed Native religious practices, and, for those individuals who chose to enter and remain living at the missions, instated a way of life defined by forced manual labor, confined living, severe punishments, circulation of deadly diseases, and other hardships . For example, Milliken (1995:90) estimates that death rates at Mission Dolores between 1780 and 1784 were more than double pre-contact death rates. However, the most devastating event was undoubtedly the measles epidemic of 1806, when almost 25% of the Native population died. The epidemic spread from east to west, and reached Mission Dolores on April 24, 1806 (Milliken 1995:194).

Milliken et al. (2009) documents in considerable detail regional trends in recruitment of specific Native groups into the missions. Initially, Ohlone populations on the San Francisco peninsula were the focus of Spanish recruitment and resettlement efforts at Mission Dolores, while South Bay Ohlone were recruited to Mission Santa Clara. Starting in 1794, effort then shifted to bringing East Bay Ohlone and Bay Miwok into Missions Dolores and Santa Clara. By 1810, no new Ohlone recruits are documented in mission documents, and most had left their villages and were living on mission lands (Milliken 1995, 2006, 2010). In contrast, Coast Miwok and Patwin recruitment into the mission system took place later in time, mainly in the early 1800s (Milliken et al. 2009:Table 5). There is the strong likelihood that not everyone went into the missions, that refugee settlements may have existed, and that other tribal members worked at the pueblos and avoided conversions (e.g., Panich and Schneider 2015; Schneider 2015a, 2015b). Overall, complex strategies (both inside and outside the mission world) designed to

maintain identity and individual agency, while attempting to accommodate the dominant society, emerged during this time and are potential contributors to colonial-period archaeological deposits.

The Spanish Period in this area lasted until 1821, when the Mexican government gained control over Alta California (Beck and Haase 1974). During the 1820s, the mission system in general began to decline, and some Native Americans left the missions. Land formerly held by Spain was divided into vast tracts—referred to as ranchos—owned by wealthy and powerful individuals. Several missions, however, continued to thrive, such as Santa Clara and San Jose, as they were exporting wheat and other products to the Russians at Fort Ross, and thousands of Indians still lived at the missions in the adobe apartments made for the married couples. Secularization grew with the creation of these land grants, the rise of a ranching class, and the growth of pueblo populations. By the mid-1830s, both the Mission and Presidio had been virtually abandoned (Hittell 1878:77; Kyle 1990:330–333; Lotchin 1974:7). Ranchos, granted by the Mexican government, were used primarily for farming and raising cattle. Many native people who had been laboring at the mission gardens and orchards moved to the ranchos, still working as manual laborers and mixing with other tribes. The region ultimately came under American control after the defeat of the *Californio* (Mexican) forces in 1847, and Yerba Buena was officially renamed San Francisco just prior to the start of the Gold Rush era of 1848–1853.

SUMMARY OF PRIOR ARCHAEOLOGICAL INVESTIGATIONS

Overview of Recorded Sites

As of May 22, 2015, Northwest Information Center records included 1,798 formally recorded cultural resources in the study area as having evidence of Native American occupation (coded as "prehistoric" or "protohistoric"). The frequency and density of sites vary greatly (Table 5). The largest number are present in the Northwest Bay region (one site every 540 acres, representing one-third of the total), while the fewest occur in the North Delta (one site every 3,578 acres, representing fewer than 4% of the total). Given the overall size of the study area, the average density of recorded Native American archaeological sites is one site for every 3.8 square kilometers (1.5 square miles; 949 acres; Table 5; Figure 15). Sites are well clustered, in part reflecting Native American settlement trends, archaeological research orientations, survey coverage, urban development, and nature and extent of cultural resources management (CRM) projects. Notably, many sites are clustered around the Bay Shore in the Northwest region—most were recorded by Nelson's (1909) pioneering survey. Detailed study would be needed to discern the relative impact of each of these factors on site discovery and recordation (and whether they are in surface or buried contexts). With such analyses, the relative density, frequency, and types of sites, and their spatial patterning, can be better understood. The following discussion highlights these general trends.

Region	NUMBER OF SITES	Percent	ONE SITE PER (ACRES)
Northwest Bay	609	33.9	540
North Delta	67	3.7	3,578
East Bay	383	21.3	946
South Delta	191	10.6	1,613
South Bay	311	17.3	940
Southwest Bay	237	13.2	735
Total	1,798	100.0	949

Table 5. Distribution of Recorded Native American Sites in the Study Area.



Figure 15. Study Area showing Recorded Pre-Contact/Contact Period Site Distribution.
Pre-contact and contact period site attributes (based on California Department of Parks and Recreation site form 523) has 16 different "attribute" codes for prehistoric/ethnographic sites ("AP#"; Appendix C; OHP 1995). They essentially identify the primary characteristics of a site, such as lithic scatter, quarry, rockshelter, or presence of burials, hearths, or habitation debris. It is important to acknowledge that the consistency in which these attribute designations are recorded on site forms, as well as their accuracy, vary considerably, in large part because of the use of survey/surface level information. Regardless, this represents the only easily available information to explore how certain attribute types are distributed for all sites in question within the study area. In doing so, we focus on eight that have the most analytical potential (Table 6). We do not consider attributes that occur in low frequency, have low analytical potential, or may be biased by historical site occupation (Ceramic Scatter, Architectural Feature, Stone Feature, Cache, Hearths/Pits, Linear Feature, and Other).

REGION	TOTAL NUMBER OF SITES	HABITATION	PERCENTAGE OF REGION TOTAL	LITHIC SCATTER W/O HABITATION	PERCENTAGE OF REGION TOTAL	BEDROCK MILLING	PERCENTAGE OF REGION TOTAL	BURIALS	PERCENTAGE OF REGION TOTAL	Petroglyph	PERCENTAGE OF REGION TOTAL	PICTOGRAPH	PERCENTAGE OF REGION TOTAL	QUARRY	PERCENTAGE OF REGION TOTAL	ROCKSHELTER/CAVE	PERCENTAGE OF REGION TOTAL
Northwest Bay	609	411	67	64	11	69	11	88	14	72	12	-	-	13	2	2	0.3
North Delta	67	31	46	18	27	17	25	12	18	2	3	-	-	-	-	-	-
South Delta	191	75	39	28	15	53	28	57	30	11	6	1	0.5	3	2	4	2
East Bay	383	184	48	41	11	67	17	93	24	23	6	2	0.5	4	1	3	0.8
South Bay	311	156	50	66	21	34	11	96	31	9	3	-	-	6	2	2	0.6
Southwest Bay	237	166	70	12	5	2	1	35	15	-	-	-	-	-	-	-	-
Total	1,798	1,023	57	229	13	242	13	381	21	117	7	3	0.2	26	1	11	0.6

Table 6. Select Recorded Site Types and Attributes in the Study Area.

Note: Percentage rounded to nearest integer except when less than one.

Table 6 presents the distributions and relative frequency of key site attribute codes by region within the study area. Overall, they vary greatly in frequency and spatial distribution (Figure 16; Table 6). These patterns have a variety of implications for the long-term trajectory of spatial trends in land use. Of course, it should be kept in mind that a variety of factors influence these patterns independent of ancient land use, including where early archaeological recording took place, the impact of early urbanization, and spatial patterning in development after the advent of cultural resources laws. Sites with habitation debris are by far the most common, representing more than half of the recorded sites. They are also, in relative terms, highly varied within the study area – most common in the Southwest Bay (70% of all sites) and least common in the South Delta (39% of all sites). Moreover, they are more spatially clustered along the Bay, major drainages, and margins of the more rugged topography compared to other sites. Sites with burials are the next most common, comprising 21% of the total. In relative terms, these sites are primarily concentrated in the South Bay and South Delta (31% and 30%, respectively, of total sites) and least common in the Southwest Bay and Northwest Bay (15% and 14%).

Sites with lithic scatters (lacking habitation debris), bedrock milling features, and petroglyphs are much less frequent, occurring at frequencies of 13% to 7% of the total number of sites (Table 6). Relatively speaking, sites with lithic scatters but lacking recorded habitation debris are most common in the North Delta (27%) and the South Bay (21%); they are least frequent in the Southwest Bay (5%). Moreover, they are highly clustered across the study area. Sites with bedrock milling features are most common in the North Delta (25%) and South Delta (28%), while they are least common in the Southwest Bay (only 1%).

Strong spatial pattering and clustering is also evident (Figure 16). Although sites with petroglyphs are infrequent, they are most common in the Northwest Bay (12%), absent in the Southwest Bay, and exhibit both multi-site clustering and wide individual site spacing (Figure 16). The remaining three site types occur in very low frequencies (1% or less). The few quarries are concentrated in the Northwest Bay, along with some in the South Bay, East Bay, and South Delta (Figure 16); even fewer rockshelters/caves, fall within the same four regions (these four regions are also the ones with the largest number of sites); and pictographs are very rare, noted only in the East Bay and South Delta.

Examination of co-variation in attributes with respect to sites with habitation debris (the most common site attribute) further reveals some interesting trends (Table 7). First, and not surprisingly, is that burials are consistently associated with habitation sites (78%). This pattern holds generally consistent across the study area, with the exception of the South Bay where only 58% of habitation sites included burials. Bedrock milling features are much less commonly associated with habitation sites (40%). However, the relative frequency varies markedly between regions—74% in the Northwest Bay and only 19% and 25% in the South Delta and East Bay, respectively. Petroglyphs are not commonly associated with habitation sites (12%). There is also variation between regions—in the South Delta, 18% of the sites with petroglyphs also have habitation debris, while in the North Delta none do.

REGION	TOTAL SITES WITH BURIALS RECORDED	BURIALS AT HABITATION SITES	% OF BURIAL TOTAL	Total Sites with Bedrock Milling Recorded	BEDROCK MILLING AT HABITATION SITES	% of Bedrock Milling total	Total Sites with Petroglyphs Recorded	PETROGLYPH AT HABITATION SITES	% OF Petroglyphs Recorded
Northwest I	Bay 88	83	94	69	51	74	72	9	13
North Delta	12	11	92	17	8	47	2	-	-
South Delta	57	45	79	53	10	19	11	2	18
East Bay	93	73	78	67	17	25	23	2	9
South Bay	96	56	58	34	11	32	9	1	11
Southwest H	Bay 35	31	89	2	1	50	-	-	-
Total	381	299	78	242	98	40	117	14	12

Table 7. Select Site Attributes Associated with Recorded Habitation Sites by Region.

Substantive Archaeological Investigations

The first extensive study of Native American occupation of the Bay-Delta Area consisted of an archaeological survey of shell mounds and middens by N. C. Nelson (1909). He recorded more than 425 sites along the margins of San Francisco Bay. A series of bay shore shell mounds was also excavated during the early twentieth century, documenting site depths and composition (e.g., Gifford 1916; Nelson 1910a, 1910b, 1910c, 1910d, 1911a, 1911b; Schenck 1926; Uhle 1907). The data generated formed the basis of subsequent cultural typologies and sequences for the region based on changes in artifacts, mortuary practices, and shellfish remains. This early interest in site formation and structure was subsequently replaced by more concerted efforts at chronology building within a cultural-historical framework (Beardsley 1948, 1954; Lillard et al. 1939). CRM-driven excavation projects dominated in the San Francisco Bay-Delta Area starting in the late 1960s (Milliken et al. 2007). Initially, many of these projects were effectively salvage efforts, with extensive data recovery occurring just prior to large-scale construction projects. As a result of limited funding for analysis, reports were often limited in scale and depth. Over time, project expectations, methods, and reporting have greatly improved.

The following summary of archaeological investigations at Bay-Delta Area Native American settlements is based on the results of archaeological excavations obtained from available reports at the



Figure 16. Study Area showing Distribution of Select Native American Site Attributes from Site Records.

Northwest Information Center and elsewhere. Effort was placed on identifying sites that have yielded important insights into Native American occupation of the study area—they are referred to here as *substantive archaeological sites*. These include all known sites with radiocarbon dates, and sites with reports that have produced readily available, quantifiable data. Besides radiocarbon assays, these data include obsidian sourcing and hydration, burials, vertebrate fauna, shellfish, and paleoethnobotanical remains (artifact assemblage data, although very important, was not considered owing to a dearth of readily available summary tables). These data sets are considered key as they allow rigorous analysis and ready comparisons with results from other sites in the general region. Also included were some sites from early excavations with substantial results that lack quantifiable data and have not been subjected to subsequent reanalysis; however, such efforts at these and other sites excavated many years ago, but minimally reported, would be a valuable direction for investigations. It is also important to keep in mind that this is not an exhaustive list of all excavated sites as numerous other sites have been subjected to smaller-scale excavations. It has, however, formed the basis of much of the research issue discussions in subsequent chapters.

A total of 299 sites was identified as having substantive excavations that yielded important insights into the Native American archaeological record of the study area (Appendix D). They are widely distributed, with more than half falling within the Northwest Bay and the South Bay regions, with few in the North Delta (Figure 17; Table 8). When the percentage of substantial sites is compared to region size, they are notably better represented in the South Bay and Southwest Bay, and to a lesser extent in the Northwest Bay, and much more infrequent in the North Delta, and to a lesser extent in the South Delta and East Bay (Table 8). Finally, substantive sites represent between 12% (Northwest Bay) and 26% (South Bay) of all recorded sites in each region (see Figures 15 and 16; Table 8).

Region	NUMBER OF SITES	PERCENT OF SITES	Region's Percentage of Total Landmass	PERCENTAGE OF REGION'S RECORDED NATIVE AMERICAN SITES
Northwest Bay	74	25	19	12
Southwest Bay	53	18	10	22
South Bay	80	27	17	26
East Bay	48	16	21	13
South Delta	34	11	18	18
North Delta	10	3	14	15
Total	299	100	100	17

Table 8. Distribution of Sites with Substantial Archaeological Investigations in the Bay-Delta Area by Region.

Table 9 summarizes the distribution of key data sets at substantive sites (see also Appendix D). Note that a variety of factors contribute to the spatial distribution of these data sets. Overall, 71% are radiocarbon dated, and between 45 and 51% have obsidian sourcing, obsidian hydration, burial, shellfish, and non-fish faunal data; sites with fish (35%) and carbonized plant remains (26%) data are much less common. The spatial distribution of these data sets is depicted in Figure 18. In general, the two regions with the smallest absolute number of sites—North Delta and South Delta—tend to have the higher relative percentage of sites with various substantive data categories; in contrast, the South Bay tends to have a lower percentage of sites with various substantive data categories. The Northwest Bay is noteworthy, with a much lower percentage of radiocarbon-dated sites than other regions.

Sites with Scheme D temporal components are identified solely on the presence of one mean radiocarbon intercept within a temporal component (Table 10). Additional radiocarbon dates from the same site are not included to reduce the impact of projects where numerous radiocarbon dates were acquired, nor



Figure 17. Distribution of Substantive Excavations at Native American Sites in the Study Area.



Figure 18. Distribution of Key Data Sets from Substantive Excavated Archaeological Sites in the Study Area.

Data Set	Northwest Bay	North Delta	South Delta	East Bay	South Bay	Southwest Bay	Total	% OF ALL Substantive Sites
Radiocarbon-dated	30	9	27	41	66	39	212	71
Obsidian Sourcing	34	6	24	29	33	22	148	49
Obsidian Hydration	40	5	22	26	35	25	153	51
Burials	35	8	19	29	43	17	151	51
Birds, Mammals, Reptil	es 34	6	13	28	30	29	140	47
Fish	27	5	12	16	19	25	104	35
Shellfish	33	2	16	19	29	37	136	45
Plants	16	7	18	16	11	9	77	26
Total Sites (n)	74	10	34	48	80	53	299	-
Total Sites (%)	25	3	11	16	27	18	100	-

Table 9. Distribution of Key Data Sets from Substantive Archaeological Sites by Bay-Delta Area Region.

Table 10. Distribution of Scheme D Temporal Components by Region Based on Calibrated Median Radiocarbon Intercepts from Study Area Sites.

Time Period (Scheme D)	Northwest Bay	North Delta	South Delta	East Bay	South Bay	Southwest Bay	Total
Pre-Late Holocene (9000–4050 cal BP)	3	3	8	5	17	5	41
Early 1 (4050–3550 cal BP)	3	3	3	5	4	3	21
Early 2 (3550–3050 cal BP)	3	2	5	6	12	1	29
Early 3 (3050–2550 cal BP)	3	2	6	12	13	2	38
Early/Middle Transition (2550–2150 cal BI	P) 5	2	1	11	12	7	38
Middle 1 (2150–1530 cal BP)	10	3	10	18	23	13	77
Middle 2 (1530–1365 cal BP)	2	1	2	10	13	8	36
Middle 3 (1365–1200 cal BP)	5	3	4	8	16	8	44
Middle 4 (1200–930 cal BP)	6	1	5	14	16	10	52
Middle/Late Transition (930-685 cal BP)	6	1	7	14	16	10	54
Late 1 (685–430 cal BP)	9	3	8	16	20	15	71
Late 2 (430–180 cal BP)	11	2	11	11	15	5	55
Mission (180–115 cal BP)	4	-	5	-	3	4	16
Total (N)	70	26	75	130	180	91	572
Total (%)	12	5	13	23	31	16	100

are other temporal indicators, such a diagnostic artifacts or obsidian hydration, considered in this tabulation. The total number of dates (n=1,586) by component at each site, however, is presented in Appendix E.

There are 573 identified temporal components, including one dating to the post-Mission Historic era which is not depicted in Table 10. Not surprisingly, the spatial distribution of components across the region reflects the frequency of dated substantive sites by region (see Table 8)—highest in the South Bay and East Bay, and lowest in the North Delta. Large portions of every region lack sites dated to particular temporal components, but an overall trend includes a relatively well-represented suite of pre-Late Holocene components. This, however, is almost entirely comprised of Middle Holocene dates, with only four Early Holocene components, including two in the South Delta (CCO-696 and CCO-697) and two in the South Bay (SCL-038 and P-01-011556). In addition, the Middle 1 and Late 1 Periods are particularly well-represented in the study area as a whole, while Mission Period components are infrequent. The uptick in components in the Middle 1 Period is in all regions except the North Delta and Southwest Bay. Finally Mission Period components are absent in the North Delta and the East Bay.

Northwest Bay Region

Seventy-four sites with substantive data were identified in the Northwest Bay region. Most are distributed along the west side of the Bay and on several islands, with a few in the foothills on the north side of the bay and along the Pacific Coast (Figure 20). Early excavations and analyses of assemblages at several substantial Bay shore mounds (Sausalito mound, MRN-3; San Rafael Foster mound, MRN-315; and the Greenbrae mound, MRN-76; Gifford 1916; Kroeber 1925:920–930; Nelson 1910b, 1910c, 1911b) provided important data for Beardsley's (1948, 1954:63–127) initial synthesis of central California cultural sequences.

Excavations at De Silva Island (MRN-17) revealed a substantial Middle Holocene occupation—a time frame infrequently identified along the Bay margin—along with a thick, overlying midden dating primarily to the Early Period (Pahl 2003). A substantial mound (MRN-67) that dates primarily to the Early Period, has also been recently excavated, with a very large quantity of burials recovered (Schwitalla and Powell 2014).

Substantial Middle Period deposits have been documented at a variety of sites, including largescale excavations at the MRN-244 and MRN-255/H mounds; the latter also includes an important Early/Middle Transition Period occupation (Bieling 1999, 2000). Notable and substantial Middle Period deposits are also documented at MRN-44 on Angel Island (DeGeorgey 2007) and at the Belvidere Island mound, MRN-39 (Chattan et al. 2005). A particularly influential study was by King (1970, 1974) at MRN-27, a small shell midden on the Tiburon Peninsula, exploring social status through analysis of mortuary data. A detailed argument asserted the presence of a ranked society and elites at this Middle Period settlement, with commoners residing at the adjacent and larger site of MRN-26. This study impacted perspectives on the nature of social complexity throughout coastal California (e.g., Gamble et al. 2001; Gardner 2013; King 1990).

Late Period sites are also very well represented in this region. A considerable number of large, single-component Late Period villages (often with features, structures, and burials) have been documented through large-scale excavations, including work at MRN-138 (Slaymaker 1972), Olompali/MRN-192 (Hansen 1970), MRN-374 (Novato Senior High Archaeology Club 1967), and San Jose Village/MRN-171 (Jackson 1974a). The varied nature of Native American-European interaction from AD 1595 onward has been the subject of investigations as well (Lightfoot et al. 2006; Russell 2011). For example, Schneider (2009, 2015; Janzen and Schneider 2009) renewed archaeological investigations at MRN-115 and nearby sites MRN-114 and MRN-328, aiming to identify Native American refugia occupation during the historic era. Although only Late Period occupation was documented, this research served to highlight the challenges and research potential of documenting how Native Americans responded to the massive changes imposed upon them by Spanish during the early part of the historic era.

More limited work has been done in the eastern portion of the region. This includes older excavations at NAP-15/H and NAP-16, which provide some insight into a long occupation span that extends up to, if not into, the historic era (Heizer 1953; Stradford and Schwaderer 1982). In addition, recent work at NAP-189/H has documented a large site with a long occupation sequence, with discrete components, features, and burials (Basgall et al. 2015). It is also useful to note that several major sites have been excavated near the City of Napa, just outside the study area (see Martin and Meyer 2005 for a summary).

North Delta

The North Delta region has the fewest sites with substantial excavations (n=10), and these are highly clustered—all but one occur in the northwest portion of this region (Figure 21). Elsewhere in the North Delta, no substantive excavations have been carried out—this includes all the Delta islands. As a result, we know the least about this portion of the study area.



Figure 19. Spatial Distribution of Radiocarbon Dated Sites in the Study Area (Map 1 of 2).



Figure 19. Spatial Distribution of Radiocarbon Dated Sites in the Study Area (Map 2 of 2).



Figure 20. Distribution of Substantive Excavations at Pre-Contact and Contact Period Sites in the Northwest Bay Region.



Figure 21. Distribution of Substantive Excavations at Native American Sites in the North and South Delta Regions.

Most of the sites are situated in Green Valley near Fairfield, where excavations have produced a long sequence of occupation spanning much of the Late Holocene—from the Early Period through Late 2 Period. These excavations have produced a considerable amount of data, such as at the unique storage/leaching pits with uncarbonized acorns at the Early Period site SOL-391 (Psota 1997; Psota and Clark 1994), the large, mainly Early/Middle Transition Period habitation site of SOL-364 with a substantial number of burials (Coleman et al. 2014), and an intact house floor at Late Period-dominated site SOL-356 (Wiberg 1996). In addition, SOL-236, situated near the Carquinez Strait, was excavated by Loud (1912) and used by Beardsley (1954:96) in his regional cultural sequence synthesis. More recently, Hildebrandt et al. (2012) discovered a buried Early Period site (Hale site, P-48-000898) along Interstate 80 during Extended Phase I excavations.

It is worth noting that a number of substantial projects have been carried out just outside the study area. Treganza and Cook (1948) reported on large-scale excavations at the Middle 3–Late 2 Period mound SOL-2 (and discuss nearby mounds) near Lindsay Sough just north of the study area (see also Coleman 2012), while Cook and Elsasser (1956) discuss Delta mounds—mostly Late Period—on islands just outside the east end of the North Delta region. A buried Early Holocene site (Laguna Creek site P-48-000897) was documented by Hildebrandt et al. (2012) along the Interstate 80 corridor just north of the study area. Recent data recovery excavations at SOL-61 (along Suisun Creek) also provide key insights into Middle and Late Period occupation, including a well-preserved structure (Whitaker and Stevens 2012).

South Delta

The South Delta region has witnessed a modest number of substantial excavations (n=34); considerably less than anticipated given its size. They are concentrated in three main areas—near Los Vaqueros Reservoir along Kellogg Creek in the southeast portion, on the Delta Islands on the east end, and near Walnut Creek on the west (see Figure 21).

The large cluster of sites near Los Vaqueros Reservoir has a well-documented sequence of occupation, with robust data sets from the Early Holocene into the Late Period (including a large Middle Period burial assemblage at CCO-696), well-summarized by Meyer and Rosenthal (1997). Wohlgemuth and Scher (2015), in a recent study of nearby CCO-755, update this synthesis, while Zimmer (2013) touches on more recent fieldwork.

A series of excavations at nearby CCO-18/H (also referred to as CCO-18/548), along Marsh Creek, undoubtedly represents the most significant recent contribution to South Delta archaeology. Large data recovery investigations on the north side of the creek documented a rich, multi-component Early Period midden (dating mainly between 4300 and 3100 cal BP), included 40 features and 480 burials (Wiberg 2010). Detailed studies of mortuary practices and burials (including DNA and isotopes) are providing unique insights into the foundations of the region's intensive Late Holocene occupation (e.g., Eerkens et al. 2013a; Griffin 2014; Jorgenson et al. 2009). Rosenthal (2010) synthesized a suite of other investigations at the site, highlighting the presence of Middle Holocene occupation along the creek that was in part temporally contemporaneous with the area investigated by Wiberg (2010); they also delve into Middle and Late Period occupation of the House mound area south of the creek.

Within the eastern site cluster, the Hotchkiss site (CCO-138—also referred to as CCO-129/138) is undoubtedly the most significant owing to extensive excavations and research on the Late Period settlement and mortuary practices associated with the more than 650 burials recovered (Atchley 1994). Similarly, work in the Walnut Creek area at CCO-368 revealed strong insight into Early Period occupation including burned house floors, features, and burials (Moratto 1995; Price et al. 1993). Results from nearby CCO-235 have provided important information on Late Period occupation and mortuary practices (Andrushko et al. 2009; Pastron and Bellifemine 2009).

East Bay

In the East Bay region, the 48 sites are highly clustered, often with large intervening areas lacking substantive archaeological excavations (Figure 22). A cluster of sites occurs near the bay along Wildcat Creek in North Richmond, on Baxter Creek within Richmond, in the Emeryville/Berkeley area, and along Alameda Creek near the Coyote Hills at the southern edge of the region. They also cluster in two localities within the inland Amador-Livermore Valley.

In the northern portion of the East Bay region, archaeological investigations have focused, from the onset, on a series of prominent mounds (Nelson 1906, 1910a; Schenck 1926; Uhle 1907), while Lightfoot (1997) and Lightfoot and Luby (2002) have provided key summaries of substantial investigations of the major mounds in the northern portion of the East Bay region. Moreover, modern investigations (including isotopic studies) of museum collections from major sites are providing key insights into diet, interaction, and regional relationships (e.g., Beasley et al. 2013; Broughton 1999; Schweikhardt et al. 2011).

Prominent sites along the East Bay margins producing particularly early dates—including the end of the Middle Holocene—include the Ellis Landing site (CCO-295), the Stege mound (CCO-298), the West Berkeley mound (ALA-307), and ALA-17 (Banks and Orlins 1981; Jones and Darcangelo 2007; Wallace and Lathrap 1975). The consistent presence of substantial Middle Period occupation in the East Bay led Lightfoot (Lightfoot 1997; Lightfoot and Luby 2002) to refer to this time interval as the heyday of mound building, social complexity, and ritual activity. For example, the Emeryville shell mound (ALA-309), the largest site in the region, was occupied primarily between 2700 and 650 cal BP—i.e., from the end of the Early Period into Late 1 (Broughton 1999), while the Ellis Landing site (CCO-295) has substantial occupation from 1100 to 250 cal BP—Middle 4 to Late 2 Period (Finstad et al. 2013), and many sites in the Richmond area also had Middle Period occupation (e.g., Banks and Orlins 1979, 1981; Holson et al. 2000). More recent investigations have also documented substantial Late Period occupation horizons, including CCO-297, a Stege mound (DeGeorgey 2013, 2016), CCO-290 on Brooks Island (Finstad et al. 2013), and CCO-750 (Kaijankoski et al. 2012).

A series of excavations in the Coyote Hills near Alameda Creek has taken place at a cluster of four mounds dating from the Early/Middle Transition Period onward (Bickel 1976, 1981; Wilson 1999). The most extensive investigations have been carried out at ALA-328, the Patterson mound (Davis and Treganza 1959; Luby 1992, 2004), and ALA-329, the Ryan mound (Coberly 1973; Leventhal 1993; Wilson 1993). Investigations of the latter, including isotopic work, are providing important insights into site function, mortuary practices, and diet (Bartelink et al. 2012; Leventhal 1993). Finally, substantial occupation has been documented at a series of inland Amador-Livermore Valley sites, and many have well-dated single component occupation events (often buried rapidly by alluviation), typically with substantial middens and burials, allowing for detailed analyses in trends in Late Holocene land use, subsistence trade, and mortuary practices (Byrd and Rosenthal 2016; Rosenthal and Byrd 2006).

South Bay

The South Bay region has the largest number of substantial excavations within the study area (n=80). Although widely distributed, sites are predominantly near the Bay Margin and in the Santa Clara Valley (Figure 23). Investigations in the San Francisquito Creek watershed on the western edge of this region have been broad-based and comprehensive, including a series of excavations in the upper, middle, and lower portions of the drainage. Notably, Bocek (1988, 1991, 1992) conducted a detailed study of the entire drainage catchment, and modeled annual settlement systems along the western side of the Bay. At the terminus of the San Francisquito drainage catchment adjacent to the Bay margin, excavations have been carried out at a cluster of sites immediately northwest of San Francisquito Creek. Only one falls within the South Bay region, the well-known Early Period University Village site (SCL-77), buried by alluvial deposition (Gerow 1968).



Figure 22. Distribution of Substantive Excavations at Native American Sites in the East Bay Region.



Figure 23. Distribution of Substantive Excavations at Native American Sites in the South Bay Region.

More extensive work has been conducted upstream, within the San Francisquito Creek watershed. Most of the sites lie within the oak woodland zone near the Stanford campus, although a few are situated higher in the evergreen uplands (Bocek 1988, 1991, 1992; Holson et al. 1999). The earliest dated occupation in the area occurs at SCL-609 (formerly SCL-33), a deeply buried skeleton dating to almost 6,000 years ago. A post-4,000-year-old Early Period occupation, contemporaneous with the University Village Site (SMA-77), is particularly well-represented at Stanford West (SCL-464) and the Children's Health Council site SCL-613 (Bocek and Rick 1986; Burson 1998; Jones 1997). A series of sites yielded Middle Period dates, while Late Period occupation is best documented in the uplands at the Jasper Ridge site (SMA-204) and also at nearby sites (Bocek 1987, 1988).

In the east-central area, early and extensive excavations took place at the large (150 x 100 x 3 meters), Castro/Ponce mound (SCL-1). The shell midden (dominated by *Cerithedia*) included ash lenses, house floors, and a large sample of burials within what appears to be an Early and Middle Period-dominated occupation (Beardsley 1954:92–94; Loud 1912; Moratto 1984:233). Directly to the east, Loud (1912) recorded a cluster of mounds, including the massive, unexcavated "Big Yñigo mound" SCL-20, measuring 850 x 400 x 1.5 meters (2,790 x 1,300 x 5 feet). Excavations at the nearby smaller Yñigo mound (SCL-12/H) documented two Early Period components with numerous features, burials, and rich cultural and ecofact assemblages (Byrd and Berg 2009), and Middle 2 Period deposits (Samuelson and Self 1995). A series of Early Period features (mainly processing) and burials was also recovered along the northern edge of the mound, and a suite of Middle Holocene burials (including some with N-series [grooved rectangular] *Olivella* beads) were recovered almost a kilometer to the north (Arrigoni et al. 2008). Middle Holocene occupation of the regions is also documented by two isolated burials (SCL-832 and the Sunnyvale Man burial) a few kilometers to the south (Bickel 1978:20; Cartier 2002).

Extensive archaeological investigations have taken place along the major drainages (Los Gatos Creek, Guadalupe River, and Coyote Creek) that feed into the southeastern end of the Bay (Allen et al. 1999; Anastasio 1988; Cartier et al. 1993; Hylkema 2002, 2007:397-420). Most of the sites date to the Middle Period onward. The Middle Period occupation Skyport Plaza site (SCL-478) on the east side of the Guadalupe River is noteworthy for the presence of a considerable number of burials with evidence of violent death, dismemberment, and other traumas indicative of conflict and possible warfare (Wiberg 2002). Recent work at SCL-755 has revealed a Middle 4 Period burial area, and isotopic and DNA analysis provide key baseline data into diet and genetic relationships (Hylkema 2009; Skrownek 1998; Skrownek and Graham 2004). The Tamien Station site (SCL-690) is probably the best-documented Middle/Late Transition site in the area, and it includes a well-defined cemetery (Hylkema 2007). Late Period occupation is also well-represented. For example work at the Yikisma mound (SCL-38) revealed a large, mainly Late Period mortuary assemblage, including a number of possible high-status burials, and recent work is providing insights into diet and other factors through study of isotopes and ancient DNA (aDNA; Bellifemine 1997; Gardner 2013; Leventhal 1998). At the Late Period occupation at SCL-846/H, a substantial burial assemblage was documented, associated with a larger number of "burn pits," one to five meters (16.4 feet) wide at the base (Pesnichak et al. 2004).

Finally, work at Santa Clara Mission (SCL-30/H) and San Jose Mission (ALA-1/H) has documented Mission Period Native American occupation and gained important insight into how indigenous groups adapted to these contexts (Allen 1998; Cuthrell et al. 2016; Hylkema 1995; Hylkema and Allen 2009; Leventhal et al. 2011; Panich 2014, 2015; Panich and Schneider 2015; Thompson et al. 2003).

Southwest Bay

A total of 53 sites with substantive data was identified in the Southwest Bay. Sites are widely distributed throughout the San Francisco Peninsula-bay shore, Golden Gate, Pacific coastline, and

uplands (Figure 24). The most prominent cluster is near Yerba Buena Cove/Mission Bay in the City of San Francisco; in general the north end of the San Francisco Peninsula is particularly well-documented. This area includes early excavations at two mounds—Crocker/Bayshore SFR-7 and the Presidio SFR-6 (Loud 1912; Nelson 1910d); and more recent excavations at another 18 sites of varying size and character (see Byrd et al. 2013 for a detailed review). These sites are often situated within sand dunes, and well-buried by natural sediments as well as by historic-era fill. This area is noteworthy for having two isolated burials (the BART [SFR-28] Transbay skeletons), very deeply buried within bay mud dating to the Middle Holocene (Henn et al. 1972; Meyer 2008; Scher and Meyer 2014). Occupation sites, however, date to the Late Holocene and are dominated by Middle and Late Period occupation—Early Period occupation is currently only documented at SFR-4/H on nearby Yerba Buena Island (Morgan and Dexter 2008). Large numbers of burials have been recovered from three sites—SFR-4/H (mostly Early Period), SFR-7 (probably Middle Period), and SFR-114 (Middle Period; Archeo-Tec 1990). Despite the impact of historic-era and modern development, these sites generally contain well-preserved features, intra-midden stratigraphy, and diverse cultural assemblages. Many also appear to represent relatively short-term and discrete occupation events.

Much less work has been done along the Bay margins and uplands elsewhere on the Peninsula. The San Bruno Mountain mound (SMA-40) is a particularly prominent sites along the Bay margin (Clark 1989), an Early Period-dominated site with dates starting at the end of the Middle Holocene. The presence of Type N grooved rectangular *Olivella* beads are particularly noteworthy as they are indicative of a well-documented and expansive western regional interaction sphere (Byrd and Raab 2007:220–221). In the vicinity of San Mateo Creek, just north of Coyote Point, notable work has been done at sites such as SMA-33, the San Mateo mound (Nelson 1911a), and at SMA-6 (Byrd et al. 2012) within a cluster of 35 shell mounds documented by Hamilton (1936). In addition, a human skeleton (SMA-273) dated to the Middle Holocene was uncovered 3.7 meters (12 feet) beneath the surface of San Francisco Bay during dredging operations off Coyote Point (Leventhal 1987).

Farther south, prominent sites include SMA-125, an important Middle to Late 1 Period site with burials (Galloway 1976; Griffin et al. 2006), and a cluster of three mounds at the southeastern edge of the region. This bay shore cluster (along with the nearby buried site of SCL-77—which falls in the South Bay region) reveals a long sequence of pre-contact occupation (Cartier 1996; Cartier and Carrico 1988; Fitzgerald 2005; Gerow 1968). The sites appear to have been occupied sequentially, starting with the Early Period University Village (SCL-77), followed by Early/Middle Transition Period occupation at the Tarleton site (SMA-248) and SMA-368/H, and then Middle 2 Period occupation at the Hillier mound (SMA-160). Proximity to a previous channel of San Francisquito Creek may in part explain why these precontact sites are concentrated in this area. Finally, a series of sites along the Pacific coast, including a cluster at Half Moon Bay, provides insight into outer coast adaptations from the latter part of the Middle Period onward (e.g., Flint et al. 2004; Hylkema 1998; Moratto 1971).



Figure 24. Distribution of Substantive Excavations at Native American Sites in the Southwest Region.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

4. DISCOVERING SITES: GEOARCHAEOLOGICAL APPROACHES TO SITE SENSITIVITY AND PREDICTIVE MODELING (with Jack Meyer and Philip Kaijankoski)

The ground surface in many parts of the Bay-Delta Area is often heavily urbanized, so there is a low probability of identifying archaeological sites by pedestrian reconnaissance. This is not to say that sites are never found in this way. One of us recently hopped out of a truck to survey a new portion of an APE on a frontage road, so confident that nothing would be found that he left all his gear (except hard hat and vest) in the vehicle. Sure enough, a remnant of a site was identified in the cutbank of a frontage road berm. Sites are routinely found just below the pavement, even in areas with long-term historical use.

Background research should be conducted prior to fieldwork to determine if there are any previously recorded sites, and to identify the potential for buried sites that may require identification measures other than a pedestrian survey. All areas should be surveyed, except when unsafe or too steep, including, for example, plowed fields and graded areas, as they may still contain the potential for undisturbed deposits. It is also important to observe any cutbanks for buried deposits. In some urban areas, planter boxes and gardens may offer a glimpse at the original ground surface. Where no original ground surface is exposed, a geoarchaeological "survey" or remote sensing is necessary. All newly identified resources should be recorded on Department of Parks and Recreation form 523, and any visit to a previously recorded site should be documented with an updated form.

MODELING APPROACH

As discussed in the *Paleoenvironmental* section (page 3-9), the Bay-Delta Area has undergone a series of significant, large-scale environmental changes since the Terminal Pleistocene, many occurring long after the region was first settled by Native people. Two major paleolandscape changes occurred in the Bay-Delta Area which had profound effects on the preservation and visibility of the archaeological record – formation of the San Francisco Bay estuary and Sacramento-San Joaquin Delta in response to sealevel rise, and development of alluvial landforms near the bay and in virtually every valley of the study area (see Figures 8 to 11). These two processes have had a substantial effect on our ability to identify and access the archaeological record of the Bay-Delta Area, particularly that portion of the record that predates 3,000–4,000 years ago. In this section we discuss the development and application of a model designed to assist in the identification of buried and submerged sites in the San Francisco Bay-Delta Area.

Archaeological sites are not distributed randomly throughout the landscape, but tend to occur in specific geo-environmental settings (Foster and Sandlelin 2003:4; Hansen et al. 2004:5; Pilgram 1987; Rosenthal and Meyer 2004a). While it is very difficult, if not impossible, to identify the full range of environmental variables that may have made a specific location favorable for past human occupation, it is often possible to identify some of the characteristics common to most human settlements in a particular region.

The discovery and analysis of buried or submerged archaeological sites are a crucial part of this inquiry, because without the full sequence of prehistoric occupation, many important questions regarding chronology, settlement, and subsistence cannot be properly refined beyond our present understanding. A robust knowledge of ancient landscapes is a necessary condition for determining how and why groups positioned and organized themselves on an annual basis.

Buried archaeological deposits associated with buried soils have been discovered in virtually every major valley in the San Francisco Bay-Delta Area, at various places in the Central Valley, and the southern North Coast Ranges (Meyer 1996; Meyer and Dalldorf 2004; Meyer and Rosenthal 1997;

Rosenthal and Meyer 2004a; Stine 1994; White 2003; White et al. 2002). The general locations of these buried sites are depicted on Figure 25.

The sheer number of buried sites in the study area demonstrates that there is a potential for such deposits in virtually all of the lowland valleys of this region where Holocene-age deposits are mapped at the surface. Furthermore, a review of radiocarbon-dated sites from the region indicates that virtually all of the sites dating to 5,000 years or greater are from buried contexts. Given this antiquity, their research potential is quite high, and therefore these sites tend to have elevated levels of significance with respect to National Register eligibility criteria. The presence of human remains at most of the above referenced sites also has implications for cultural significance, and further emphasizes the need to identify such resources early in the planning process.

One of the issues affecting studies of environmental settings and buried resources are geomorphic processes which have profoundly altered both the local and regional landscapes, driven by environmental conditions that differed greatly from today (such as rapid global warming and sea-level rise in the Terminal Pleistocene/early Holocene). Nowhere is this more obvious than in the littoral setting of San Francisco Bay where changes were rapid and profound, altering both where land and sea met and where rivers flowed, and what food resources were available within each context.

Models of surface, buried, and submerged sites are being regularly revised as additional information become available. As such, it is important to go beyond a simple review of soil age (though this is a necessary first step). For archaeologists to rigorously investigate archaeological site distributions (surface, buried, and submerged), reconstruct how populations adapted to a changing landscape, and model the decision-making processes that underlay settlement and subsistence choices, it is necessary to reconstruct paleogeography and paleoecology. Such a reconstruction then provides a solid basis for refining predictive models of where sites are most likely to be located (a key factor in buried-site sensitivity modeling), and it also provides robust insights into the diachronic changes in settlement patterns and subsistence strategies. In the following discussion, we use the term sensitivity to refer to the factors used to create the model, while "potential" is used to refer to the modeling results and maps (i.e., site potential maps). This terminological distinction is intended to differentiate between the possibility for sites versus their probability or potential.

In spatial applications, the known occurrences of the phenomenon under study are a set of point locations or training points (e.g., archaeological sites), and the predictor variables are a set of thematic maps or evidential themes (e.g., slope of terrain), usually reduced to binary patterns (e.g., presence/absence of sites within a particular slope interval). The set of training points is compared against each of the evidential themes in an attempt to identify a pattern. Ideally, a modeling technique known as "weights of evidence" can be used to describe how sites are associated with evidential themes.

Prior studies have examined as many as 16 environmental variables to describe settlement patterns in central and northern California (e.g., Byrd and Wee 2008; Byrd et al. 2008; Meyer and Dalldorf 2004; Meyer et al. 2010, 2011b; Pilgram 1987; Rosenthal and Meyer 2004a). Grouped into seven major environmental themes, they include climate, ethnography, latitude, hydrography, lithic sources, topography (aspect, elevation, slope, metabolic cost), and vegetation class. Using a logistic regression model, Meyer (2013) compared the performance of all significant themes in several different physiographic provinces and geomorphic settings. Based on the results of this analysis, three environmental factors—distance to water, slope, distance to confluence—were identified as effectively classifying the majority of known site locations across all zones. After evaluating these environmental factors, a weighted value was assigned to each in proportion to the relative contribution to the overall model. The distance to water factor was weighted higher than the other factors because it proved to have the greatest positive and negative correlation with known site locations. The relative contribution of the factors of slope, and distance to confluence were found to be nearly equal, and were weighted accordingly.



Figure 25. Distribution of Selected Buried Sites in the Study Area.

Slope

An elevation layer was used as a template for all subsequent layers to control cell size and alignment throughout the modeling process. A Digital Elevation Model was acquired from the USGS Seamless Server (Gesch 2007; Gesch et al. 2002). All elevation sets were resampled with a nearest neighbor roving window technique to create a smoothed 98-x-98-foot (30-x-30-meter) grid cell surface.

The resulting elevation model was used to calculate the percent of slope of land surfaces for the entire project area. All spatial analyses were carried out using ESRI ArcMap 10.3 and the Spatial Analyst extension. All GIS datasets were saved as standard ESRI grids, shapefiles, or personal geo-databases.

Hydrography

Due to the importance of water in the region, a perennial, natural water source layer was created based on the National Hydrography Database Plus, historic-era maps, and review of topographic maps and aerial imagery. Perennial water was identified by attributes in the dataset and included streams and springs. Further processing was required with the removal of all artificial lakes, ponds, and channels (e.g., reservoirs, canals, and ditches) identified as perennial. Second, stream segments coded as "ephemeral" that connected two perennial segments were re-coded as perennial after verifying the status of the segments on appropriate topographic quadrangles.

Stream channels were attributed with the appropriate stream level (i.e., order) based on the size and number of connecting tributaries. Stream confluences were derived from this dataset by identifying the endpoints where two lines converged. Additional confluences were added where streams met the historical shoreline. Finally, in the area where perennial segments were separated by an artificial lake (i.e., Anderson Dam), the lake polygons were replaced by "artificial paths" to create reasonably contiguous drainage networks.

SURFACE SITE POTENTIAL MODEL

Based on the weighted model of environmental criteria described above, a map depicting the potential for surface archaeological sites was developed. Surface site potential was calculated using the relative contribution, or weighted value, of each environmental theme (score) for every 30-x-30-meter grid cell across the entire study area. Table 11 lists the model criteria classes as well as the weight for each class. The overall sensitivity score was derived by adding the appropriate weight for each layer. For example, a location with a slope of 3%, 200 meters (656 feet) from water, and 50 meters (164 feet) from a confluence would get a score of 3.33+2.33+3.33=8.99. Figure 26 presents a surface sensitivity mapping for archaeological sites in the study area. While the surface site model itself does not alter the "geologic potential" of a landform to contain buried sites, it does provide a rationale to better distinguish areas with the highest buried site potential from those with lower potential, even across the same landform.

BURIED SITE POTENTIAL MODEL

To develop a model of buried site potential, a map of landform age was developed from existing soils surveys following methods outlined in Rosenthal and Meyer (2004a), Meyer and Rosenthal (2008), and Meyer et al. (2010, 2011b). The buried site potential model is based on two working assumptions: (1) archaeological deposits cannot be buried within landforms that developed prior to human colonization of North America (Rosenthal and Meyer 2004a, 2004b); and (2) there is typically an inverse relationship between maximum-age of Holocene surface landforms and their potential to contain buried archaeological deposits. Regarding the latter, the potential for older landforms to contain buried sites is



Figure 26. Surface Sensitivity Mapping for Archaeological Sites in the Study Area.

ENVIRONMENTAL THEME			Scores		
Slope (%)	>20	15 to 20	10 to 15	10 to 5	0 to 5
Distance to Historic-era Streams (meters)	>1,200	600–1,200	300-600	150-300	0–150
Distance to Confluence or Historic-era	>1,200	600–1,200	300-600	150-300	0–150
Shoreline (meters)					
Combined "Weight"	-	0.33	1.33	2.33	3.33

Table 11. Surface Model Weights by Environmental Criteria.

Cumulative scores were grouped into sensitivity classes as follows.

SENSITIVITY CLASS	CUMULATIVE SCORE
Highest	>7
High	5–7
Moderate	3-<5
Low	1-<3
Lowest	<1

generally lower than younger landforms because: (1) the amount of time for human occupation was shorter for older landforms than for younger ones; and (2) human population densities were lower compared to later periods, resulting in fewer site locations. From this perspective, the potential for Early Holocene surface landforms to contain buried sites is generally low, not because such sites are potentially absent, but because the overall probability that people occupied any one point on the landscape that was buried by a landform of this age is low.

The same logic applies to the sensitivity of all subsequent Holocene landforms. The younger the age of the landform, the higher the likelihood that buried archaeological deposits will be discovered. This results from two main factors: (1) Holocene surface landforms commonly contain multiple Holocene buried soils (i.e., former land surfaces); and (2) within young surface landforms, the aggregate of time represented by Holocene buried soils is greater than the aggregate of time represented by buried soils in older surface landforms. Also, it is assumed that archaeological deposits from later time periods are more common overall due to higher population densities. Formerly stable land surfaces buried later in time, therefore, have a higher probability of containing archaeological material than those buried earlier in the Holocene.

Using these assumptions, landforms that are either non-depositional or too old to contain buried sites can be confidently excluded from further consideration using the age assignments derived from the soil database. Once these distinctions are made, age differences between younger depositional landforms can then be used as a measure of the relative potential (i.e., probability) for buried sites. Buried sites, therefore, are expected to occur in locations with relatively high potential for surface sites where the surface deposits post-date one or all periods of Native American occupation.

To operationalize these assumptions, age multipliers that correspond to each time period were applied to the score derived from the surface site model to generate a revised age-based buried site potential score. As shown in Table 12, the age multiplier was determined by taking the age ranges for each period and dividing these by two to arrive at a "mean age" cal BP, which was divided by 14,500 years, or maximum span of human occupation, to determine the proportion of the span that elapsed by the time the surface landform was created. Although the youngest surface "deposits" are mapped as water or Historical to Modern, these units were not given a multiplier of 100% due to their variability and their tendency to be part of active channels or floodplains unsuitable for settlement, or to represent areas where archaeological deposits were likely removed by erosion. The buried site potential model is, therefore, essentially an age-based version of the surface sensitivity model that takes into account the

Age Group (cal BP)	AGE MULTIPLIER	LANDFORM AGE UNIT
0	-	Water
<100	0.15	Historic-Modern (channels)
<100	0.30	Artificial Cut/Fill
<100	0.55	Historic-Modern
600–100	0.99	Recent Holocene
1150-600	0.96	Medieval Climatic Anomaly
2200-1150	0.92	Latest Holocene
4200-2200	0.84	Late Holocene
8200-4200	0.70	Middle Holocene
11,700-8200	0.41	Early Holocene
12,900–11,700	0.16	Younger Dryas
25,000-12,900	0.08	Terminal Pleistocene
>25,000	-	Older Pleistocene/Pre-Quaternary

Table 12. Age-Based Buried Site Potential.

Cumulative buried sensitivity scores were grouped into classes as follows.

SENSITIVITY CLASS	CUMULATIVE SCORE
Highest	>7.5
High	5.5–7.5
Moderate	3.0-<5.5
Low	1.0-<3.0
Lowest	<1.0

amount of time for human use before and after the formation of the surface deposit. The ranges of resulting scores were then stratified into various classes of buried site potential according to the scheme shown in Table 12. Figure 27 provides buried sensitivity mapping for archaeological sites in the study area.

SUBMERGED SITE POTENTIAL MODEL

Modelling for sites submerged by rising sea level in San Francisco Bay required a different approach than terrestrial surface or buried site models due to a lack of environmental data such as streams and geology. Therefore, we generated streams, slope, and sea levels based on bathymetric data.

To reconstruct the submerged topography of the San Francisco Bay, we acquired modern elevation/bathymetry data from National Oceanic and Atmospheric Administration tsunami modeling dataset (Carignan et al. 2011). This elevation model was modified based on information acquired to generate the sea level curve. Specifically, since there is no evidence of a bay prior to 11,500 years ago, we modified the elevation data so the sea came through the Golden Gate at that time. To do this, we had to reduce the elevation of the sediments directly outside the gate and increase the elevation in the gate. It is assumed that the depth of the Golden Gate and accumulation of sediment outside the gate are direct results of tidal action after these areas were submerged.

Then, the thickness of younger bay mud as mapped by Goldman (1969) was combined with the modified modern elevation data to create a digital elevation model. The contours in the 2009 bay mud thickness digital dataset (Goldman 1969) were corrected against the original map (Goldman 1969:Plate 3) to identify and remove discrepancies. The final elevation dataset was created by subtracting the thickness of the bay mud from the modified elevation dataset within the pre-contact bay margins, as mapped by the San Francisco Estuary Institute (2012).



Figure 27. Buried Sensitivity Mapping for Archaeological Sites in the Study Area.

Based on the elevation curve (see *Paleoenvironment*, page 3-9), elevations of pre-contact sea levels were calculated at 500-year increments, from 12,000 to 500 years ago. The pre-contact bay was defined as the extent of area below the calculated elevation and contiguous with the ocean. This prevents low points in the elevation data from appearing to be part of the bay too early in time.

Submerged stream centerlines were generated from the submerged elevation model with the ESRI hydrology toolset (ESRI 2015). The resulting stream centerlines were cleaned to remove small tributaries, and the remaining streams were connected to historical perennial water sources, digitized for the terrestrial sensitivity model, to create a plausible network.

Similar to the surface model, site potential was calculated by weighting our environmental layers for the area between the ancient sea level and historical shoreline (Table 13). The submerged site potentials are calculated as the cumulative score for each of these models. This method results in areas that are exposed for a longer time to get the highest potential, while areas submerged early in time get a low potential. Figure 28 provides a map of submerged sensitivity for archaeological sites in the study area.

Table 13. Submerged Model Weights by Environmental Criteria.

ENVIRONMENTAL THEME			Scores		
Slope (%)	>24	18 to 24	12 to 18	21 to 6	0 to 6
Distance to Submerged Streams (meters)	>1,200	600–1,200	300-600	150-300	0–150
Distance to Confluence or Ancient Shoreline (meters)	>1,200	600–1,200	300-600	150-300	0–150
Combined "Weight"	-	0.33	1.33	2.33	3.33

USING THE MODELS

The overall utility and predictive power of the sensitivity models are undoubtedly affected by some obvious and perhaps not-so-obvious limitations. First and foremost, just as "the map is not the territory," the models are not the phenomena being modeled. Instead, the models are designed to approximate a selected series of conditions found in reality for a specific set of purposes (i.e., locating archaeological sites). The models are based on factors derived from multiple datasets, each with their own inherent limits, strengths, and weaknesses. Consequently, the strength or weakness of one dataset can reinforce, compensate, or weaken another, resulting in many possible outcomes that may or may not be intended when they are used in combination.

For example, although the surface model compensates for some of the limitations of the landform-age map by independently considering the influence of certain environmental factors, it does not fundamentally change the baseline predictive value of landform age, nor does it change or correct the shape (i.e., area) of the associated soil polygons. Thus, in emphasizing or de-emphasizing the variables considered most relevant for predicting surface site locations, the buried site model is essentially an enhanced version of the landform map and should be viewed as such.

While the surface model does account for certain environmental factors, it does not explicitly account for other possible relationships on the distribution of sites. Though the overall influence of other factors is presumably negligible compared to those adopted for the model, the potential for sites may be overestimated in some areas and underestimated in others due to fundamental geomorphic or environmental differences that were not modeled, or are best modeled for smaller areas or specific drainage basins.

The spatial resolution of the models are further limited by the size of the 90-x-90-meter (295-x-295-foot) grid cells used to determine the aspect, convexity, and degree of surface slope. At this scale, however, the model does not recognize or account for more subtle variations in the land surface that exist at smaller scales or resolution. Since the model does not convey possible differences in archaeological



Figure 28. Submerged Sensitivity Mapping for Archaeological Sites in the Study Area.

sensitivity that may be associated with variations in slope within the cells, the potential for sites may be overestimated in some areas and underestimated in others. Furthermore, since the model is based on the present configuration of the landscape, it does not account for potential changes in aspect, convexity, and degree of surface slope that occurred over time in response to erosion or deposition. This is a particular problem in basins and other lowland areas where younger deposits often overlie land surfaces that were used in the past, thus masking important variations in topography.

Similarly, because the distance-to-water criterion is based on current locations, the models do not explicitly account for long-term fluctuations in the availability of water (i.e., lakes, springs, marshes, ponds, or pools) or changes in the physical position of stream and river channels over time. Since ancient drainages did not always follow the same courses they do today, some pre-contact site locations are not related to the current position of active channels, but are instead related to the position(s) of formerly active (abandoned) channels, or bays (see *Paleoenvironment*, page 3-9). Some areas with no visible evidence of a channel may actually have more potential for sites than an area located near a present-day channel. Consequently, working assumptions about site locations and the distance to water must be viewed with caution, as present channel positions are not always reliable indicators of where pre-contact sites may be located.

In addition, the meander belts of some streams and rivers may not have been conducive for the burial or preservation (i.e., storage) of archaeological deposits due to down-cutting and lateral channel migration within these belts. When channels become inactive, they tend to quickly fill with sediments during floods. Or they become marshy or wetland areas (i.e., abandoned slough, cutoff meander, or oxbow lake) that are themselves unattractive settings for human settlement. In either case, abandoned channels usually do not contain well-developed buried soils or archaeological sites because they are relatively unstable features of the landscape. This is clearly the case in areas where segments of pre-contact or historic-era stream or river channels were filled with relatively recent sediments (i.e., Recent Holocene or younger), or were abandoned due to artificial straightening of the channel. Because these circumstances vary greatly from one location to the next, the actual potential for buried sites may be less than predicted in some areas where Historic- to Modern-period deposits are mapped at the present surface.

Given these many limitations and imperfections, the sensitivity models and maps cannot be expected to always provide accurate predictions of site potential (or locations), as some age assignments and estimates of potential are undoubtedly based on inadequate, incomplete, or incorrect assumptions or datasets. This will almost certainly be true if no further effort, thought, or discretion is used to determine how best to interpret, adapt, and implement the models and maps in different areas for different purposes. If these caveats and limitations are acknowledged and tested in the field, however, most can be overcome by revising the model's parameters to suit specific areas or the needs of specific projects.

By design, the predictive power of the models lies in their ability to distinguish areas with the greatest from those with the least potential for archaeological sites. Because of this, the models will likely be most accurate in predicting areas that are at either extreme, but less successful in discerning the potential for sites in areas where the potential lies somewhere in between. While the predictive power of the surface site model is strong, a preliminary assessment of the buried site model indicates it clearly does not predict the location of every known buried site. This is most evident in upland areas where existing soil maps are over-generalized and small depositional landforms are often not recognized or included.

In contrast, the buried site model is far more accurate in basin and lowland areas where the existing soils are generally mapped at higher resolutions than in the uplands. But even in these areas, several known buried sites are in areas with a Moderate or even Low potential according to the model. In most of these instances, however, these sites are either located more than 400 meters (1,300 feet) from an identified water source, or they are located adjacent to cells (i.e., <90 meters [<295 feet]) with a High or Very High modeled potential.

Thus, the model is a first approximation that generates relatively conservative estimates of buried or submerged site potential, with the probable error equal to the width of at least one grid cell (±90 meters [±295 feet]) in lowland settings, and at least two grid cells (±180 meters [±590 feet]) in upland settings. Given these levels of uncertainty, the model should not be used rigidly, as if the estimated sensitivity of each 90-x-90-meter (295-x-295-foot) cell is the last word in the matter. Instead, it should be viewed as a guide to be consulted primarily for planning and research purposes. Alternatively, the landform age map may be used if a more liberal sensitivity approach is needed.

DATA APPLICATION AND TESTING THE MODELS

Geoarchaeological backhoe/core testing is becoming standard procedure in areas identified as high or very high potential for buried/submerged sites. Results from each project should modify or refine the models. One such test occurred in 2011 when Far Western Anthropological Research Group, Inc., prepared a buried site sensitivity assessment of the Interstate 80 corridor in District 4, Solano County, in response to numerous proposed projects (Hildebrandt et al. 2012). This resulted in the identification of 20 areas of high or very high sensitivity for buried sites. Most of these areas were quite small, however, because watercourses flowing from the Coast Ranges in the west bisect the corridor at a roughly perpendicular angle, so the probability of encountering a buried site in this corridor would seem quite low. However, geoarchaeological explorations in 18 of these areas accessible to testing resulted in the identification of two deeply buried archaeological sites of vastly different ages in separate areas of high sensitivity. These results demonstrate the utility of modeling combined with exploratory testing in advance of project construction. Proactive geoarchaeological studies can also provide detailed information on the nature and age of landforms underlying a particular project area that can be used to justify archaeological recommendations for future projects in the same vicinity, a benefit that can rarely be derived from archaeological construction monitoring.

Site-specific excavations can also contribute to the model's improvement. Indications of old stream channels can be gleaned from close analysis of unit or trench profiles; soils can be dated to refine landscape evolution, particular of the Bay; older sites, as they are identified, can be incorporated into the model, as can site-specific data on soil type, stream and confluence locations, and slope. The actual sensitivity map should not be used at the site-specific level, but the model and map should be referenced for each project as a starting point to assess landscape change and effects on the archaeological record.

FIELD METHODS

The ability to locate buried sites depends on whether or not appropriate field methods are used. Similarly, the ability to explore and sample subsurface deposits is often precluded or severely constrained by logistical or safety reasons. Although trenching is generally the most efficient and effective method for identifying buried sites in many settings (Monaghan et al. 2006), it is often not feasible or practical to excavate an open trench in urban areas. Given that the size and number of areas available for exploration are severely limited and the thick nature of subsurface deposits (which often exceed the maximum depths normally reached by a backhoe or excavator), boring or coring may be the only exploratory method that can be used regularly to identify buried sites in this urban setting.

Given these constraints, it is often beneficial to conduct archaeological explorations simultaneously with any other subsurface geotechnical work that may be needed, to reduce the overall time, effort, and related logistical issues. The success of such a "piggyback" approach would depend largely on the ability of the archaeologist to coordinate these efforts with the geotechnical firm and drilling crew, and the crew's willingness to accommodate the needs of the archaeologist. For example, it is common for geotechnical studies to recover "skip samples" from given intervals within a core instead of obtaining a continuous
sample of the deposits from within the core. While interval sampling may be routine for most geotechnical work, it is largely inadequate for archaeological work, because many archaeological deposits are thin and can be missed in an interval that was skipped. Thus, coring for archaeological purposes will usually require continuous core samples, at least through the Holocene-age portion of the subsurface deposits. If this is not possible, information generated from interval borings may be used to guide and focus the archaeological coring efforts by helping investigators identify and avoid sampling thick deposits of artificial fill, bay mud, or deposits that are too old to contain buried archaeological sites.

Direct push continuous-core sampling devices such as a "geoprobe" have been used successfully for subsurface archaeological explorations. Experience has shown that a dual-wall coring system provides the highest-quality sample by preventing "sluff" or mixing from the top of each sample, and the collapse of the boring hole between samples. This tool is most effective when the underlying deposits are soft, fine-grained sediments, but is quite limited when an area is underlain by rubble-filled artificial deposits or dune sand.

If archaeological deposits are identified by subsurface coring or trenching, then some additional exploration as part of the identification effort may be needed to sample the deposits to determine their general nature and extent within a project area. Radiocarbon dating is also needed to determine the age of the cultural deposit and/or buried soils that may occur above or below the deposit. The age and depth of these deposits can then provide target depths for further archaeological investigations and/or construction monitoring, if required. These results will provide a basis for determining whether subsequent phases of investigation (archaeological testing and evaluation, and possible data recovery) will be needed.

Finally, if safe and adequate exploratory work cannot be conducted prior to demolition and construction, then archaeological monitoring and/or spot-checking may be the only archaeological identification option, even though it is the least preferred and often most costly alternative. If it becomes necessary, an effective monitoring program requires a daily, if not hourly, awareness of project schedules and activities to insure that important opportunities for archaeological discovery are realized, and potentially important archaeological resources are recognized during demolition or construction.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

SECTION 2 – RESEARCH ISSUES

This section presents selected, currently relevant research issues that serve as starting points for determing site eligibility and designing data recovery plans. It begins with a research orientation and a user's guide to building research designs. We also inclue one-page abstracts of each issue so researchers can quickly identify topics appropriate for each site, and for use in research designs for site-specific investigations.

TOPICS

- National Register Eligibility Requirements
- Summary of Research Issues
- Research Issues



5. SUMMARY OF RESEARCH ISSUES

This chapter begins with a description of the research orientation taken in developing the domains discussed in the following chapters. A user's guide to research designs presents two tables—one summarizes the potential research issues that can be addressed given the archaeological artifact, ecofact, and feature types commonly found in San Francisco Bay-Delta Area Native American sites (Table 14); the second identifies research issue data requirements for National Register eligiblity thresholds (Table 15). The chapter ends with a series of one-page abstracts for each of the research domains, highlighting key points. Detailed presentations of each research domain are in Chapters 6–14. They explicitly focus on providing a framework for evaluating significance of archaeological resources under National Register Criterion D.

RESEARCH ORIENTATION

In this research design, we have attempted to cover the breadth of current research approaches used in northern California. We start with the acknowledgement that archaeological research has moved away from the application of rigid hypothetico-deductive frameworks that tend to posit a limited set of explicit questions and test implications (Salmon 1993; Watson 1990). This is due to the recognition that research moves forward through a complex interplay between inductive and deductive steps filtered through the paradigmatic biases of individual scholars' research orientations (Clark 1993). Therefore, research designs are generally presented in prose form and aimed at clearly linking important research problems within the context of broad research themes with material correlates of the archaeological record.

It is well recognized that the discipline of archaeology today embraces multiple theoretical approaches (Wylie 2002). For example, Hegmon (2003) has distinguished four major theoretical orientations employed in recent years by North American archaeologists: behavioral archaeology—the relationship between behavior and material culture (Schiffer 1999); Darwinian archaeology—applying Darwinian theory to the archaeological record (O'Brien and Lyman 2000); human behavioral ecology—using evolutionary ecology to explain human actions (Kelly 2000; Winterhalder and Smith 2000); and processual-plus—the melding of post-processual concepts (with its interest in individuals, agency, gender, and symbolic meaning) into the processual approach (e.g., Duke 1995; Gamble et al. 2001; Otterbein 2000).

Each of these theoretical orientations has proponents within a single North American region. In the California-Great Basin area, one of the heartlands of hunter-gatherers, a human behavioral ecology approach is increasingly employed. There also appears to be a trend, particularly in central California, to emphasize historical contingency in explaining the past (e.g., Jones et al. 2008). This approach stresses the importance of sequential events in a local area, and in some contexts, such as the San Francisco Bay-Delta Area, this has the potential to reinforce a long-held emphasis on culture history and particularism. Traditional applications of this approach are largely devoid of theoretical orientation, and lack the goals of middle-range theory with its emphasis on identifying broader patterns of the human condition. However, when responses to historical events are considered within a larger theoretical framework, like behavioral ecology (e.g., Bettinger and Baumhoff 1982), a much more complete understanding of longterm trends in human behavior can be achieved.

Diversity in theoretical orientation is healthy, as it facilitates multiple perspectives on key research issues, and should be embraced. Archaeology is diminished if research and debate are constrained within a single theoretical orientation; in fact, interpretive debates regarding events and patterns in prehistory are most vibrant when they derive from alternative theoretical perspectives. In the end, "inference to the best explanation" is the rational reasoning that most archaeologists employ to generate hypotheses and explanations of the past (Fogelin 2007:609–610). This practical strategy for

explanation examines both the breadth and diversity of evidence, and encompasses causal and contrastive explanations. As Fogelin (2007:618–620) outlines, successful explanations include the following traits: empirical breadth, generality, refutability, conservatism, modesty, simplicity, and multiplicity of foils. This is the approach embraced here, where the compelling power of an explanation is appreciated regardless of the theoretical approach from which it originates.

Research Potential in a Cultural Resources Management Context

A mixed theoretical approach is especially important in identifying research potential at sites excavated within a CRM framework because site excavation is based on project impacts and overall project management decisions rather than solely on research-driven archaeological considerations. In this sense, CRM archaeologists must be nimble in their theoretical and methodological orientations to maximize the information gained from sites impacted by project-specific construction activities.

It is also important to acknowledge that CRM-based excavation is often limited by project impacts, and therefore archaeologists may not recover samples reflective of the densest deposits or full suite of site attributes. There may also be a lack of access to some data sets recovered at a site. As such, there are two important facets to CRM-based research:

- 1. Identifying research issues tailored to the types of archaeological remains likely to be recovered during project-specific studies.
- 2. Recognizing the cumulative potential of archaeological data from a series of small-scale excavations, along with cumulative insights from data acquired at regional sites.

These two factors provide a running theme in the research issues described in this section—**regional synthesis of aggregated site data provide the backbone of all analyses**. Explicit in the framing of regional research issues is an understanding that small archaeological assemblages may not be able to provide substantive information by themselves, but when aggregated may reveal interesting and important patterns.

One other factor to consider is deposit integrity, particularly in relation to component assessment. Integrity is the ability of a cultural resource to convey its significance. A significant cultural resource must retain one or more of the following—"integrity of location, design, setting, materials, workmanship, feeling, and association" (36 CFR 60.4). The importance of each depends upon the resource and its relevant criterion or criteria (Little et al. 2000). Each of these aspects of integrity is contingent upon knowing why, where, and when the property is significant.

Archaeological sites and districts almost always have integrity of location where significant displacements have not occurred. However, a loss of integrity of location would not necessarily preclude the eligibility of a site that contains secondary or redeposited deposits (Little et al. 2000). Consideration of an archaeological site's integrity of design generally refers to whether informative intra-site artifact and feature patterning exist. Integrity of materials within archaeological sites is usually described in terms of whether intrusive artifacts and/or features are present, the completeness of the assemblage, or the quality of artifact or feature preservation. Integrity of association is generally measured in terms of the strength of the relationship between the site's data or information and the important research questions (Little et al. 2000). This might be illustrated by the degree to which subsurface archaeological deposits are identified in undisturbed depositional contexts, and the degree to which discrete chrono-stratigraphic data at a site is provided in Chapter 6.

A USER'S GUIDE TO BUILDING RESEARCH DESIGNS

There are 29 research issues broken down into 10 major research domains explored in the following chapters. Each research domain focuses on one aspect of the broad-scale evolution of adaptive strategies and associated socio-political developments. Caltrans does not expect that each of these issues will be examined in determining the significance of a particular site. Instead, the research issues offer a framework to aid in assessing potential avenues for research. While the purpose of the contextual discussion and research design is to make it easier to develop site-specific research designs for compliance purposes, a thoughtful consideration of the types of data found at a particular site, and how these might be applied to regional research issues, are still required. Moreover, these are not considered to be an exhaustive list of all potentially important research topics, but instead reflect well-recognized, regional topics that have been explored in recent years. For example, research issues particularly germane to Terminal Pleistocene and Early Holocene pre-bay occupation are not highlighted given the dearth of sites dating to this time span, yet such topics could be explored if appropriate sites were identified. It is expected that other research topics may be fruitfully explored in the Bay-Delta Area, and new research topics and datasets/techniques will emerge in the future.

Applicability of Site-Specific Research Issues

Table 14 summarizes data germane to each research issue. Each column has a specific data set, with coded and shaded measures of the likely applicability of each data type to a given research issue unlikely, possible, probable, and certain. If, for instance, we wanted to select research topics to evaluate the potential eligibility of a site with a scatter of flaked and ground stone, the user would look in the "flaked stone debitage/tools" and "ground stone tools" columns. This would narrow the 28 research issues to 10–12. At this point, the user might simply present the abstracts of those 10 topics from this chapter, or might narrow the range of topics depending on additional information. For flaked and ground stone scatters, one could include *Inferring Social Patterning from Intra-Site Spatial Trends* and *Discerning and Modeling Settlement Organization* (ranked as probable applicability for both flaked and ground stone). One might also include issues with certain applicability for one of the classes (in this case

flaked stone)—*Obsidian Hydration as a Chronological Tool,* and *Obsidian Exchange* if obsidian is likely or present, as well as the issue of *Reconstructing Population Movements,* regardless of flaked stone material type (ranked as probable applicability). Depending on the types of ground or flaked stone tools, the context of the site (i.e., bayshore versus interior; south bay versus north bay), and particular interests of the researcher, other topics with lower general applicability could also be selected.

Eligibility under Criterion D cannot be calculated or determined simply by tallying the number of research topics to which site data might apply.

Well-reasoned archaeological discussions must justify the application of site-specific data to the archaeological record.

Research Issue Data Requirements

Table 15 provides a brief summary of the types of archaeological data needed to address each research issue, and the likely minimum threshold for eligibility; however, these are not the only scenarios under which a site may be determined eligible. It is important to note that the identity of at least one stratigraphically and chronologically bounded occupational component, or a secondarily deposited site that dates to a single time period, is necessary before addressing the issues.

Again using a flaked and ground stone scatter as an example, if obsidian and diagnostic artifacts are present, the issue of *Chronology and Dating* could be addressed, allowing for other issues, such as *Exchange*, to be examined.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

for Native American Archaeological Res	San Francisco Bay-Delta Regional Cont
sources, Caltrans District 4	text and Research Design

Table 14. Guide for Archaeological Data Types to Specific Research Issues.

Research Issues Page Number:	FLAKED STONE DEBITAGE/TOOLS	CROUND STONE TOOLS	5 BONE AND SHELL TOOLS	DIETARY SHELL 12-52	DIETARY BONE	Image: PLANT Remains	14 HUMAN REMAINS/BURIALS	15 SHELL BEADS	InternationalInternationalInternational(Shell, Bone, Stone)	51 ANTHROPOGENIC 11 STRATIGRAPHY	は STRUCTURAL FEATURES は (HOUSES, PTTS, HEARTHS)	CEREMONIAL FEATURES D AND OBJECTS	15 BEDROCK MILLING 9 FEATURES	HIDDEN (ANTHROPOGENIC HENRICHED SEDIMENT)
TEMPORAL TRENDS IN OCCUPATION														
Radiocarbon Dates (things you can date)	-	-	+++	+++	+++	+++	+++	+++	+++	+++	+++	+	-	+++
Obsidian Hydration as a Chronological Tool	+++	-	-	+	-	+	-	-	-	+	-	-	-	-
Refining Accuracy of Scheme D	+	-	-	+	+	+	+++	+++	+	-	++	++	-	+
SETTLEMENTS IN SPATIAL CONTEXTS														
San Francisco Estuary Adaptations	+	+	-	++	++	++	++	-	-	++	-	-	-	++
Discerning and Modeling Settlement Organization	++	++	+	+	+	++	++	+	+	++	+++	+++	++	++
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	+	+	+	++	++	++	-	+	-	+++	++	+++	-	+++
Bay-Delta Area Sedentism – Causal Factors and Trajectory	++	++	++	+	+	+	++	+	-	+++	+++	++	-	+++
Seasonality of Occupation	-	-	-	+++	++	++	-	-	-	++	++	-	-	++
EXPLORING CHANGES IN DIET AND HEALTH														
Resource Intensification	++	++	++	+++	+++	+++	+++	-	-	++	-	-	+++	++
Fishing Trajectories	-	-	+	+	+++	-	+	-	-	++	-	-	-	++
Species-Specific Exploitation Histories	-	-	-	+++	+++	-	-	-	-	++	-	-	-	++
Dogs in the Diet	-	-	-	-	+++	-	-	-	-	++	-	++	-	++
Shellfish Gathering	-	-	-	+++	-	-	-	-	-	++	-	-	-	++
Plant Resource Exploitation	-	++	-	-	-	+++	-	-	-	++	++	-	+++	++
Diet and Health from Human Remains	-	-	-	-	-	-	+++	-	-	-	-	-	-	-
Construction of Anthropogenic Landscapes	-	-	-	-	+	+++	-	-	-	++	-	-	++++	++
IMPORTANCE OF TECHNOLOGICAL CHANGE														
Milling Tools, Plant Foods, and Adaptive Strategies	-	+++	-	-	-	+++	-	-	-	-	++	-	+++	++
Social/Economic Implications of the Bow and Arrow	+++	•	-	-	+++	++	-	-	-	-	++	-	-	-
HUMAN DEMOGRAPHY AND POPULATION MOVEMENT														
Reconstructing Population Movements	++	-	++	-	-	-	+++	-	+++	-	-	++	-	-
Prehistoric Demographic Transitions	-	-	-	-	-	-	+++	-	-	-	-	-	-	-
Violence-Related Activities	-	-	-	-	-	-	+++	-	-	-	-	-	-	-
TRACKING TRENDS IN PREHISTORIC SOCIAL INTERACTION														
Assessing Assertions of Socio-Political Complexity	-	-	-	-	-	-	+++	+	+++	-	-	+++	-	-
Role of Gender in Social Interaction	+	+	++	-	-	-	+++	+	+++	-	-	++	-	-
Animal Interments - Window into Ceremonial Activities	-	-	-	-	-	-	-	-	-	-	-	+++	-	-
Inferring Social Patterning from Intra-Site Spatial Trends	++	++	-	-	-	-	++	-	-	++	+++	++	-	++
RECONSTRUCTING REGIONAL INTERACTION SPHERES														
Obsidian Exchange	+++	-	-	-	-	-	-	-	-	-	-	-	-	-
Olivella and Clamshell Bead Manufacture and Trade	++	-	-	-	-	-	-	+++	+++	-	-	-	-	-
Abalone Pendant Exchange	-	-	-	-	-	-	-	++	+++	-	-	-	-	-
INDIGENOUS ASSIMILATION AND PERSISTENCE														
Assessing Indigenous Persistence	+	-	-	+	++	++	-	+	++	-	-	+	-	-

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; ++ = Certain. This table is not meant to be exhaustive — data may be germane to additional topics, and not all data that apply to a given topic are listed. <u>Underline</u> indicates hyperlink to section.

Table 15. Summary of Data Requirements and National Register Eligibility Thresholds for Bay-Delta Area Research Issues.

Research Issue	DATA REQUIREMENTS	MINIMUM ELIGIBILITY THRESHOLDS
TEMPORAL TRENDS IN OCCUPATION		
Exploring Occupation Trends with Radiocarbon Dates	Dateable organic material	Major data gaps include sites dating prior to 4000 cal BP or later than 174 cal BP, or dated components from the North Delta, outer coast or upland settings. Discerning the timing of the key event is also critical.
Refining Appropriate use of Obsidian Hydration as a Chronological Tool	Obsidian sample >25 pieces sourced to Napa Valley/Annadel	Site with paired radiocarbon/obsidian hydration samples, particularly from buried contexts, or sites with radiocarbon dates and Annadel and Napa Valley obsidian.
Refining Accuracy of Scheme D	Olivella beads, radiocarbon dates	The presence of <i>Olivella</i> beads, particularly those with good temporal resolution (e.g., F and G series beads) that can be subjected to radiocarbon analysis.
SETTLEMENTS IN SPATIAL CONTEXTS		
San Francisco Estuary Adaptations	Dietary data	Provides insight into the early stages of bay margin adaptations; site components with faunal and archaeobotanical assemblages can contribute by evaluating the Index of Cultural Significance. Nearby off-site paleoenvironmental data also needed to reconstruct the evolution of San Francisco Bay.
Discerning and Modeling Settlement Organization	Seasonality data, aggregated regional data	Evidence of a specific season of use (and specific activities) at a site, or evidence of year-round occupation as evidence of sedentism. Requires correlation with other seasonal use of other nearby sites and activities. Seasonality studies may be necessary.
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	Intact stratigraphy, features, artifact/ ecofact assemblages	Intact stratigraphy that can be used to ascertain site formation processes, ceremonial features, and lack of manufacturing debris/dietary remains (to signal only ceremonial use), or abundant and varied manufacturing and dietary evidence.
Bay-Delta Area Sedentism – Causal Factors and Trajectory	Structural features, seasonality data	Sites with structural features and cemeteries are likely a sign of sedentism.
Seasonality of Occupation (shellfish harvesting example)	At least 20 whole shell samples of the same species	Large assemblage of well-preserved shells from the same species that can be subject to stable isotope analysis.
EXPLORING CHANGES IN DIET AND HEAD	ЛН	
Resource Intensification	Identifiable faunal bone	Large assemblage (100 NISP/m ³) of dietary bone identified to family or lower (preferably species- level) of large species of interest (e.g., deer, elk, geese, sea otter, large fish) that can be contrasted with smaller species.
Fishing Trajectories	Identifiable fish bone	Presence, in abundance, of fish bone assemblages based on study of wet-screened 1/8-inch and 1/16-inch samples.
Species-Specific Exploitation Histories – Bay Ray, Otters	Bay Ray, Sea Otter, or other species of interest bone	Sufficient samples of sea otters or bat rays (or other vertebrate taxa of interest) to track exploitation histories.
Dogs in the Diet	Canid bone	Sites with dog interments or moderate quantities of dog bone in generalized midden deposits with evidence of ceremonial versus non-ceremonial deposition. mDNA analysis of canid bone is encouraged to demonstrate remains are dogs.

Table 15. Summary of Data Requirements and National Register Eligibility Thresholds for Bay-Delta Area Research Issues continued.

RESEARCH ISSUE	DATA REQUIREMENTS	MINIMUM ELIGIBILITY THRESHOLDS
Exploring Changes in Diet and Heal	TH continued	
Shellfish gathering	Shell	Presence of quantifiable shell within well-dated component contexts. Sufficient preservation to obtain weights and MNI statistics and/or whole shells on which measurements can be taken to examine diachronic trends in exploitation.
Plant Resource Exploitation	Preserved plant remains	Burnt plant macrofossils from bayshore contexts, contexts older than 5000 cal BP, and from Mission Period occupations are likely eligible, but feature and general midden assemblages from nearly any context have potential to contribute to this issue.
Insight into Diet and Health From Human Remains	Human remains; permission to analyze human remains	Human remains from intact deposits can contribute to issues of diet and health through osteological examination or analysis of stable isotopes.
Construction of Anthropogenic Landscapes	Plant and faunal remains	Presence of micro- or macro-botanical remains and faunal bone inconsistent with the habitats found today, but consistent with habitual burning (i.e., grasslands where there is no chaparral).
IMPORTANCE OF TECHNOLOGICA	L CHANGE	
Milling Tools, Plant Foods, and Adaptive Strategies	Milling tools, archaeobotanical remains, house remains, storage features, seasonality data, cooking stones	Presence of milling tools in relation to archaeobotanical remains and evidence for residential mobility versus permanence.
Social/Economic Implications of the Bow and Arrow	Complete, near-complete, or bases of temporally diagnostic projectile points	Arrow versus dart-sized points within intact Middle/Late Transition and Late Period temporal components.
HUMAN DEMOGRAPHY AND POPULATION	N MOVEMENT	
Reconstructing Population Movements	Human remains	In particular, sites with human remains from Meganos Aspect or Pre-Meganos Aspect are key. Permission of the MLD is needed to conduct strontium and mDNA analysis.
Pre-Contact Demographic Transitions	Human remains; site size information	Sites with large, well-dated burial assemblages, including teeth that can be sampled for oxygen and nitrogen isotopes to track age at weaning, sites with age/sex data available on large burial assemblages.
Violence-Related Activities	Mortuary assemblages	Well-dated mortuary assemblages with sufficient preservation to identify violence. No evidence of violence need be identified, however, as negative evidence is important as well.
TRACKING TRENDS IN PRE-CONTACT SO	CIAL INTERACTION	
Assessing Assertions of Socio-Political Complexity	Mortuary-associated artifacts	Mortuary-associated artifacts from well-dated contexts with sufficient preservation to identify the age/sex of individuals with whom the artifacts are associated.
Role of Gender in Social Interaction	Mortuary-associated artifacts	Mortuary-associated artifacts with sufficient preservation to identify the age/sex of individuals with whom the artifacts are associated.
Animal Interments – A Window into Ceremonial Activities	Animal interment features	Evidence of intentional interment of animals either as sacrifice and disposal as "ceremonial trash," dedicatory interment, or simple interment.
Inferring Social Patterning from Intra- Site Spatial Trends	Structural features or well-defined activity areas	Presence of structural features with the presence of artifact and ecofact assemblages both within and outside the feature, or similarly defined assemblages for distinct activity areas.

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Table 15. Summary of Data Requirements and National Register Eligibility Thresholds for Bay-Delta Area Research Issues continued.

Research Issue	DATA REQUIREMENTS	MINIMUM ELIGIBILITY THRESHOLDS
RECONSTRUCTING REGIONAL INTERA	CTION SPHERES	
Obsidian Exchange	Obsidian sourcing	Presence of substantial assemblages (>25% of sourced obsidian) from sources other than Napa Valley or Annadel, or large assemblages of obsidian from well-dated contexts.
<i>Olivella</i> and Clamshell Bead Manufacture and Trade	Shell beads, manufacturing debris and tools	Presence of shell bead manufacturing debris (blanks and shell modification), drills, and shell beads.
Abalone Pendant Exchange	Abalone pendants/manufacturing Debris	Presence of abalone pendants and/or abalone manufacturing debris. Only one pendant at a site is unlikely to meet eligibility requirements.
INDIGENOUS ASSIMILATION AND PER	SISTENCE	
Archaeological Assessments of Indigenous Persistence	Euro-American plants, animals, artifacts, or post-mission radiocarbon dates	Sites with introduced domesticates (wheat, barley, sheep, goats, cow) or European-manufactured tools. Sites that can be confidently dated to the Mission Period if these objects are not present.

Notes: NISP - Number of identified specimens; MNI - Minimum number of individuals; MLD - Most likely descendant; mDNA - Mitochondrial DNA.

A Note on Research Domain Summaries

The remainder of this chapter consists of one- or two-page summaries of the 10 research domains presented. They serve as abstracts to the more detailed discussions, but just as reading an abstract of an academic article does not provide the breadth and nuance of the article as a whole, the short summaries only present the most important points to help the researcher quickly identify those topics to investigate further. These summaries should be helpful, however, in research designs for site-specific investigations, assuming the broader discussions are summarized and referenced.

SITE AGE AND OCCUPATION HISTORY (Chapter 6)

Although this is not a research issue by itself, all research issues in this document rely on the central concept of discerning site age and occupational history through archaeological components as the basic units of analysis. Although the term "component" is particular to a culturehistorical perspective espoused by certain academic traditions (UC Berkeley under Bennyhoff; Sonoma State University under Fredrickson), the concept of identifying stratigraphically and temporally distinct archaeological assemblages is key to archaeological analysis worldwide. Examining changing archaeological patterns over space and through time requires the definition of an assemblage within all or portions of a site that can be placed within a distinct period of time. The approach that we advocate here is detailed in Chapter 6 but consists essentially of combining chronological data (bead or projectile seriation, obsidian hydration, radiocarbon dating) with stratigraphic and geomorphological data to divide the record into meaningful units of time.

This strategy is not to be confused with a simple listing of time periods represented ("there is evidence for site

occupation during the Middle and Late Periods"), but instead should include a starting and ending age for component occupation bounded by horizontal and vertical distribution at a site ("a Middle Period occupation dating to between 1800 and 1550 cal BP is identified in Control Unit 2 between 20 and 40 centimeters below surface"). Under this method, it is acceptable to expand the temporal range of a component across and beyond period designations. In addition, portions of sites that lack temporal continuity can be classified as "undated" or "residual" components; while artifacts from these contexts might be discussed in the reporting of assemblages, they offer much less analytical power than dated component contexts.

To appropriately identify comparable temporal components—the fundamental objective of archaeological investigations—the following must be undertaken: (1) use Scheme D (Groza et al. 2011) for period designations (a component can cross period boundaries); (2) carefully examine and present site stratigraphy (nature and thickness of cultural deposit[s]); assess integrity); (3) appropriately select and interpret radiocarbon samples (e.g., single shell, carbonized annuals [seed, nuts] preferred, explicitly state calibration curve, apply reservoir correction on shell); (4) present sourced obsidian hydration ranges, eliminate outliers (Chauvenet's criterion), indicate calendar age conversion used, use coefficient of variation statistics (\leq 25% for discrete component), apply effective hydration temperature (EHT) corrections (Rogers 2008, 2010); (5) identify temporally associated artifacts; and (6) adequately document the rationale for component identification.

TEMPORAL COMPONENT IDENTIFICATION

Required before addressing other research issues. **Components should be:**

- Adequately documented
- The focus of site analysis

Field:

- Examine horizontal and vertical site structure
- Track location of temporal indicators
- Adjust field methods to findings

Laboratory:

- Select radiocarbon samples
- Select obsidian for source and hydration analysis
- Identify temporally diagnostic artifacts (projectile points, beads)
- Combine site structure and temporal data to search for patterns

Documentation:

- Detailed rationale for components
- Use charts and figures for visual presentation
- Problem solving e.g., conflicting temporal data; mixed data
- Use only component-associated data for detailed analyses

TEMPORAL TRENDS IN OCCUPATION (Chapter 7)

Three distinct chronology research issues are: (1) exploring temporal trends using radiocarbon dates; (2) refining the appropriate use of obsidian hydration as a chronological tool; and (3) refining the accuracy of the Scheme D chronology.

A synthesis of nearly 1,600 radiocarbon dates from the Bay-Delta Area reveals varied and patchy spatial coverage (with clear data gaps in the North Delta region, the outer coast, and upland areas), and several time segments lack adequate data for the region as a whole. In particular, temporal components from contexts older than 4000 cal BP are infrequent (the Early and Middle Holocene) and those predating 6000 cal BP are very rare in the Bay-Delta Area. In addition, a decline in the number of temporal components in the Scheme D Middle 4 Period (1200-930 cal BP) is notable, and Native occupation components that post-date founding of the Spanish missions (174-115 cal BP) are poorly represented. More dates from good contexts are needed to try and fill these data gaps and better assess the role of social and environmental factors in structuring regional and Bay-Delta Area-wide temporal trends.

TEMPORAL ISSUES AND RESOLUTIONS

Radiocarbon Gaps:

- Older than 4000 cal BP
- Younger than 174 cal BP
- Outer Coast, Uplands & North Delta

Develop Napa Obsidian Hydration Rate:

- 5-10 specimens in secure association with AMS-dated organic material
- Buried or stratified assemblages

Develop Annadel Obsidian Hydration Rate:

- 5-10 Annadel obsidian specimens in secure association with organic material that can be AMS dated
- Stratified sites with multiple components
- **Refining Scheme D:**
- Shell beads associated with human burials or AMS-dated organic material
- Proper identification of bead types
- Direct AMS dates on beads, and oxygen isotope readings to correct for marine reservoir effect
- Paired AMS dates and temporally diagnostic bead types

Obsidian hydration is an excellent tool for providing an age estimate to a site. Unlike radiocarbon dating, the age estimate from obsidian hydration is from artifacts themselves, and therefore offer age estimates directly related to human behavior (although post-depositional factors can impact hydration rim thickness). Attempts to define an obsidian hydration rate for Napa Glass Mountain obsidian have yielded mixed results. Rates that include corrections for EHT, and those that do not, have been found to yield comparable results for surface and near-surface deposits, and none successfully predict the age of deeply buried contexts as measured by radiocarbon dating or shell bead chronologies. Sites with buried components containing Napa Glass Mountain obsidian and associated dateable organic material can help to address this issue. Ideally, these contexts will be stratified and offer comparable near-surface and buried components.

All previous rates have estimated the age of Annadel obsidian based on comparisons with Napa Glass Mountain obsidian. Sites with good association between Annadel obsidian and dated organic material could be synthesized to generate an acceptable rate.

The establishment of the Scheme D chronology (Groza et al. 2011) was an important milestone in our understanding of central California temporal trends (it also demonstrated that Scheme B of the 1970s is inaccurate and obsolete). Refinements in the Scheme D chronology (which is based on changes in shell bead types), however, can be made in the future. Some minor areas of ambiguity around the timing of key transitions (such as the start of the Early/Middle Transition Period) are identified based on recent direct Accelerator Mass Spectrometry (AMS) dating of beads, although changes in marine reservoir correction through time hamper the precision of this method. Enhancing precision of Scheme D will require comparison of direct dates on beads with associated, dated organic materials, such as human bone and charred plant remains. The former is preferred, particularly if dated beads are recovered from the burials and can be directly associated with the interred individual.

SETTLEMENTS IN SPATIAL CONTEXT (Chapter 8)

This research domain includes: (1) San Francisco Estuary Adaptations; (2) Discerning and Modeling Settlement Organization; (3) Construction, Structure, and Function of Bay-Delta Area Shell Mounds; (4) Bay-Delta Area Sedentism – Causal Factors and Trajectory; and (5) Seasonality of Occupation - Insights from Shellfish Harvesting. This research domain explores various facets of understanding how Native Americans organized themselves across a diverse and changing landscape that included the San Francisco Bay estuary, as well as a variety of inland and open coast settings. Settlement trajectories are explored a number of ways within the five research issues, with some taking a macro-approach to understanding changes over time in regional occupation patterns, while others examine issues tied to seasonality, settlement permanence, or function at a single site. Invariably this discussion places considerable attention on the numerous mounds and middens that ring the San Francisco Bay.

Issues include those focused on broader patterning across the bay and fine-grained analyses of single sites to determine the nature of local occupation through time. On a regional scale, theoretical models such as the Ideal Free Distribution use ecological and cultural information to identify the most likely habitats to identify settlement. One such measure is the *Index of Cultural Significance* (ICS) which ranks resources based on the ethnographically recorded

SETTLEMENTS IN SPATIAL CONTEXTS

San Francisco Estuary Adaptations:

- Suitability from indices of cultural significance
- Ideal free distribution modeling
- Radiocarbon-dated site components
- Subsistence data required to check model
- Discerning/Modeling Settlement Organization:
- Previous studies argue for varied settlement patterns at bayshore sites
- Seasonality data:
 - o Plant/animals restricted to single season
 - Isotopic analyses of shellfish
- Site Features:
 - Storage pits
 - o Residential versus non-residential architecture

Bay Area Mounds:

- Ceremonial versus residential uses of mounds
- Presence of house floors?
- Investigate site formation processes geoarchaeologically
- o Microconstituent analysis
- Accretional versus intentional construction

Bay Area Sedentism:

- When did sedentism arise in the Bay Area?
- Did settlement permanence decline or vary over time?
- Seasonality of Occupation:
- Shellfish isotope studies provide seasonal and month-ofdeath timing of occupation
 - Multiple shell samples from well-dated contexts subject to oxygen isotope analysis

importance of plants and animals. Subsistence data and broad patterns of settlement measured through radiocarbon dating can test and refine the general predictions of habitat suitability.

Discerning site-specific occupational histories is the focus of this domain's four research issues. A topic of central concern is whether bayshore mounds are accretional deposits formed by use as habitation sites and/or processing events, or ceremonial features constructed and used for feasting and mortuary practices, or a combination of these elements. Linked with these studies is the origin of sedentism in the Bay-Delta Area—if mounds are residential sites, then when was the Bay first occupied by sedentary hunter-gatherers; if they are not, then where are the residential sites associated with the ceremonial mounds.

These issues can be addressed through the aggregation of site-specific seasonality studies. Within sites, the presence of storage pits or house floors evinces residential use, and geoarchaeological study can tease out site formation processes. Microconstituent analysis of site remains can provide seasonality data and evidence of feasting versus more habitual consumption. Isotopic analysis of shellfish (which is highlighted) can provide either seasonal or month-of-harvest data to reconstruct the seasonal use of individual sites. Sufficient site-specific analyses also will allow for broader syntheses of regional settlement.

EXPLORING CHANGES IN DIET AND HEALTH (PART 1: VERTEBRATE FAUNA; Chapter 9)

This research domain includes eight research topics, broken into two summary pages. The first is Vertebrate Fauna, focusing on: (1) Resource Intensification and Subsistence Regimes; (2) Fishing Trajectories; (3) Species-Specific Exploitation Histories; and (4) Dogs as Walking Larder for Feasting or Tough Times.

Resource intensification, as measured through the relative proportion of high- versus low-ranked animal taxa, is a prominent aspect of archaeological study in the region (invertebrates and plants can also be used). Faunal studies by Broughton at Emeryville shell mound and elsewhere have shown a consistent trend toward relative decreases in the proportion of elk, deer, sturgeon, salmon, and cormorants in Bay-Delta Area sites (along with a few notable temporal exceptions). This is interpreted by some as signaling increased population pressure, with over-exploitation of highranked taxa and resulting decreases in the net foraging efficiency of hunter-gatherers through time. More recently, the purely dietary motivation for foraging has been called into question, and potential non-subsistence motives for hunting and micro-environmental change cited as potential alternative causes of the observed diachronic hunting patterns.

Rigorous investigation of fish remains is much less common than analysis of vertebrate faunal remains.

CHANGES IN DIET AND HEALTH

Direct evidence of diet through faunal remains

Resource Intensification:

- Testing Prey Abundance Indices, Declining Foraging Efficiency and Resource Depression
- Marked by relative increase in "low-ranked" vs. "highranked taxa through time
- Also must account for environmental change and nonsubsistence foraging goals
- Requires assemblages of faunal bone with at least sizeclass level identifications

Fishing Trajectories:

- Fishing has been under-emphasized in studies
- Local habitats were exploited and there is strong regional patterning in key taxa
- Requires fish bone assemblages from wet-screened 1/16- and 1/8-inch mesh

Species-Specific Exploitation Histories:

- Local and site specific abundances of individual taxon deserve special attention
- Species of note: bat ray, sea otter
- Dogs as Walking Larders: Feasting vs. Food:
- Domestic dogs may be most common canid in interments and midden contexts
- Regional patterning in ceremonial vs. dietary uses
- DNA and Stable Isotope Studies are needed to track and understand these trends

Syntheses of fishing trajectories through time demonstrate a strong effect of site setting, with regional fish assemblages reflecting habitats found nearby. Given detailed sampling, a heavy reliance on smallerbodied fish, such as smelt and rockfish, herring, and surfperch, is documented, varyingly in emphasis depending on setting. Further studies of fish remains recovered using fine-grained wet-screened mesh (best obtained from bulk soil samples), will greatly aid in discerning the complex and divergent procurement strategies suggestive of different social and technological milieus that shaped historical fishing trajectories.

Research into species-specific exploitation histories provide opportunities to gain insight into broad changes in diet, the impacts of human exploitation, and changes in species life histories. Two examples are highlighted—sea otters and bay rays—although many others (such as herrings) are possible. The potential research value of each seemingly lower-ranked taxon (based on subsistence value) is discussed with respect to their social value. The record of exploitation of these two species is identified mainly through the aggregation of regional data.

Finally, canid interments have long been recognized as an integral part of the central California archaeological record, and canid remains are abundant in midden deposits at some Bay-Delta Area sites. Recent aDNA research by Byrd et al. (2013) show that domestic dogs may dominate these contexts, rather than coyotes or wolves (as previously suggested by some), indicating that dogs may have been periodically consumed in certain situations, such as during ceremonial feasting or famines.

EXPLORING CHANGES IN DIET AND HEALTH (PART 2: SHELL, PLANTS, ISOTOPES, AND ANTHROPOGENIC LANDSCAPES; Chapter 9)

The second set of diet and health-related research topics focuses on shellfish, plants, and bone geochemistry (stable isotope analysis), including: (5) Shellfish Gathering; (6) Plant Resource Extraction; (7) Diet and Health from Human Remains; and (8) Anthropogenic Landscapes.

Shell is a common constituent of Bay-Delta Area midden sites and the predominant taxa vary across time and space; the old bay-wide model, where shifts in shellfish use were uniformly linked in tight temporal fashion, is invalid. Future research should explore the role of social factors and localized environmental conditions in structuring the record. Changes in the relative abundance of shellfish species over time must consider ranking of shellfish resources, resource availability within the daily foraging range, the willingness of site inhabitants to procure shellfish on more distant logistical forays, territorial constraints, the role of environmental change, and the possible impact of overexploitation. Long-term trends are also heavily influenced by social choices regarding how efforts were placed on obtaining more costly resources. Future research could explore the social dynamics of procurement strategies and their potential impacts to various species.

Archaeobotanical studies conducted in the Bay-Delta Area suggest marked difference between interior and bayshore contexts with earlier acorn and small seed intensification in interior settings. Outstanding research

CHANGES IN DIET AND HEALTH

Social/Behavioral Aspects of Shellfish Gathering:

- Divergent trends in species emphasis, varying in time and space within bay area, now apparent
- Shifts may be due to localized environmental change or change in social factors
- Population packing and territoriality may be limiting factor in gathering of particular species

Plant Resource Exploitation:

- Intensity measured through ratios, while reliance measured by frequencies and ubiquity
- Timing of intensive acorn harvesting varies regionally but precedes small seed intensification
- Differences in interior vs. bayshore plant use
- Introduced domestics appear in Mission Period

Insights into Diet/Health from Human Remains:

- Studies of nutrition, illness, trauma on bones (Harris Lines, Enamel Hypoplasia)
- Stable nitrogen and carbon analysis for diet provide general dietary patterns
- Stable isotopes can provide information about weaning and residential patterns
- Studies require consent of Most Likely Descendant
- Construction of Anthropogenic Landscapes:
- Human landscape modification increased productivity of plants and forage for animals
- Burning as key management tool
- Can be identified in plant and faunal remains

issues for plant remains include defining localized histories of plant food orientation, timing of speciesspecific intensification, the role of scheduling conflicts in resource orientation, and the adoption of Old Word domesticates and weeds following Spanish contact. Eurasian crops may also be used to identify Mission Period archaeological deposits.

Bioarchaeological work can take two forms—osteological analysis/direct examination of human skeletal remains, and stable isotope studies. The former can provide information on nutrition and health, showing periods of dietary stress and malnutrition as well as evidence of trauma. Stable isotopes reveal broad dietary patterns including marine versus terrestrial diet, and animal versus plant components of the diet. More recently, stable isotope studies have identified patterns of weaning in children and residential patterns. Future research, undertaken with the permission of the MLD, can continue to build a database of individual dietary histories that complement the subsistence record found in plant macrofossils, shell, and animal bone.

Growing evidence identifies a pattern of localized burning by Native Californians that created mosaic vegetation communities to increase overall productivity. In contrast to resource depression models, burning would have increased plant yields and may have increased artiodactyl and other animal populations through the production of increased forage. The extent and onset of burning remain unresolved.

THE IMPORTANCE OF TECHNOLOGICAL CHANGE (Chapter 10)

Two technological-oriented research issues are presented: (1) milling tool design changes in relation to adaptive strategies, plant values and productivity, and archaeobotanical evidence; and (2) development of the bow and arrow in time and place.

Handstones and millingslabs represent а comparatively expedient technology that functioned within a settlement-subsistence system organized around frequent residential moves. They represent a flexible, timeminimizing adaptive strategy of low investment. Mortar and pestle use reflects greater residential stability, representing an energy-maximizing strategy, emphasizing delayedreturn, with storage and high technological investment. Most commonly processed with these tools are nut crops (e.g., pine nuts, acorns) and small seeds, available at different times of the year as sequential, complimentary resources. Acorns and pine nuts have high return rates, exceeding many small seeds, and can last for a year or more in the shell without spoilage. Although archaeobotanical evidence does not suggest a difference in the types of plant foods associated with diachronic changes in milling technologies, previous

TECHNICAL CHANGE

Milling Tools:

- Handstone/Millingslab expedient technology, residential mobility, time minimizing, low storage investment.
- Mortar/Pestle acorn intensity, residentially stable, economic intensification, energy maximizing.
- Establish timing of mortar/pestle introduction by sub-region; correlate with archaeobotanical remains, economic developments, and settlement systems.

Bow and Arrow:

- No projectile point typologies exist for the Bay region
- Stockton serrated arrow point

 Independent development
 - Discrete distribution
- Cultural Transmission

 Guided Variation
 Indirect Bias
- Social and Economic Change
- Social and Economic Change
 Cultural and Ethnic Continuity

research shows that the proportions of specific plant foods in the diet changed, especially acorns and small seeds, reflecting increasing storage and use of off-season resources. This transformation appears to track with evolving patterns of labor organization, increasing residential stability, and the overall intensity of plant use (Basgall 1987; McGuire and Hildebrandt 1994; White et al. 2002:536–537; Wohlgemuth 2004). Surplus foods, like small seeds, also may have served as barter with neighbors, as regional economic integration increased through the Late Period (e.g., DeGeorgey 2016; Rosenthal 2011a).

The bow is an immensely better weapon than the atlatl but was inconsistently adopted across time and space, from different directions, and by alternate forms of cultural transmission, ultimately leading to smaller economic and political groups (Bettinger 2015:149–152). The earliest recognized arrow point in the Bay-Delta Area is the independently developed, deeply serrated, obsidian, Stockton Series (e.g., Dougherty 1990; Johnson 1940). Earliest examples are found in late Middle/Late Transition Period components (circa 745–685 cal BP), continuing through the Late Period; arrow points were used in the southern Sacramento Valley as much as 200 years earlier. Bettinger (2015:98) suggests that the arrow's variable and delayed introduction in the Bay-Delta Area was due to: (1) an emphasis on group hunting requiring shared quarry (e.g., surround hunts and drive fences, fire-drives, pit-traps, snares, nets, dogs, and decoys); or (2) the dart and atlatl may have been a better hunting implement for waterfowl common in the marshes and estuary of the Bay-Delta Area. The Stockton serrated point was adopted through *indirect bias*, acquiring the basic technology through trial and error, suggesting *in situ* development and cultural continuity from the Middle/Late Transition through the Late Period. Bettinger (2013, 2015:149–152) has argued that adoption of the bow and arrow increased kin group autonomy, led to private resource ownership, and initiated a settlement shift to less-populated interior woodlands and prairie.

HUMAN DEMOGRAPHY AND POPULATION MOVEMENT (Chapter 11)

This research domain includes: (1) reconstructing regional and local population movements; (2) pre-contact demographic transitions; and (3) violence-related activities.

It is now possible to apply mitochondrial DNA (mDNA) analysis and comparative linguistics to explore population movements and genetic relationships. The challenge for the Bay-Delta Area is to reconstruct how the complex spatial configuration of Coast Miwok, Wappo, Patwin, Bay Miwok, and Ohlone languages at Spanish contact developed. Ideal free distribution modeling (Codding and Jones 2013) stresses that high ecological diversity is a necessary condition for the emergence of linguistic diversity, while areas with low ecological diversity, and subsequent low population, should witness full population replacements. Conjectured migrations include proto-Penutian or proto-Utians/Yok-Utians displacing Hokan language speakers, followed by the Meganos Intrusion of people from the Delta evidenced by violence increased and dismemberment/cultural modification of human bone. The last suggested migration is the Patwin's entry into the northeast edge of the Bay-Delta Area. Information on an individual's life history can be obtained through a variety of empirical data (e.g., stable strontium, sulfur isotopes, stable oxygen, nitrogen isotopes, and mDNA).

Much research is needed to understand the demographic trends in the Bay-Delta Area that

culminated with the very high contact-period Native American population densities (between six and 15 people per square mile). Such studies must consider adaptive change, population pressure, subsistence stress, socio-economic change, climate change, and carrying capacities. New insights are aided by consideration of production costs; foraging efficiency; settlement permanence; the reliance on costly, but efficient technologies; and the nature of the political structure needed to handle resource asymmetry.

Trends in pre-contact violence and conflict are primarily explored through evidence of cranial vault fractures, projectile injuries, and forearm parry fractures. When these are concentrated among young males they are inferred to be traumatic injuries from intergroup warfare. Dismemberment/skeletal element removal is often tied to avenging prior deaths, proof of successful conflict, or symbols of supernatural protection and spiritual power. Evidence for such events includes multiple projectile point wounds and haphazard burial of like individuals. Discerning temporal trends of violence may provide insight into increased social stratification, individual-driven status acquisition, or in-migration. Late Holocene trends in violence-related activities lead to insight into warfare, territoriality, contested social boundaries, status and social complexity, and population pressure; however, this cannot be done without a fine level of chronological resolution.

HUMAN DEMOGRAPHY ISSUES AND RESOLUTIONS

Reconstructing Population Movements:

- Comparative linguistics
- Ideal free distribution modeling
- Population migrations
- Mitochondrial DNA of burial populations
- Reconstructing a Life History
 - Stable strontium/sulfur isotopes location
 - Stable oxygen and nitrogen isotopes diet
 - Mitochondrial DNA genetic relationships

Demographic Transitions:

- Well dated burial assemblage populations
- Subsistence data
- Juvenility Index
- Oxygen isotope analysis age of weening and dietary differences
- Change in health status
- Changes in site size, number of sites/occupation components per unit of time
- Change in size of burial populations

Violence-Related Activities:

- Detailed analysis of human remains
- Perimortem injuriesAccurately date the remains
- Direct dating
- Dating well-associated material
- Compare to well-dated sites within Scheme D
- Native American Most Likely Descendant approval for analyses

TRACKING TRENDS IN SOCIAL INTERACTION (Chapter 12)

The four major topics focusing on societal structure and group interaction are: (1) assessing assertions of socio-political complexity; (2) role of gender in social interaction; (3) animal interments—a window into ceremonial activities; and (4) inferring social patterning from intra-site spatial trends.

Ascribed status and hierarchical inequality are considered to have emerged during the Late Holocene in the Bay-Delta Area. It is uncertain whether or not this was a steady or fast process, when it emerged, and how it persisted. Such research focusses on offerings interred in graves, and the presence of numerous items in a subset of the population that crosscuts age and sex. It is also based on the assumption that the treatment of an individual at death reflects their status in life. However, mortuary offerings may also reflect social roles and memberships tied to age-grade patterns that cross-cut kinship lines, reflecting increasing multi-faceted social obligations.

Much more work is needed to understand the social meaning of mortuary-associated offerings. Mortuary practices, as they pertain to males and females, can also reflect aspects of social identity and interaction. Functional items in burials might reflect gender roles or labor categories, with only men

TRENDS IN SOCIAL INTERACTION

Socio-Political Complexity:

- Analysis of cemetery populations ascribed status and hierarchical inequality or social strategies as stabilizing forces
- Grave offerings by age and sex
- Quantity of grave offerings by individual
- Examine production costs, of grave-associated items
- Diachronic investigations

Mortuary Items and Gender Roles:

- Types of items can reflect functional categories
- Correlation of items by sex can reflect gender roles
- Bioarchaeological studies of work-related skeletal stress by sex

Animal Interments:

- Animal sacrifice and disposal, retaining portions for ritual activities
- Dedicatory interment
- Expedient disposal
- DNA analysis to determine canid species

Social Patterning and Community Organization:

- Intra-site spatial patterns function and space
- Residential versus non-residential structures
- Spatial distribution of burials, features, activity areas, and subsistence remains
- Household size and structure

buried with hunting items and women with grinding and weaving equipment; conversely, they might reflect a lack of division of labor. Further, patterns in the distribution of elaborate grinding tools over time can reveal changes in status and authority by females if so associated.

Animal interments can provide insight into trends in ceremonial and ritual events, and sociopolitical complexity. A variety of animal interments, particularly dogs, are documented during the last 1,000 years in the Bay-Delta Area. Most were sacrificed and ceremonially interred; some may also represent personal property or food offerings to the dead.

Sedentism invariably results in heavier exploitation of local subsistence resources, leading to more limited sharing networks, more resource competition, and differential access. Regulatory mechanisms for community integration likely emerged, such as inheritance rules, conflict resolution, and suprahousehold organization. Material correlates of social relationships include increased village population, new forms of community organization and layout, formalization of public space, and shifts in household size and structure. Research should focus on discerning spatial patterning in residential or ceremonial activities through spatial organization of structures, the location of features and activity areas, spatial distribution of burials, and patterning in subsistence remains and artifacts.

RECONSTRUCTING REGIONAL INTERACTION SPHERES (Chapter 13)

The nature, scale, stability, and temporal and spatial orientation of supra-territorial interactions are manifested through trade and exchange networks, travel corridors, and socio-ideological interactions. Here we focus on three important items of trade and exchange: (1) obsidian; (2) *Olivella* beads and clamshell disc beads; and (3) abalone ornaments.

Obsidian is common in Bay-Delta Area sites, with several notable trends in temporal and spatial distribution: (1) Napa Glass Mountain obsidian is always predominant; (2) obsidian from the eastern Sierra does not penetrate the North Delta and Northwest Bay regions; (3) eastern Sierra obsidian is increasingly more common along a north-south gradient in the South and East Bay; (4) nearby Mt. Konocti and Borax Lake obsidian do not enter the Bay-Delta Area; (5) there is a dramatic increase in the percentage of obsidian to chert in the Middle/Late Transition and Late Periods; (6) there is a decrease in the percentage of Sierran sources during Late 2 Period; and (7) Napa Valley obsidian shows a peak use between about 1000 and 850 cal BP, and a strong drop in the frequency of samples circa 380 cal BP, perhaps coinciding with initial

RECONSTRUCTING REGIONAL INTERACTION SPHERES Trade and exchange networks, travel corridors, and socioideological interaction **Obsidian Exchange:** Patterns of temporal and spatial distribution 0 North Bay versus East and South Bay Local versus Sierran sources 0 Chert versus obsidian frequencies 0 Changes in frequency of Napa Valley obsidian 0 Olivella and Clamshell Bead Manufacture/Trade: Chronology 0 Middle Period peak in diversity Oval and round wall beads Northern Late Period clamshell disc beads 0 Minimal evidence for Olivella bead manufacturing Some forms specific to central California 0 Abundant evidence for regionally limited clam disc manufacturing in Late Period Stable isotope analysis to study bead origins Abalone Pendant Exchange: Insight into social organization and ritual Species source and manufacture locations 0 Trade and exchange networks 0 Control over manufacturing 0

Diachronic trends in South Bay

European contact. Several studies have identified breaks in distribution patterns of raw materials as indications of directionality of trade rather than a strict distance-decay relationship between sources.

Beads and ornaments of the *Olivella biplicata* (the purple olive snail) were widely traded throughout the late Holocene. Studies of formal variations in these bead types focus on: (1) chronological stages (e.g., Middle Period diversity and first use as commodity); (2) social importance; (3) manufacture (minimal evidence), political complexity, and elites; (4) regional interaction networks (coastal access?); (5) implications in mortuary contexts; and (6) economic importance (e.g., currency). A swift change came post 450 cal BP when clam disc bead manufacturing swept across the Northwest Bay and North Delta regions. One research focus is the study of bead origins and identification of source areas.

Abalone (*Haliotis*) pendants and ornaments were widely traded and highly prized. They had four functions: decoration, social organization, religious, and subsistence. Important issues for abalone research include: (1) source and manufacture locations; (2) nature of trade and exchange networks; (3) were source locations the focus of exploitation?; (4) did different species have related source locations?; (5) was there a shift in the choice of species over time?; (6) were abalone ornaments manufactured near coastal sources, or traded as whole pieces and formed inland?; and (7) did a tight control over manufacturing in the Early and Middle Periods give way to local manufacturing centers in the Late Period? Avenues of research include source locality, species identification, and diachronic trends in precontact use in the South Bay where Monterey abalone would have been more readily available.

INDIGENOUS ASSIMILATION AND PERSISTENCE (Chapter 14)

Indigenous assimilation and persistence issues focus on reconstructing the Native American social landscape just prior to and during the Mission Period by tracking assimilation and persistence. A potent research tool is the CDM, a systematic record of Native baptisms, marriages, and deaths based on mission record data and all available ethnographic studies (Milliken 2006, 2010). Archaeological research is also needed to gain insight into this issue.

Between the 1770s and 1830s, the majority of tribal people of the San Francisco Bay-Delta Area left their native communities and moved to Missions San Francisco Asis (Dolores), San Rafael, San Francisco Solano, San Jose, and Santa Clara. Populations of between 200 and 400 individuals, living within well-defined tribal territories, variously dealt with Spanish colonial settlement, mission outreach, mission life, escape and capture, disease, and depopulation. The only systematic written sources available to reconstruct Native life during this period are the Franciscan mission records of baptism, marriage, and death. The mission records also contain the only information regarding the original home groups of the vast majority of Native people in the Bay-Delta Area. These data make it possible to track declining village populations, as individuals and groups were assimilated into the missions.

INDIGENOUS ISSUES AND RESOLUTIONS

Community Distribution Model:

- Reconstructs Tribal landscape
- Tracks indigenous assimilation
- Assesses indigenous persistence
 - Access at Bancroft Library, Berkeley
 - (https://dash.berkeley.edu/xtf/search)
 - Use and refine CDM maps and database to identify local and regional patterns in population density and baptism rates, by region
 - Examine marriage networks and social outreach data
 - o Examine sequential events of Spanish colonialism
 - Study ethnographic data on village abandonment, resistance, refuge, and indigenous autonomy
 - o Expand, revise, and annotate the CDM database

Archaeological Data:

- Obtain fine-grained chronological data for Late 2 Period and Mission Period sites
- Identify sensitivity assessment, based on records of baptism, for indigenous persistence
- Identify rapid changes in orientation, technology, or material culture, and introduction of non-native plants and animals

The CDM identifies mapping "regions," which estimate the territorial extent of communities or tribelets, which were present throughout the Bay-Delta Area. Mission record studies can record the sequential events of Spanish colonialism and subsequent emptying of tribal territories, tracking each landholding groups' history of migration to the missions and survivorship in them. Data on cumulative baptism rates of each identified region, for example, relate to patterns of assimilation, by mission, often supporting Bennyhoff's (1977) general principle that rancherias close to missions generally sent their people for baptism earlier than villages at greater distances, resulting in a "domino" effect outward from each mission.

Ethnographic studies also detail village abandonment due to disease, attacks from neighboring groups located further from the missions, and population decline. Studies on resistance, refuge, and indigenous autonomy offer clues on this persistence, particularly in relation to archaeological models of post-mission settlement. Drawing on CDM data, an initial sensitivity assessment based on baptism records shows the likelihood that evidence of persistence in indigenous occupation in the Bay-Delta Area will be present in the archaeological record (*High* likelihood 0–40% baptized; *Moderate* likelihood 40–80%, and *Low* likelihood 80–100%). Archaeological evidence of this persistence would include rapid changes in technology and material culture at the end of the Late Period into the Mission Period, particularly the inclusion of European items such as ceramics, glass, non-native plants, and non-native animals.

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6. SITE AGE AND OCCUPATION HISTORY

Here we focus on chronology and component identification, critical aspects of analysis that are essential to any further research. We first present the appropriate temporal scheme to be applied and then discuss analytical methods for selecting and interpreting radiocarbon samples and obsidian hydration/ sourcing information. Since archaeology is fundamentally a comparative science, the primary and initial consideration for any archaeological research is to identify, isolate, and effectively sample temporally discrete units of study. Ultimately, if single-period site components are not identified, many research issues cannot be adequately addressed. Higher-order research problems require chronologically and behaviorally cohesive assemblages to understand how and why cultures changed through time in a particular place; or differed geographically during any one time period. Here we articulate the component-based approach, and discuss the issues and problems associated with common methods of dating archaeological deposits in the Bay-Delta Area.

COMPONENT-BASED APPROACH TO THE ARCHAEOLOGICAL RECORD

Important methodological considerations underpinning this approach revolve around an awareness of the dynamic nature of hunter-gatherer land use, and the implications of these patterns for site formation processes. As is often noted, any given location could have served as a residential base during part of the year, a resource collecting camp during another, and a processing locale during still a third. When hundreds of years are added to the equation, it becomes even more difficult to unravel the remains of potentially disparate land-use patterns. The easiest way to learn about hunter-gatherers from their archaeological remains is by isolating spatially discrete and chronologically restricted deposits, or "components." This approach minimizes the effort of trying to sort out badly mixed or jumbled accumulations and also avoids building assemblages and interpreting pre-contact behavior based on intermixed cultural remains throughout a site area.

Fredrickson (in White et al. 2002:45) defines components as "temporally related aggregates of artifacts, features, and other residues representing the material remains produced during a specific time span of residence or other use at a specific location, ideally found associated with a definable horizontal/vertical fraction of a site or landform." Component chronological assignments are most reliable when based on several independent lines of evidence, including bead or ornament seriation, point types, regional comparison ("cross-dating"), obsidian hydration, and ¹⁴C dating. However, integrity is relative, and more often defined by analytical utility. Operationally, one can expect considerable variability in temporal resolution: some components may have mixing and are therefore more inferential, and others may be stratigraphically well segregated and chronologically well defined. Some components represent very brief spans of occupation, while others were accumulated over hundreds of years of similar activity.

This methodological approach recognizes that a component is first a geomorphic phenomenon, and second an inferential archaeological unit. The methodology involves the deployment of both field and lab resources in a feedback system aimed at isolating and defining individual temporal phenomena. This includes detailed examination of site stratigraphy from a geological perspective (Waters 1992), which, in central California, requires that natural soil horizons be distinguished from physically separate depositional strata, including buried soil horizons. This fundamental distinction is rarely made, even in modern archaeological studies. With respect to sampling strategy, initial site investigations should seek to document general chrono-stratigraphic structure and spatial patterning, define the range of components available, and attempt to isolate the horizontal and vertical distribution of temporally discrete assemblages (Mikkelsen 2013).

CHRONOLOGY AND DATING

Here we discuss the objectives and methods of chronology building and stress how outdated approaches need to be abandoned. Then, the methods used to build an up-to-date calibrated radiocarbon chronology are presented, followed by an approach to most appropriately use obsidian hydration as a chronological tool.

Objectives, Methods, and Outdated Approaches

A fundamental objective of archaeological investigations is to define the age of anthropogenic deposits, thereby identifying single-component assemblages. Ideally, the temporal extent of site components will be of sufficient resolution to allow detailed study of adaptive, technological, and social changes through time within the San Francisco Bay-Delta Area. Using Groza et al.'s (2011) Scheme D chronology, there is potential to distinguish occupation components with a temporal resolution of 165 to 270 years duration during the last 1,500 years of the occupation sequence, and about 500 to 600 years duration for the preceding 1,500 years. Data from well-dated site components can then be used to address higher-order issues of hunter-gatherer occupation in the region.

Accomplishing this fundamental baseline objective requires an analysis of site structure to determine the nature and thickness of cultural deposits and whether they retain physical integrity. An assessment of site-formation processes and the extent of post-depositional disturbances from a geoarchaeological perspective is crucial to defining such components. This is particularly important for sites that may lie buried directly below, or have been impacted by, historical and modern construction events. Such disturbance events can have a significant impact on site integrity. Radiocarbon dating is also essential for assessing the research utility of re-deposited midden sediment, since it provides substantive insight into whether the material was derived from a single, multi-component, or mixed site.

Very different approaches are needed to discern discrete occupation events depending on the type of site under consideration. For midden sites, the objective is to accurately assess the length of time it took for the cultural deposits to accumulate. This objective is relatively straight-forward for small sites or loci, although thicker middens naturally require more dates than thin middens. Very large sites with thick deposits, such as shell mounds, are much more challenging, since they were generally occupied for long periods of time, and portions of the sites often built up at different rates. As such, similar depths in different areas of a site may have been occupied at very different time periods, and occupational hiatuses can occur as well. Dating of such sites requires detailed stratigraphic understanding in combination with the use of a sequence of dates at multiple locations. Such a technique provides a basis for understanding the full time-range of occupation and the spatial extent of occupation for a particular period.

Determining the time span of site occupation is arguably the single most important facet of archaeological investigation, since the utility of all subsequent research themes rests on this foundation. The amount of project funds and the analytical effort and rigor used to address this topic, however, are often relatively minor. Successful dating efforts invariably entail assessing initial dating results and then submitting additional samples to resolve outstanding issues. The following discussion outlines investigative protocol for ensuring that this research theme is addressed using state-of-the-art standards.

Selecting and Interpreting Radiocarbon Samples

Whenever possible, single items will be submitted for radiocarbon dating (such as one piece of a carbonized plant remain, bone, or shell). This invariably requires the use of the AMS technique, and sometimes micro-sample AMS counting, rather than conventional dating (which requires larger samples). Although AMS dating is more expensive than conventional dating, it provides both greater precision (i.e., a date with a smaller standard deviation) and more accuracy. Greater accuracy is obtained because

submittals of multiple pieces or fragments (such as scattered charcoal fragments or several shell fragments) often yield averaged dates from a series of possibly disparate events. Such dating can potentially mask the presence of two discrete occupation events that have been mixed by post-depositional processes (e.g., Breschini and Haversat 2005).

Reliance on carbonized annuals (such as seeds or nuts) is preferred, since it avoids the problem of dating wood charcoal derived from old trees—the "Old Wood" effect (Schiffer 1986). Shellfish dating also needs to take into account the differences in radiocarbon content between terrestrial and marine systems (generally referred to as the reservoir effect). Typically, marine shellfish provide measured radiocarbon ages considerably different than terrestrial carbon samples from the same setting, as it takes 200–500 years (depending on the ocean) for present-day carbon dioxide in the atmosphere to be incorporated into and distributed through ocean water (Beta Analytic 2015). It is therefore necessary to apply an appropriate reservoir correction (varied by geographic location). As demonstrated by Ingram (1998) in a study of paired charcoal and oyster shellfish samples throughout the long West Berkeley shell mound (ALA-307) temporal sequence, one must take into account changes in the radiocarbon reservoir driven by location and age. Finally, it is strongly recommended that multiple dates be obtained from each component. Typically, a significant percentage of radiocarbon dates are inaccurate, due most often to post-depositional disturbance. As such, several dates are needed from each site component to assess occupation duration and to exclude inaccurate dates.

A series of basic analytical exercises is needed to gain strong insight into chronology:

- Determining the duration of occupation.
- Assessing whether or not spatially discrete occupation events within a site are temporally discrete.
- Assessing whether any of the radiocarbon dates do not accurately reflect the actual occupation event.

Measured or conventional radiocarbon dates cannot be used to address these issues. Instead, dates must be calibrated to determine their probable age in calendar years before 1950 (Stuiver et al. 1998). This ensures that secular variations in the amount of atmospheric radiocarbon over time is taken into account (Reimer et al. 2004; Stuiver and Reimer 1993; see *Radiocarbon Calibration and Reporting*, page 6-4, for details). Furthermore, as Telford et al. (2004) cogently demonstrate, calibrated mean intercepts should not be compared, since these are not accurate assessments of the probable age range of a sample. Instead, weighted averages, probability distributions, or statistical tests must be used to assess chronological issues. In this study, all dates are calibrated ages.

Using the Most Up-to-Date Chronology

Considerable progress has been made during the last decade on refining and understanding the region's chronology (Groza 2002; Groza et al. 2011; Milliken et al. 2007). These include: replacement of the old Scheme B chronology (Bennyhoff and Hughes 1987) with the Scheme D chronology; replacement of uncalibrated radiocarbon dates with calibrated dates; and the recognition that obsidian hydration is a much coarser-grained absolute dating technique that should not be used in place of radiocarbon dating.

The Scheme B chronology was constructed in the 1970s, although not formally published until 1987 (Bennyhoff and Hughes 1987). The temporal distinctions used in the chronology were based on seriation of *Olivella* shell-bead styles of short duration recovered from burials. Although this 14-part chronology has been widely embraced, it was built upon an imprecise foundation that involved a poor association between radiocarbon dates and the shell beads themselves. Dates were typically on charcoal from the same broad site component, and sometimes on bone collagen before accurate bone-dating techniques had been

developed. This Late Holocene chronology also predated the development of calibration curves to correct radiocarbon dates so that they accurately reflect actual calendar years (Groza et al. 2011:14–15).

The Scheme D chronology corrected these problems, in large part by directly dating a large sample of key shell bead types, applying a reservoir correction to these marine shells, and calibrating the dates (Groza et al. 2011). Notably, the resulting, much more accurate (and in some places quite divergent), 10-part chronology finally brought the timing of central California shell bead horizons into alignment with the chronology of shell bead horizons in southern California (Groza et al. 2011; Hughes and Milliken 2007). For a detailed comparison of the changes between the Scheme B and Scheme D chronologies, see Groza et al. (2011:Figure 1).

Therefore, it is important to keep in mind that most previous discussions of chronological issues in the region were based on the old Scheme B chronology and measured or conventional radiocarbon ages, rather than the new standard calibrated chronology. Moreover, dating was generally considered only with uncritical reference to mean intercepts (which have a very low likelihood of actually representing the age of the item in question), rather than age ranges based on standard deviations, probability distributions, or the use of median estimated probabilities of sample age. As such, prior dating discussions using Scheme B have little or no validity today, except in a historical perspective. The dates or date ranges previously used will not accurately reflect the duration of occupation, temporal comparisons with newly dated sites (unless previous dates are calibrated), or where occupation events fall within the revised sequence of periods in the Bay-Delta Area (see Table 3).

Unfortunately some scholars have continued to use the obsolete Scheme B chronology, creating confusion and making temporal comparisons very challenging. For example, Finstad et al. (2013), despite having developed chronological sequences at two large bay mounds based on a detailed suite of calibrated radiocarbon dates, classified them into temporal periods using the outdated Scheme B chronology. In doing so, they refer to their temporal sequence from 1100 to 250 cal BP as the Late Period, when this time span encompasses the Middle 4 and Middle/Late Transition Periods as well. Although this dating effort is readily converted to the modern chronological sequence (since it is based on clearly presented calibrated dating evidence), the authors lost the opportunity to consider the implications of their data with respect to the suite of cultural changes taking place during the latter part of the Middle Period into the Late Period.

Similarly, a number of recent studies of human health and violence have typically continued to use the Scheme B chronology (e.g., Bartelink et al. 2013). Converting these results to modern time periods is much more challenging and perhaps impossible, particularly if they have used a combination of radiocarbon dates (calibrated or not) and shell bead types to assign site components to a time period. Reassessing the adequacy of the trends identified in these studies, unfortunately, requires access to the raw data organized by site component, rarely provided in the publications. It is therefore important to always include laboratory reports with measured and conventional radiocarbon results in appendices; this will allow dates to be reassessed as updates to the radiocarbon calibration program are available.

Radiocarbon Calibration and Reporting (by Jack Meyer)

The suggested approach to calibration is based on the compilation and analysis of nearly 1,600 ¹⁴C dates from the study area. All available radiocarbon dates from archaeological contexts in the study area were calibrated using CALIB version 7.04 (Stuiver et al. 2014; see discussion of substantive results, page 7-1). Overall, this involved the compilation of 1,587 dates from 211 sites, from a wide range of sample types. These include charcoal (n=804), dietary marine shell (n=247), human bone (n=365), shell beads (n=125, mainly Olivella), and non-human bone (n=46). Dates on soil organics are not included in this study given their coarse-grained resolution and ambiguous association with cultural events (such dates can have value in assessing the timing of natural processes and bracketing the age of cultural events).

The calibration process involved a series of steps, with sample types treated differently.

- 1. Sample reporting was assessed to determine whether a ¹²C/¹³C ratio had been obtained (i.e., isotopic fractionation used to better estimate the true age of the dated material); generally this only applies to samples submitted post mid-1990s.
- 2. Any samples without corrections for ${}^{12}C/{}^{13}C$ were assigned an average ${}^{12}C/{}^{13}C$ value based on their material type.
- 3. Uncorrected dates (i.e., though without a ¹²C/¹³C value) were run through a spreadsheet provided by CALIB to obtain a "corrected" or conventional ¹⁴C date.
- 4. Dates on similar material types were then calibrated in batches using the appropriate curves and Delta-R for the different material groups, including a percentage marine correction, as appropriate, for samples of human bone that have measured ¹²C/¹³C values.

Choosing an appropriate reservoir correction (Delta-R) for marine shell is a challenging process, since there are potential differences between outer coast and Bay species owing to the effects of freshwater input on those in the Bay; or even between Bay species as habitats vary (Ingram and Southon 1996). The actual reservoir correction also varies over time as well. For example, Ingram (1998) conducted a study comparing charcoal and oyster shell dates from 15- to 30-centimeter levels at the West Berkley mound (ALA-307) dating from circa 1250 to 4900 cal BP. Estimated reservoir correction values fluctuated widely between -170 ± 90 and 870 ± 90 (averaging 200 years), with the highest values occurring late in the sequence (potentially reflecting drought conditions) and the lowest early in the sequence. Although these results suggest that reservoir values differed over time, it is also possible that an unknown portion of this variation is driven by archaeological context-related issues. This includes the lack of clear temporal and depositional association between shell and charcoal (only occurring in the same 30-centimeter excavation level), and the potential for dating old wood. A comparable study by Rosenthal and Kaijankoski (2014) of 56 paired mussel and charcoal dates from nine coastal Sonoma County sites revealed comparable variation across a 9,000-year Holocene time span, averaging a delta R of 263 years. These studies highlight the differences that time and space play in the amount of reservoir correction necessary to accurately convert shell dates to actual calendar years.

The approach we chose was to use a reservoir correction consistent with a geoarchaeological study conducted for Caltrans District 1 in northwest California (Meyer et al. 2011). This involved using a marine reservoir correction of 315 ± 50 for all sites north of the Carquinez Straits (as they fall within the northern California zone), while a marine reservoir correction of 285 ± 35 was used for all sites south of the Carquinez Strait (as they fall within the central California zone). These correction factors represent the weighted average of radiocarbon determinations from pre-bomb (i.e., AD 1950) shells obtained along these sections of the California coast, as compiled in the 14CHRONO (2010) Marine Reservoir Database.

In the reservoir correction process, we applied an additional correction for a small number (~20) of very late shellfish dates (those post-dating 815 ± 30 radiocarbon years). This was done because the default correction made pre-contact samples date well into the historic era (either historic/modern or actually cannot be corrected using the calibration program). We verified a series of these samples (with associated shell bead types) to see if they also needed to be corrected differently—all resulting calibrated dates appear to make archaeological sense. Similarly, shellfish assays predating 815 ± 30 radiocarbon years also appear to be calibrating correctly after a similar examination of context and other evidence. This is a bit surprising, but it may suggest that there is a shift in reservoir correction around the time of the Medieval Climatic Anomaly (1150–600 cal BP; see Figure 7, page 3-10). The reasons are unclear, however, since logically a dry spell should actually increase the marine influence in estuary contexts, thereby needing a greater reservoir correction). It should be noted that the possible reservoir effect on

freshwater shells has not been directly studied in the region, and could vary dramatically from one drainage to another (e.g., limestone or none), and across time.

Olivella shell beads were calibrated differently than dietary marine shell. For these beads, we used a reservoir correction of 265 ± 50 —which is the overall average for the entire California coast. This approach recognizes that we do not know where individual *Olivella* beads originated (some are certainly from the southern Channel Islands), but we do know they are not local to San Francisco Bay. This value is also very close to the 260 ± 35 used by Groza et al. (2011) in their study of shell beads.

Finally, human bone samples were corrected where possible to account for individuals who had heavy marine diets (thereby creating the necessity of correcting for the intake of older carbon). The approach we took was to use the actual ¹²C/¹³C values available for individual samples to estimate the percentage of marine influence, using a sliding scale (Appendix F). A human bone sample with a -20 ¹²C/¹³C value was considered to have a 100% terrestrial diet, while a sample with -12.5 was considered to have a 50% marine diet, and a sample with a ¹²C/¹³C value of 0 was considered to have a 100% marine diet. Individual samples were then calibrated accordingly using the mixed marine analysis in CALIB version 7.04.

Figure 29 shows the distribution of radiocarbon dates by material type for the five broad categories defined above in 200-year increments for the past 5,000 years (older samples, which comprise 7% of the total, are excluded from the graphs for better clarity of the late Middle Holocene and Late Holocene record). Also included for comparison are temporal components to assess the relative impact of material type on component-driven temporal trends. Median probability ages are plotted (rather than mean intercept values) because this value represents the point in the probability distribution for a given date where the estimated age is just as likely to be older than the value as it is to be younger. The large datasets, namely charcoal and marine shell, show a distinct pattern that is obvious in the dataset as a whole—a gradual increase of dates up until between 200 and 400 cal BP after which there is a distinct drop in the number of dates, related either to issues with the calibration curve, or the dramatic effect of European arrival on Native populations in the study area. A close look at the marine-shell dates shows a distinct peak in the number of dates between 350 and 400 cal BP, which could be related to the reservoir values and calibration curve used to correct these dates. Consequently, shells that date between 200 and 400 cal BP must be interpreted with caution until more accurate techniques for dating proto-historic-aged shell samples are identified by future studies.

Non-human bone has been infrequently sampled in the study area and appears to offer a fairly consistent record of trans-Holocene occupation, with no more than seven dates and five components in any give 400-year time segment. The human bone distribution is clearly the result of sampling bias, evident by the large number of dates between 4000 and 3000 cal BP from burials, almost all of them at CCO-18/H. The time span from 2000 to 1200 cal BP is the next-most sampled period with an increase in the number of dates, but with a limited variation in the number of dated components. Shell bead dates are also driven by sampling, as the vast majority of these beads were dated as a result of Groza's (2002; Groza et al. 2011) Scheme D dating project and subsequent shell bead dating research.

Reporting Obsidian Hydration Data and Definition of Cohesive Temporal Components

Obsidian hydration as a dating tool has become standard practice in the Bay-Delta Area, but a number of methodological issues continue to plague its application to archaeological questions. As mentioned above, it should not be used in place of radiocarbon dating owing to its much coarser-grained accuracy. In the following sections we present issues associated with obsidian hydration as a dating technique. Perhaps the largest misunderstanding in regards to obsidian hydration dating is the variability inherent in the calibration of rim values to years before present. Just as radiocarbon dates should be



Note: The scales on the graphs are different for each sample type.

Figure 29. Radiocarbon Dates and Components in 200-Year Intervals during the Past 5,000 Years for the Five Major Material Types in the Study Area.

presented both with an intercept or median probability age *and* the range of one- or two-standard deviation probabilities, it is important that the possible range of ages of obsidian hydration means is accounted for in reported values. Three important considerations should be made when interpreting obsidian hydration assemblages—eliminating outliers, defining discrete assemblages of obsidian, and properly reporting the inherent variation in hydration means (Figure 30).

Eliminating Outliers

The first step in interpreting obsidian hydration data should be to identify statistical outliers in a given assemblage. This can be accomplished through the use of Chauvenet's criterion. This statistical tool is designed to assess whether one piece of outlying data (in this case a hydration rim reading on an individual artifact) is likely to be spurious. Chauvenet's criterion is a statistical test that applies data to a Normal Distribution and identifies data that fall outside this expected distribution. Outliers can be determined in spreadsheet programs such as Microsoft Excel using the Normal Distribution function. The mean and standard deviation for all samples (including potential outliers) is first calculated. A probability statistic (p) is then calculated for each individual reading by calculating the probability for a given value (x) on a normal probability distribution, with the mean and standard deviation equal to those calculated for the sample as a whole. A second probability statistic (cc) standardizes the observations for the number of samples that were used to create the mean and standard deviation using the equation cc=1-(1/2n) where n is the number of samples in the population. If cc is greater than p, the value is an outlier and should be removed from the sample prior to calibrating the mean. Unfortunately, rate calibrations that include both EHT and calibration in a single equation (e.g., Hull 2001) cannot be subjected to outlier analysis using Chauvenet's criterion, as means and standard deviations are too large once rim measurements are converted to age estimates in years BP. As a result, Rogers' (2007a, 2007b, 2008, 2010) method, using EHT corrections for both elevation and depth below surface to convert raw rim measurements to adjusted rim measurements before applying a calibration equation, is preferable.

Identifying Chronologically Discrete Assemblages

Whether or not they can be securely placed to a calendar year, we advocate the use of coefficient of variation (CV) statistics to identify chronologically related contexts. The CV statistic entails a simple calculation that evaluates the extent to which a sample population clusters around the mean. The CV statistic is calculated by dividing the standard deviation by the sample mean. This type of measurement is appropriate for obsidian hydration results because of the variability inherent to these measurements. Any number of intrinsic and external factors are thought to affect the rate at which an individual piece of obsidian absorbs water, and various physical processes can affect the retention of a hydration band (Lloyd et al. 2002). Because of this, even obsidian samples introduced to the archeological record at precisely the same time and apparently subject to identical environmental factors will return a range of hydration readings. This is well illustrated by a number of single-event obsidian caches, all of which have never produced identical hydration measurements, but instead return sample standard deviations between about 0.05 and 0.70 (Table 16; Rosenthal 2012).

Although they are not identical, biface cache hydration readings do return low CV values on the order of 0.01 to 0.21. Obsidian deposited periodically over long periods will have substantially more variation around the mean and thus a higher CV value. We assume that obsidian hydration readings representative of a single time period will take the form of a normal (or Gaussian) distribution—i.e., a bell-shaped curve. So, we expect the majority of readings to cluster toward a mid-point (in this case the probable time of deposition), but with a range of variation around this central tendency. Normal distributions can be defined by two basic parameters—the mean and standard deviation. To the extent

INCORRECT TECHNIQUE

Step 1: Calibrate Rim Measurements for Each Sourced Obsidian Artifact from a Defined Context.

Sample of Napa Valley obsidian hydration measurements: Art. No. cal BP1 Microns 1825 1 3.5 2 3.6 1931 3 4.0 2384 4 4.1 2505 5 4.4 2884 6 4.4 2884 7 4.5 3017 8 4.7 3291 9 7.9 9105 10 8.0 9430

¹ – cal BP – calibrated years before present; based on Napa Valley obsidian conversion rate from Rosenthal (2005).

Step 2: Interpret the Results.

"There is evidence of site occupation spanning at least 1,400 years, between 3291 and 1825, with additional evidence of Early Holocene occupation as well."

CORRECT TECHNIQUE

Step 1: Determine Mean and Standard Deviation (s.d.) of Sourced Obsidian Artifacts from a Defined Context.

Sample of Napa Valley Hydration Measurements:	count	10
3.5, 3.6, 4.0, 4.1, 4.4, 4.4, 4.5, 4.7, 7.9, 8.0	mean	4.91
s.d. – Quantifies the amount of variation in a set of values; Excel: =STDEV(range).	s.d.	1.65
c.v. – The amount of variability relative to the mean: divide s.d. by the mean	c.v.	0.34

Step 2: Determine and Eliminate Outliers in the Data Set.

 (a) Calculate the probability (p) that each rim value falls within a normal distribution (bell-shaped) curve using the sample mean (the center of the curve) and standard deviation (the shape of the curve). In Microsoft Excel, use the function: "=Norm.Dist((frim value, mean, standard deviation].FALSE)" 	Rim Value 3.5 3.6 4.0	р 0.17 0.18 0.21	p-cc 0.12 0.13 0.16
e.g.,=Norm.Dist(3.5, 4.91, 1.65, FALSE)= 0.167, rounded to 0.17	4.1 4.4	0.21 0.23	0.16 0.18
(b) Calculate the standardized probability value (p-cc) to identify extreme	4.4	0.23	0.18
In Microsoft Excel, use the function:	4.7	0.24	0.19
$=[p]-(1/(2^{*}[count]))$ " e.g., =0.17-(1/(2*10)) = 0.12 If p-cc is negative, the sample is an outlier.	8.0	0.03	-0.01

Step 3: Recalculate the Sample Mean, Standard Deviation, and Coefficient of Variation (c.v.).

count	8
mean	4.15
s.d.	0.43
c.v.	0.10
_	_

Step 4: Interpret the Results.

- (a) Do the obsidian hydration data indicate a single temporal component (c.v. less than ~0.25 [Rosenthal 2012]), or do the data indicate a mixed assemblage (c.v. greater than ~0.25).
- (b) Using the mean and s.d. of the sourced obsidian, determine the hydration age range using a calibration formula (e.g., Rosenthal et al. 2005 for Napa Valley), and place within the appropriate temporal period(s) using Scheme D. Hydration mean of 4.15 microns = a mean hydration age of ~2560 cal BP, the Early Period. At one sigma (mean ± s.d), the hydration micron range is 4.58 – 3.72, or 3125-1835 cal BP, extending from the Early Period into Middle 1.
- (c) If necessary, strategically choose additional samples to refine component areas.
- (d) These calibrated obsidian hydration dates then need to be compared to other temporal and stratigraphic data to refine the range of occupation.

Figure 30. Example of Applying Statistical Corrections to Obsidian Hydration Profiles to Determine Internal Consistency and Age of an Assemblage.

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Site	Source	Mean (microns)	SD	CV	COUNT	Range (microns)	Reference
Little Lake Cache	Coso (WS)	3.7	0.07	0.01	26	3.5–3.8	Garfinkel et al. (2004)
CA-MRP-94	Casa Diablo	3.6	0.18	0.05	7	3.4–3.9	Hull and Mundy (1985); Montague (2005)
CA-TUO-4501	Mono Glass Mtn.	1.2	0.10	0.08	16	1.1 - 1.4	Bevill (2009)
CA-GLE-138	Borax Lake	3.6	0.05	0.01	10	3.5–3.6	Rick and Jackson (1985)
CA-MNO-446	Bodie Hills	4.7	0.06	0.01	3	4.6-4.7	Bettinger (1981)
CA-SOL-69	Napa Valley	4.4	0.43	0.10	5	3.9-4.9	Wiberg (2002)
CA-INY-30	Coso	5.7	0.70	0.12	8	4.7-6.9	Basgall and McGuire (1988)
CA-MEN-1608	Mt. Konocti	3.7	0.11	0.03	14	3.3-4.9	Gary and McLear-Gary (1992)
35DS268	McCay Butte (OR)	1.5	0.14	0.10	8	1.2-2.2	Scott et al. (1986)
Lava Island Rockshelter	McCay Butte (OR)	2.1	0.39	0.19	6	1.4-2.5	Scott et al. (1986)
China Hat Cache	Quartz Mountain	1.2	0.23	0.21	8	1.0-1.7	Scott et al. (1986)
Hay Ranch	Coso	6.0	0.64	0.11	55	4.7–7.9	Gilreath (2017)

Table 16. Hydration Summary from Obsidian Caches.

Notes: WS - West Sugarloaf; OR - Oregon; SD - Standard deviation; CV - Coefficient of variation.

that the CV statistic describes the relationship between these two parameters, it is an appropriate measure of chronological integrity.

For our purposes, we defined a temporally discrete context as one that has a CV value equal to or fewer than 25% (i.e., 0.25; Gilreath and Hildebrandt 1997; Rosenthal 2011b), only slightly larger than the maximum value (0.21) identified among single event caches.

Within archaeological sites, discrete components can be identified by calculating mean, standard deviation, and CV statistics for various subsets of horizontally and vertically distinct deposits at a site. When these can be differentiated stratigraphically, the argument for discrete chronological components is stronger. In many California sites, bioturbation has obscured stratigraphic breaks, and trial and error (i.e., adding and subtracting hydration readings from successive levels within a unit) can reveal areas with single component assemblages. Generally, when assemblages have a CV greater than 0.25 after outliers have been eliminated, they are considered chronologically mixed; therefore, associated cultural assemblages are not representative of a single period of occupation.

Reporting Obsidian Calibration

The inherent variability in obsidian hydration measurements also has implications for how obsidian hydration calibration is reported and interpreted. A common technique is to report the range of obsidian hydration data and then the range of calibrated age estimates on the individual obsidian specimens without further qualification. This is misleading given: (1) the variation in individual hydration rim measurements; and (2) the imprecision of hydration calibrations, which are based on central tendencies of calibrated obsidian/radiocarbon pairs. Instead, we advocate reporting the estimated calibrated age of the mean of hydration rim values from a given context, preferably one that is defined based on stratigraphic evidence or similar depositional consistency. Although calibration provides an exact date, this should be taken as a general measure of the timing of occupation, but with a large range of error. Importantly, obsidian hydration calibration age estimates should be compared to other chronostratigraphic information to determine the exact timing of occupation. Components can be built using the steps outlined above to first remove outliers and then to find assemblages with internal consistency in hydration measurements (i.e., CV values smaller than 0.25). It is ideal if stratigraphic evidence provides upper and lower bounds within a soil column for a given depositional unit. Lacking this, trial and error

can be used to add or eliminate contexts from the top or bottom of a depositional setting to find areas with high chronological consistency.

Temporally Diagnostic Artifacts

The final factor in confirming component definition is the presence of time-sensitive artifacts within defined strata. Projectile points and shell beads are the most commonly used time-markers in the Bay-Delta Area contexts, but shell ornaments (i.e., abalone pendants) and modified bone specimens may also be used. Dating scheme D relies heavily on shell bead chronology, and therefore beads are the most accurate, as well as commonly identified, diagnostic artifact found in Bay-Delta Area sites.

Shell Bead Typology and Identification

The presence of shell beads provide complementary chronological information, but only for some types of beads and only if identifications of bead type are correct. Milliken (2012) outlines metric and non-metric traits that can be used to identify beads under the D Scheme. The identification manual is designed as a companion to a set of replicated comparative bead specimens. Taken together, these guides along with careful measurements of basic bead attributes allows for the correct identification of bead type. It is important to include a table of bead measurements and traits within any discussion of the temporal association of beads so that if any changes are made to subsequent chronologies the beads might be re-typed according to their metric attributes.

Shell Ornaments and Bone Tools

Shell ornaments and bone tool styles are less time sensitive but particular types are associated with broader pre-contact time periods in Bay-Delta Area. An excellent example is the Banjo-style abalone pendant, which is found throughout the Bay-Delta Area as a marker of the Late Period, particularly in the south bay (Hylkema 2002, 2007). Other bone and shell ornament typologies were suggested by Gifford (1940, 1947) and have never been re-evaluated except on local scales. Synthesis for various regions of the Bay-Delta Area are presented in summary chapters by Milliken et al. (2007); Hylkema (2002, 2007); and Hughes (ed., 1994).

Projectile Points

Unlike the Great Basin and some areas of California, projectile point typologies play a minor role in the development of regional chronologies. The most obvious time-sensitive artifact, found throughout the Bay-Delta Area as a Late Period marker, is the Stockton Serrate arrow. Desert Series projectiles, associated with Late 2 Period assemblages are also commonly found. Early and Middle Period points are darts, but the types vary by region. Similar to shell ornaments, projectile point typologies have been proposed for various regions within the Bay-Delta Area, but no synthesis has been successfully completed. Regional summaries of projectile points for Eastern Contra Costa Valley, Sonoma County, and Santa Clara County are found in Milliken et al. (2007) who draws on data from Hylkema (2002, 2007). No chronology has been developed along the Bay margin in San Mateo, San Francisco, Marin, Contra Costa, and Alameda counties and therefore the most useful time-marker in these regions may be the difference between darts and arrows.

PUTTING IT ALL TOGETHER-BUILDING COMPONENTS

Once radiocarbon analysis, obsidian sourcing and hydration, and artifact typologies are all completed they should be combined with the stratigraphic profiles of the site to identify distinct chronostratigraphic components. One method for determining these components is to create a master site profile on which radiocarbon dates, obsidian hydration means (or calibrated age ranges), and time-sensitive artifacts are plotted (Figure 31). It is rare for all of these data to match and at times one type of data or another must be disregarded in favor of an overwhelming preponderance of other chronological information. The accuracy of a given method of dating should also be considered when determining which piece of conflicting data to include. For example, a given stratum might contain three Stockton Serrate points, E-series beads (found exclusively in Late 2 Period components), and a radiocarbon date with a median probability of 400 cal BP, but Napa Valley obsidian hydration averages 2.5 microns (calibrated to around 930 cal BP). Since the artifacts and the radiocarbon date indicate a Late 2 Period occupation and the hydration is just slightly older, you could conclude it represents a mixed Late 1/2 Period occupation, or you could argue that the obsidian hydration calibration is in error and rely on the weight of the other evidence in purporting a Late 2 Period assemblage.

There are rarely clean spatial divisions between components and therefore, even when distinct stratigraphic transitions are identified in site deposits, there are often contexts that are chronologically mixed. It is often necessary to disregard these mixed areas and confine components to the chronologically discrete portions of a deposit. A site with two stratigraphic components might have the following delineation in component areas: 0–20 centimeters below surface (cmbs) is a Late Period component, 20–40 cmbs is mixed, and 40–80 cmbs is a Middle Period component. Detailed analyses should then focus on artifacts/ecofacts recovered from 0 to 20 and 40 to 80 cmbs.

Finally, it is important to recognize that components are likely to be horizontally as well as vertically confined. Often the first consideration in building components should be the horizontal distribution of strata, artifacts, and chronological markers. Once these have been delineated, stratigraphic differences within loci can be considered.


Figure 31. Example of Site Component Profile at CA-SFR-4 (from Rosenthal 2008).

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7. TEMPORAL TRENDS IN OCCUPATION

This chapter presents the first of a series of research domains relevant to assessing the potential of archaeological field investigations to contribute important new insights into regional occupation. First, we explore radiocarbon-based temporal trends in the Bay-Delta Area, and highlight several specific research questions that result from this analysis. Next, we present an approach to more appropriately use obsidian hydration as a chronological tool and ways that future research might refine this approach. Finally, we present a research approach to refine the accuracy of Scheme D in the future.

EXPLORING OCCUPATION TRENDS WITH RADIOCARBON DATES

This section explores the very basic and relevant research issue of gathering and interpreting chronological data by presenting a series of analyses of compiled, corrected radiocarbon dates (see *Chronology and Dating*, page 6-2), which are used to interpret temporal trends in Bay-Delta Area occupation, as well as a series of issues that arise from those data.

Two types of chronological data are presented, and rely on the median probability radiocarbon age of 1,587 individual dates obtained on materials from archaeological contexts from 211 sites across the study area (Figure 32). We employed median probability ages rather than mean intercept values because the former represent the point in the probability distribution for a given date where the estimated age is just as likely to be older than the value as it is to be younger. We acknowledge that the "point-in-time" approach that these analyses follow belies the uncertainty of any single age estimate, but we believe that these differences are diminished by the large sample size. In addition to using the individual median probability estimates of the sample set, we also calculated the number of components by the presence or absence of occupation evidence at each site in each time segment. Component identification eliminated redundant dates from the same site falling in the same time interval. In the component analysis, a single date or 20 dates from the same time interval are counted simply as one component. Three different time intervals were used in the analyses-400- and 200-year arbitrary intervals (to account for varied period durations) and Scheme D periods (Groza et al. 2011). The use of components eliminates the biases imposed by anomalously large numbers of dates from a small number of well-sampled sites that might otherwise swamp the analysis. For example, of 208 dates on human remains from the Marsh Creek site (CCO-18/H), 170 fall between 3000 and 4000 cal BP. Robust sampling from this single site would result in an over-representation of this time period.

Dates by Arbitrary Intervals

The 1,587 dates compiled for the Bay-Delta Area are grouped in 400-year increments beginning at 200 cal BP; dates with a median probability between AD 1750 and 1950 are compressed within an initial 200-year time span. Using 400 year intervals and starting at 200 cal BP, the radiocarbon dates can be arrayed into 584 distinct components (Figure 33), revealing a clear pattern of increasing frequency beginning at 6000 cal BP. Both the number of dates and components show a largely steady increase from 6200 cal BP to 400 cal BP. The exceptions are dramatic fall offs in the number of dates (but not components) from 3400 to 3000 cal BP and 3000 to 2600 cal BP, and a slight decrease in the number of components between 1000 and 600 cal BP and after 200 cal BP. The fall-off in dates between 3400 and 3000 cal BP is explained by the large number of dated burials just prior to this interval from site CCO-18/H. If these dates are removed, a pattern of gradual increase by 400-year interval is evident.



Figure 32. Distribution of Radiocarbon-Dated Archaeological Sites in the Study Area.





Figure 33. Median Probability Distribution of All Radiocarbon Dates and Components in 400-Year Increments for the Study Area.

Dates by region are presented in Figure 34 to examine spatial trends within the study area. For this analysis, 200-year groups were used, resulting in a near doubling of total components to 980 (Table 17). Note that the 52 dates predating 5000 cal BP, representing 43 components, are not presented in Figure 34 due to scaling issues and the rarity of these components in every region. The distribution of components (and associated dates) is not surprising as it roughly tracks the intensity of archaeological investigations during the modern era (i.e., post-1960), when radiocarbon dating has been widely employed. When the component assemblages are divided out by region, many of the patterns apparent in the overall dataset are obscured. In the North Delta, 33 components are fairly evenly distributed across the time sequence, with sample sizes too small to provide any meaningful information. The South Delta shows two pulses of occupation with increasing numbers of components until 3200 cal BP, after which they decrease, particularly between 2000 and 2400 cal BP. There appears to have been fairly stable occupation throughout the remainder of the sequence, with a final increase in occupation late in the sequence.

The South and East Bay samples broadly track with the patterns observed in the entire study area dataset, with some potentially interesting divergences. This is not surprising as they represent the largest two regional samples, with initially low and stable records of occupation, a doubling of components around 2800–3200 cal BP, and a continuing rise to peak component density between 1200 and 1400 cal BP in the South Bay, and 1400 and 1600 cal BP in the East Bay. In the South Bay, the initial peak is followed by a decrease for the subsequent 400 years. The East Bay does not exhibit the same drop-off as the South Bay until both show the dramatic effects of missionization after 200 cal BP.

The Northwest Bay has a smaller dataset, but better matches the pattern in the South Delta, with a steady number of components through time until a later increase. The Southwest Bay has mainly a Middle Period and later occupational signature, with few components before 3800 cal BP, and between five and 10 components thereafter, except the intervals between 1200 and 1400 cal BP and 800 and 1000 cal BP which have 18 components each, and between 400 and 600 cal BP where there are 15 components.

Region	TOTAL COMPONENTS	TOTAL DATES
Northwest Bay	90	162
North Delta	33	52
South Delta	105	327
East Bay	167	456
South Bay	214	399
Southwest Bay	106	191
Total	715	1,587

Table 17. Number of Radiocarbon Dates and Components, by Region, in 200-Year Intervals.

Dates and Components by Scheme D Period

A second set of analyses examines trends in dates and components under Scheme D (Groza et al. 2011; see *Using the Most Up-to-Date Chronology*, page 6-3). Direct comparisons of dates by period are misleading since the overall length of each interval is different. To standardize the dates and components for comparison, we divided the number of dates or components in a time period by its length. The resulting values represent the number of dates or components per year for each period (Figure 35; Appendix E).

The sample includes 573 components over 13 periods (excluding post-Mission Period dates), mimicking the pattern observed in the overall radiocarbon data. There is a trend toward increasing occupational evidence (in the form of components/year) from the Early 1 to the Middle 3 Periods. A clear decrease in the number of components per year marks the Middle 4 and the Middle/Late Transition,







Figure 34. Number of Radiocarbon-Dated Component Assemblages by Region for 200-Year Intervals during the Past 5,000 Years.



Time Period (cal BP)



Note: Dates are normalized by 100-year intervals to account for the varied period durations.

Figure 35. Median Probability Distribution of All Radiocarbon Dates and Components by Scheme D Periods for the Study Area.

followed by an increase back to Middle 3 levels in the Late 1 Period, after which components per year drop back slightly but continue to be high through the Mission Period.

The same analysis was run for each of the regions, with general trends holding true, along with some interesting divergences (Figure 36). The North Delta has few dates and a relatively flat trend through time; the exception is an increase in components per year during the Middle 3 followed by a decrease in Middle 4. Similar spikes in Middle 3 are observed in the Northwest Bay, the South Delta, and the South Bay. Corresponding peaks are observed in Middle 2 in the Southwest Bay and East Bay. Similar to the full dataset, Late 1 has the highest number of components, or a number of components equal to the Middle 3 in the South Bay, the East bay, and the Southwest Bay. Interestingly, the Northwest Bay and the South Delta diverge from the overall trends by showing increases in the number of components in the Late 2 and Mission Period, each of which have more components per year than any other time period in these samples. This reveals persistence of Native occupation during the initial time span of the Mission Period (see Chapter 11).

Data Requirements

For a site to contribute meaningfully to our understanding of Bay-Delta Area chronology (and for all other research topics, since they also require chronological control), several data requirements need to be fulfilled. First, the site must contain one or more demonstrably single-component depositional contexts and one or more classes of temporal information: e.g., organic remains suitable for radiometric assay; time-sensitive artifacts such as projectile points, beads, or other temporally diagnostic artifacts; obsidian artifacts for hydration and source studies; or association with a dateable geomorphic context. If a site lacks chronologically sensitive data, it cannot contribute significant information to a wide range of research issues. By the same token, the simple presence of one or more of these data sets does not necessarily make a site chronologically significant, as evidenced by the common occurrence of temporally mixed deposits in California which produce rich assemblages with no chronological resolution. **This situation also highlights the utility of aggressively dating small, short-term occupation episodes. Such sites have reduced likelihood of component mixing and hence greater potential to provide insight into a discrete set of correlated activities.**

Middle Period Adaptations and What Happened during the Middle 4?

There is clearly a significant decrease in the number of components from the Middle 3 to the Middle 4 Periods throughout the Bay-Delta Area. In most places, the peak of documented occupation components occurs during the Middle 3 Period followed by a decrease in components per year in the Middle 4 Period. The start of the Middle 4 Period roughly corresponds with the onset of the Medieval Climatic Anomaly, and therefore it is possible that environmental factors may have played a role in the sudden decrease in occupation components throughout the Bay-Delta Area. Whether this reflects changes in population or settlement size (with, for example, aggregation in larger settlements near stable water supplies) is uncertain. The earlier downturn in component frequency in the East Bay and Southwest Bay, however, suggests that cultural factors (including in-migration) were likely an important influence as well.

Data Requirements

Addressing the timing of downturns in site habitation during the Middle Period requires the identification of component assemblages dating to the Middle 2, 3, and 4 Periods. This, in turn, requires radiocarbon dates that firmly place site components in these periods and interpret them within the context of broader regional trends, as presented here. This makes it possible to address broader regional patterns, as well as those identified on a site-by-site basis.



Figure 36. Regional Patterns in Radiocarbon-Dated Component Assemblages by Scheme D Period during the Past 5,000 Years.

Identifying Temporal Trends in the Occupational Signature of the North Delta

Little is known about the archaeology of the North Delta, and few sites have been dated relative to other subregions of the Bay-Delta Area. Therefore, newly identified sites in this region have the potential to provide valuable information and, therefore, the threshold for National Register eligibility of such sites may be lower than in other Bay-Delta Area regions.

Data Requirements

Identifying distinct component assemblages with radiometric data that can be applied to a North Delta dataset will provide data germane to this research topic.

Pre-Late Holocene Research

As the datasets presented here make clear, there is a dearth of knowledge regarding the pre-Late Holocene record in the Bay-Delta Area. Few sites dating to the Early and Middle Holocene have been identified, and many dates from these early periods are from isolated finds and human burials. Little is known regarding cultural adaptations, and any component assemblages dating to this period are likely to provide important information regarding adaptations before and during the formation of the San Francisco Bay and the establishment of Bay-Delta Area cultures as observed beginning approximately 5,000 years ago.

Data Requirements

Addressing this research issue requires the identification of site components greater than 4,200 years old. Any site deposit with associated assemblages dating to this period is likely to be capable of addressing myriad research questions and therefore is likely to be eligible for listing on the National Register. The majority of these sites will be found in buried or submerged contexts (e.g., Rosenthal and Meyer 2004).

REFINING THE APPROPRIATE USE OF OBSIDIAN HYDRATION AS A CHRONOLOGICAL TOOL

As noted in Reporting Obsidian Hydration Data and Definition of Cohesive Temporal Components (page 6-6), obsidian hydration should not be used as a substitute for radiocarbon dating as it is a much less accurate technique. It is, however, a valuable tool for measuring the age of archaeological materials made of volcanic glass, providing information useful for interpreting the chronological relationships of individual artifacts as well as other spatially and stratigraphically associated materials. The utility of obsidian hydration dating derives from a certainty that analyzed samples relate to cultural activities (as opposed to the potentially spurious associations of radiocarbon dates based on soil samples or charcoal), and the relatively low cost of obsidian sourcing and hydration, which allows many more individual samples and contexts to be dated. Furthermore, obsidian is ubiquitous in most regions of central California. Although obsidian hydration "dates" are often presented as if they are as accurate as radiocarbon assays, the main drawback to obsidian hydration dating is that age estimates from individual artifacts are prone to a large margin of error. Many researchers choose to ignore this fact, or are unaware of the range of factors that affect obsidian hydration and/or the physical imprecision of the chemical process. As hydration readings are not directly comparable to radiocarbon dates or other absolute age measures (e.g., tree-ring chronologies), some correction factors are necessary to convert hydration measurements to calendar-year estimates, allowing results to be standardized. Although much work has been done to refine the conversion of hydration rim means to calendar years before present, further refinement is necessary as is an understanding of the limitations of the method.

Two obsidian sources from the North Bay—Napa Glass Mountain and Annadel—make up more than 90% of the sourced specimens, totaling nearly 8,000 hydration rim measurements from study area

sites. Because the vast majority of obsidian in the study area comes from either Napa or Annadel sources, we concentrate on the history and potential errors in interpreting the age of artifacts from these two sources, as measured by obsidian hydration, and present some avenues for future research into better developing obsidian hydration profiles for Bay-Delta Area sites as a chronological tool.

As with many of the chronological tools available to archaeologists, it is important to understand the chemical processes, the method of analysis, and ways that potential errors can skew results for a given artifact. Obsidian hydration analysis assumes that a fresh surface, exposed by flint knapping, begins to slowly absorb water from its environment, generating a thin rind known as a hydration rim. The speed at which this rim forms depends on environmental temperature, chemical composition of the obsidian, mineralogical structure, and intrinsic water content (Liritzis 2014). Although the use of optical microscopy has been the exclusive method used in California hydration analysis to date (e.g., Ericson 1981; Origer and Wickstrom 1982), other methods have been developed over the past 20 years that provide greater accuracy but require more elaborate equipment. These new methods include the measurement of water mass uptake or loss versus time by infrared, and direct measurement of water profiles by secondary ion mass spectrometry (Liritzis 2014).

Friedman and Smith (1960) first suggested that an artifact's age could be determined based on the thickness of the measured hydration rim using the equation $x=(kt)^{1/2}$, where x is the hydration rim width in microns (μ), k is the hydration rate of a particular source at a particular temperature/relative humidity, and t is time. To determine time in this equation requires a source-specific hydration rate adjusted for archaeological site conditions. Source-specific hydration rates take one of two forms – *intrinsic rate dating* requires experimentally determined rate constants as well as a measure of site temperature, whereas empirical rate dating requires correlating the width of hydration rims with independent chronometric data, such as radiocarbon assays. In California, laboratory-derived intrinsic rates have never enjoyed much support, proving to be poor temporal predictors in archaeological applications (Hall and Jackson 1989; Tremaine 1993; but see Stevenson et al. 1998). Instead, archaeologists have focused on developing local empirical rate calibrations through the use of radiocarbon-hydration pairings from discrete stratigraphic or feature contexts (e.g., Basgall 1990; Basgall and Hildebrandt 1989; Cleland 1995; Ericson 1977; Glassow 1991; Hildebrandt and Mikkelsen 1995; Hull 2001; Origer 1982; Rosenthal 2005; Stevens 2005) as well as other, less resolute methods (e.g., Basgall and Giambastiani 1995; Hall and Jackson 1989; Jackson and Ballard 1999; Rosenthal and Waechter 2002). Although some of these rates have proven to be reasonably accurate (e.g., Origer 1982), others have generated mixed results (e.g., Hall and Jackson 1989).

The problem most likely to skew the results of intrinsic rates is the inherent differences between the growth of the hydration front based on differences in air and ground temperature (e.g., Hull 2001; Mundy 1993; Onken 1991; Origer 1982). Among the factors previously identified as confounding obsidian hydration results are elevation- and geographic-mediated differences in temperature between sample localities and the depth(s) at which artifacts are buried. Although a calculation of EHT (Bouey 1995; Hull 2001; Origer 1982; Rogers 2007a, 2007b, 2008; Stevens 2005) has been commonly employed to account for temperature differences, adjustments are largely speculative (e.g., 6% for each degree difference; Bouey 1995) and remain unproven. The issue of subsurface temperature effects has not been systematically addressed until relatively recently (Rogers 2007a, 2007b; though see Mundy 1993).

Within the past few years, Rogers (2007a, 2007b, 2008, 2010) has considered both ground and air temperature in an attempt to refine hydration rate corrections for Coso and Bodie Hills obsidian. This work resulted in a template of corrections for the Coso source rate in the Sierra Nevada which Rogers believes can be applied to other regions.

A second possible confounding factor is the possibility of intra-source variation in hydration rates. Such intra-source variation has been noted for the Coso and Casa Diablo sources but has not been explored for Napa Glass Mountain or Annadel.

Development and Refinement of the Napa Valley Hydration Rate

There are 5,132 samples of Napa Glass Mountain obsidian with readable hydration rims (see ahead to Figure 61). Using Rosenthal's (2005) calibration rate, the overall pattern of obsidian use shows a steady increase in the relative frequency during the Early and Middle Periods, with a peak in the Middle/Late Transition-Late Period I, after which obsidian use was greatly reduced. Assuming that thicker rims are older, general trends through time are visible in the histogram of hydration rim measurements. Dates in the following description of general trends are based on Rosenthal's (2005) calibration rate that does not correct for temperature or depth of burial, but is equally accurate as rates that provide such corrections. Few rims have been identified early in time, with gradual increases in the frequency of rims measuring from 7.0 to 4.5 microns (8380–3017 cal BP). A plateau of similar frequencies is evident for rim measurements between 3.9 and 2.9 microns (2270–1250 cal BP). This is followed by a dramatic increase in relative frequency, with peak frequencies of 2.5–2.3 microns (430–250 cal BP). Obsidian use falls back to lower but still consistent use between 1.7 and 1.3 microns (430–250 cal BP) when if falls off dramatically. This last decrease is presumably the marker of Spanish contact.

Origer (1982) was the first to systematically define an obsidian hydration rate for Napa Glass Mountain obsidian using a small sample of five hydration means and radiocarbon pairs from sites in Sonoma and Napa Counties. Origer's is an empirically derived rate based on a series of obsidian hydration means and associated radiocarbon dates from a sample of sites in the Santa Rosa-Cotati Valley. Origer established a local effective temperature, which he assumed to have been a constant for all pairs used in the derivation of his rate. He suggested that coastal samples, and those from other non-Sonoma County contexts would need to be corrected based on differences in temperature. Using an equation developed by Lee (1969), Origer calculated an EHT of 16.1 °C. Bouey (1995) re-examined Lee's equation and Origer's use of it in deriving the Sonoma EHT, and found that Origer had used annual, rather than monthly, mean temperatures and therefore argued that the appropriate EHT for the Sonoma and Napa sites was 17.1 °C. Bouey (1995) was interested in calibrating Napa obsidian recovered from Central Valley sites, and adjusted his obsidian hydration measurements to the warmer Central Valley, accordingly using an EHT of 18.2 °C. He then assumed that there was a 6% per degree difference in the obsidian hydration rate and multiplied his hydration rim values for individual sites by this difference to obtain a corrected rim value based on monthly mean temperatures at or near sites.

Despite the temperature correction, Bouey found that the calibrated rim values were younger (i.e., thinner) than expected given radiocarbon dates at his study site. He concluded that Origer's rate, which was based on relatively young hydration-radiocarbon pairs—the oldest was only 1980 cal BP—underestimated the rate of hydration from these sources in the Sacramento Valley. Bouey (1995) expanded the sample of pairs to include six from the Sacramento Valley, and re-calculated the rate. His rate, however, did not provide results that improved upon Origer's, with seemingly young hydration calibrations the norm.

Rosenthal (2005) took advantage of a much larger sample of hydration-radiocarbon pairs from 30 burial associations in archaeological sites throughout the Bay-Delta Area and Central Valley. An additional sample came from obsidian debitage produced by Ishi, the Yahi Indian who lived at UC Berkeley's Lowie Museum from 1911 until his death in 1916 (Origer 1989). Although Rosenthal noted a 3.6 °C difference in effective temperature (using Lee's [1969] equation), he also noted that there was no significant trend in the thickness of hydration rims based on effective temperature—obsidian hydration rims from cooler sites were not always thinner than those from contemporaneous warmer ones. Rosenthal (2005), therefore, did not include a temperature correction in developing a new rate.

Rosenthal's rate (Years cal BP = $148.99\mu^2$, where μ is the rim thickness of an artifact), though only slightly different than Origer's, has proven effective at providing age estimates for a number of surface contexts at sites in the Bay-Delta Area (e.g., Hildebrandt et al. 2012; Rosenthal et al. 2009; Whitaker et al. 2009; Whitaker and Carpenter 2010), but consistently underestimates the age of buried site components at others (e.g., Hildebrandt et al. 2012; Pahl 2003; Whitaker and Stevens 2012). Whitaker and Stevens (2012) attempted to derive a rate correction for deeply buried obsidian using methods employed for Coso obsidian by Rogers (2007a, 2007b, 2008, 2010) or by applying an empirically derived correction factor based on depth of burial. They found that neither of these methods adequately accounted for vast differences in buried versus surface assemblages of obsidian.

Recently, Schneider et al. (2013) have defined a revised intrinsic rate based on obsidianradiocarbon pairs from Origer's original sample and burial associations at NAP-399. They found that this new rate works quite well for the St. Helena Valley, but do not test its efficacy outside this small region. As such, we advocate for the use of Rosenthal's rate, but encourage further refinement of the effects of depth of burial and effective temperature on regional obsidian hydration dating.

Development and Refinement of the Annadel Hydration Rate

Origer's (1982) study that developed a rate for the Napa source also included a comparison of Napa and Annadel obsidian projectile points and radiocarbon-hydration pairs. This study was among the first to demonstrate substantial differences in the rate at which these two obsidian sources hydrate. Both data sets showed that Annadel obsidian absorbs water at a slower pace than Napa obsidian, resulting over time in thinner hydration bands on Annadel specimens. These findings were subsequently confirmed by induced hydration experiments conducted by Tremaine (1993). Based on differences in the hydration rim thicknesses on Napa and Annadel obsidian subject to similar lengths and conditions of exposure, Tremaine (1993:270) developed comparison constants which show that Napa hydrates at an average cumulative rate of 1:0.78 relative to Annadel. This value agrees closely with differences identified by Origer (1982:84) between hydration measurements on samples of Napa and Annadel projectile points, revealing an average ratio of 1.0 micron Napa to 0.81 microns Annadel.

Gmoser et al. (2007) used the regional hydration information from single-component sites in the Santa Rosa-Cotati Valley region. The study mainly confirmed early studies in finding that contemporaneous assemblages showed a slower rate (i.e., thinner hydration rims) for Annadel. The exceptions were the two youngest sites in the sample, which produced Annadel means that were 0.1 microns thicker than Napa, suggesting that the rate at which Annadel obsidian absorbs water is initially faster than Napa, but slows significantly over time. Gmoser et al. (2007) found an average ratio of Napa to Annadel equaling 1:0.76 microns, but also that the ratio decreases over time from 1:1.07 in the youngest samples, to 1:0.47 in the oldest sample. Although the decrease is not linear, there is a strong trend showing that the rate of Annadel hydration slows over time, suggesting that a single comparison constant, such as that proposed by Tremaine (1993), may not be appropriate for characterizing differences between these two obsidian sources.

Additional comparisons further suggest that Annadel obsidian may actually reach a threshold beyond which hydration is substantially reduced—beginning about three to four microns. Gmoser et al. (2007) found that mean hydration rates from the two sources for single-component localities and projectile points did not correlate well. This further suggests that a model other than the theoretical diffusion formula may better describe the Annadel hydration process. While the poor correlation achieved in this comparison could simply be due to temporally mixed obsidian samples, Gmoser et al.'s (2007) conclusions matched well with the logic by which Origer (1982) eliminated the oldest Annadel/radiocarbon pair citing a substantially different rate constant than the other five pairs he used. Based on these studies, it appears that a standard diffusion model for Annadel obsidian is not possible and that until the issue is better resolved, neither a comparison constant, as proposed by Tremaine (1993) and Origer (1982), nor any existing hydration rate, are valid for estimating the age of obsidian artifacts. So they therefore remain a relative dating tool.

Can a Correction for Buried Components be Developed?

Despite nearly 30 years of refinement and almost 8,000 hydration readings from sites within the study area, the application of obsidian hydration calibration to regional samples is plagued by inaccurate estimates in many contexts, lack of consistent correction factors and use of rates, and misunderstandings of the complexities involved with arriving at estimated ages of artifacts (see Refining the Use of Obsidian Hydration as a Chronological Tool, page 7-9). Particularly perplexing is the apparent inaccuracy of obsidian hydration in buried contexts, which make up a large percentage of sites in the study area. Although Whitaker and Stevens (2012) found little reason to suspect that a correction factor could be applied to such buried components, and point out that the issue of correcting for buried components is complicated as components remained on the surface for some time before being buried. As a result, while a depth correction would be useful if all obsidian were buried to the depth at which they were recovered immediately following use, diverse depositional processes (both cultural and natural) affect the timing of burial, and therefore make such a correlation difficult. Additional data, or synthesis of hydrationradiocarbon pairs, could refine the accuracy of such age estimates. This will require not only additional data from buried contexts around the Bay-Delta Area, but also a detailed understanding of the geomorphological history of individual contexts applied to a correction factor for buried components. We suspect that such a correction need not include a depth-specific variable that is incorporated into the hydration calibration of each artifact, as Rogers (2007a, 2007b) suggests, but rather a correction of assemblage means from these contexts. This remains an empirical problem for future research.

Data Requirements

Although radiocarbon dating has become an increasingly cheap and effective way to date sites, there is still a place for obsidian hydration as a tool to examine not only the timing of site occupation, but also to directly measure patterns of obsidian exchange (see pages 13-2 to 13-8). Addressing the issues outlined above requires obsidian hydration of multiple samples from the same context to obtain a mean hydration value with a low coefficient of variation. Such samples in association with radiocarbon dates will provide data that can be applied to the derivation of refined Napa and Annadel rates that may be able to account for buried contexts and the differences between the rates of hydration for the two Bay-Delta Area obsidian sources.

Obsidian sourcing is also critical to this research topic. Napa Valley and Annadel obsidian can often be visually sourced by hydration analysts, but this visual sourcing should be confirmed by X-ray fluorescence spectrometry sourcing of at least a subsample of the assemblage. As technology improves, the cost of such sourcing should decrease making it easier to confirm the source profile of obsidian samples.

A site with potential to contribute to obsidian hydration research issues should have substantial assemblages (>25 pieces) of obsidian from the Napa Valley and/or Annadel sources found in clear association with dateable organic material or within distinct stratigraphic contexts. Sites that contain obsidian found in buried contexts are more likely to be eligible under this topic than those found on the surface.

REFINING THE ACCURACY OF SCHEME D

Traditionally, there are three primary ways that time has been measured archaeologically in the Bay-Delta Area and wider central California: radiocarbon dating, obsidian hydration, and stylistic changes in shell beads. Other temporally diagnostic artifacts may exist as well (e.g., projectile points, charmstones, or shell ornaments), but there has been little effort or success in demonstrating chronostylistic variation useful for inter-regional comparisons. To this point, there is no better chronological measure widely available than radiocarbon-dating. Although material suitable for radiocarbon-dating is very common in Bay-Delta Area archaeological sites (e.g., charred material, bone, shell), there remains a need to identify and refine the age of shell bead types and better calibrate obsidian hydration results, particularly to understand broad-scale cultural processes. Likewise, cross-comparisons of the three types of chronological information allow for a better understanding of the resolution of each.

Although not without its own problems, radiocarbon-dating provides a common scale against which to evaluate the resolution of both shell bead styles and obsidian hydration results from Bay-Delta Area archaeological sites (e.g., Groza et al. 2011; Origer 1982). The primary difficulty of interpreting radiocarbon dates comes from the variable results obtained on different types of material (a geochemical problem of fractionation) and associations between the materials dated and the phenomenon which is the subject of dating. Beginning with initial seriation studies in central California, it was recognized that human graves represent a unique opportunity for chronology building, as these contexts provide reasonably high confidence that all of the intentionally associated objects co-existed and were buried at precisely the same time (even if the age of manufacture varied, as in the case of curated items). Of course, this understanding served as the foundation for the shell bead typology and chronology that Bennyhoff developed over several decades of careful study (Bennyhoff and Fredrickson 1967; Bennyhoff and Heizer 1958; Bennyhoff and Hughes 1987). The success of the central California bead chronology was confirmed in 2002 when Randall Groza was able to directly date many of the bead types Bennyhoff defined, and clearly demonstrate their temporal relationships based on 300 paired bead and AMS dates (Groza 2002; Groza et al. 2011). Groza's (2002) study also revealed subtle differences in some bead types that Bennyhoff had not detected (e.g., saddle beads; Milliken and Schwitalla 2012), providing additional chronological resolution. It was also demonstrated that some bead styles persisted longer than previously thought (Groza et al. 2011), as well as other important findings that would not have been possible without directly dating the beads.

While Groza's (2002; Groza et al. 2011) study goes a long way toward refining the shell bead chronology, there continues to be ambiguity around the timing of some of the primary temporal transitions (e.g., the Early to Early/Middle Transition Period or Middle 1 Period). And while the new Scheme D chronology has proven quite reliable, one major interpretive problem lies with the reservoir correction used to calibrate the radiocarbon dates. Since ocean water (and fresh water) often contains old carbon, it effects the radiocarbon ages of marine samples, making them appear older than they actually are. A worldwide marine reservoir correction needs to be supplemented by a local reservoir correction to adjust the dates obtained from marine samples. The final Scheme D chronology uses a reservoir correction of 260 ± 35 (referred to as the Delta-r correction) to calibrate the measured radiocarbon age of Olivella shell beads, which Milliken (Groza et al. 2011; Hughes and Milliken 2007) deduced from the known age of beads made in the Spanish Missions. This correction is very close to the average reservoir correction of 265 ± 35 which is obtained when all pre-atomic bomb samples from the entire California coast are combined. Consequently, the Scheme D chronology relies on an average reservoir correction for the California coast. However, we know the influence of old carbon is, on average, lower in southern California than it is in Northern California. We also know that the reservoir effect was variable over time in relation to the amount of coastal upwelling and other factors (Hendy et al. 2013; Ingram 1998). As a result, the apparent age of any particular bead is affected by where the shell was collected and the environment in which the mollusk lived (e.g., Ingram and Southon 1996). To improve the Scheme D chronology, these characteristics need to be better controlled. Recent research may make these refined corrections possible. For example, Eerkens and colleagues (Eerkens et al. 2005, 2007, 2009, 2010) have used oxygen isotope information to determine the general location where shells were collected along the California coast. Likewise, there are efforts to identify a time-specific reservoir correction for portions of the California coast (e.g., the Santa Barbara Channel) using varved sediments (e.g., Hendy et al. 2013) and other methods.

Another approach which can be employed to evaluate the bead chronology is to date other organic material, including human remains directly associated with different bead styles. Of course, since humans also ingest marine foods, radiocarbon dates on human bone can also be affected by the old carbon problem. However, by determining the ¹²C/¹³C ratio of the sample (routinely measured and reported for AMS dates), an estimate of percent marine carbon can be made, and the calibrated date adjusted using a mixed-marine calibration. Again, however, an appropriate reservoir correction is necessary. This approach would be best in circumstances where isotopic evidence suggests no marine influence. Alternatively, in cases where fire was part of the burial event (i.e., cremation or pre-interment pit burning) radiocarbon-dating of charred material in association with shell beads would also be a suitable way to evaluate the reservoir effect.

As an initial test of the Scheme D chronology presented in Groza et al. (2011), we compiled paired bead and radiocarbon dates from 458 discrete contexts from central California, primarily human graves. We also compiled obsidian hydration and sourcing information from these same contexts, as well as residential features where shell beads and/or radiocarbon dates were also associated.

In some cases, the beads themselves were directly dated, including those in Groza's (2002) original study, and in subsequent studies (Groza et al. 2011), for a total of 225 bead dates. Another 15 dates originate from marine shell that appeared in reliable association with a bead lot (e.g., a shell ornament). The sample also includes 133 contexts where human bone was dated, and another 82 contexts where charred material, such as wood charcoal, was dated. For comparative purposes, seriation of the associated shell bead lots was used to organize the assemblages in time, placing each sample into one of eight time periods as defined in Scheme D (Groza et al. 2011). However, the Middle 2–Middle 4 Periods were grouped into a single period because many of the bead lots identified for this study were analyzed prior to the definition of the saddle bead type F4, which allows these three periods of the Middle Horizon to be differentiated (for more details regarding F4 beads, see Groza et al. 2011; Milliken 2012).

Results of the radiocarbon seriation are presented by material type in Figure 37, and were organized into each period based on the associated bead types, summarized in Table 18. There is excellent agreement overall between the dates from human bone, charcoal, and shell, indicating that the period divisions outlined in Scheme D are largely correct. However, these results suggest that the Early/Middle Transition Period may need to be extended to about 2775 cal BP (Figure 37), a time poorly resolved in the Groza et al. (2011) sample. While there is good correspondence overall between the different types of dated material, there are some obvious discrepancies. For the most part, the shell dates correspond closely to the Scheme D chronology (as they should). It is mainly the human bone and charcoal dates that are out of phase, often by a significant amount of time. This is likely a result of poor associations or some problem with the dated material, rather than a problem with Scheme D. For example, as discussed in *Radiocarbon Calibration and Reporting* (page 6-4), the out-of-phase human bone dates are also consistently too old, perhaps the effect of old wood, such as oak heart wood, or a spurious association.

Since each of the 458 contexts employed in this study were grouped by period using associated bead lots, the summary seriation in Table 18 largely conforms to the predicted bead types for each horizon of Scheme D. However, a few F2 saddle beads from contexts at NAP-399 are too early. In this case, the radiocarbon date seems correct as numerous similar dates were obtained from the site, and isotope information does not suggest a heavy marine diet. What this problem points up is the difficulty in accurately identifying shell bead types. Although the Milliken and Schwitalla (2012) bead guide and replica set have gone a long way in making the typology more usable by an inexperienced analyst, it remains difficult to accurately identify beads even for experienced researchers. Subtle variations often determine the style and time differences. Some types simply cannot be differentiated metrically



Figure 37. Seriation of Central California Radiocarbon Dates Associated with Shell Beads.

Data	Period	HISTORIC	LATE 2	LATE 1	MLT	MIDDLE 2–4	MIDDLE 1	EMT	EARLY	PRE-EARLY	
беад Түре	Scheme D (cal BP)	≥180	180–430	430-685	685–930	930–1530	1530–2150	2150-2550	2550-5000	>5000	TOTALS
Glass		494	2	-	-	-	-	-	-	-	496
H1 (Oliv	ella)	3,541	37	-	-	-	-	-	-	-	3,578
Clamshe	ell disc	1,766	235	-	-	-	-	-	-	-	2,001
E (Olivell	la)	555	133	1	-	-	-	-	-	-	689
K (Olivel	la)	3	368	2,057	-	-	-	-	-	-	2,428
A1/2/3 (0	Olivella)	39	561	9,000	1,030	4,800	43	47	2,150	986	18,656
B1/2/3 (C	Olivella)	-	1	983	535	1	-	1	116	1,634	3,271
M2 (Oliv	vella)	-	1	8,848	151	191	-	-	-	-	9,191
M1 (Oliv	vella)	-	-	17,744	13,449	4,429	-	-	-	-	35,622
D1 (Olive	ella)	-	-	-	14,401	-	-	-	-	-	14,401
F3 (Olive	ella)	-	-	-	4,861	26,997	-	-	-	-	31,858
F2 (Olive	ella)	-	-	-	52	5,298	-	9	-	-	5,359
G1 (Olive	ella)	1	3	2	13,103	99	2	18	-	-	13,228
Steatite		-	8	1	-	1	59	29	-	-	98
G2 (Olive	ella)	-	-	3	114	35,472	4,386	38	-	-	40,013
G3 (Olive	ella)	-	-	-	1	1	3,597	7	-	-	3,606
G5 (Olive	ella)	-	-	-	201	1,984	932	35	-	-	3,152
C (Olivel	la)	-	-	1	1,118	346	538	55	3	-	2,061
F1 (Olive	ella)	-	-	-	-	-	157	-	-	-	157
L1 (Olive	ella)	-	-	-	-	-	-	-	241	-	241
L2 (Olive	ella)	-	-	-	-	-	-	-	1,940	-	1,940
L3 (Olive	ella)	-	-	-	-	-	-	-	166	-	166
L4 (Olive	ella)	-	-	-	-	-	-	-	158	-	158
N (Olivel	lla)	-	-	-	-	-	-	-	1	12	13
Total		6,399	1,349	38,640	49,016	79,619	9,714	239	4,775	2,632	192,383

Table 18. Summary of Bead Types Associated with Radiocarbon Dates and Obsidian Hydration Readings by Period

Notes: Notes: MLT - Middle/Late Transition; EMT - Early/Middle Transition. See Table 3 for bead type names.

(Bennyhoff and Hughes 1987; Milliken and Schwitalla 2012), while others are identified primarily by one characteristic over another. For example, a small perforation diameter is more important than the bead outline when identifying saddle beads (F2 and F3). Other types require careful metrical comparisons to differentiate. In this respect, when age discrepancies occur, the first solution should be to carefully confirm bead type identifications. Milliken (2012) provides additional metrical and non-metrical observations that address some of the shortcomings of the original Bennyhoff and Hughes (1987) typology, but new or additional discriminating metrics may be necessary to resolve ongoing typological issues. Since the few recognized shell bead experts in central California are no longer active in their field, it may also be necessary for current bead analysts to participate in blind tests until a high level of comparability is achieved.

As a final check on the Scheme D chronology, Table 19 summarizes Napa Valley obsidian hydration results by period from the same burial and feature contexts included in the comparisons above. A total of 179 contexts (257 total readings) included Napa Valley obsidian hydration information. As can be seen in Table 19, there is a sequential progression in the mean hydration thickness from the Early Period through the Historic Period. However, as shown in Figure 38, substantial overlap exists in these samples at one standard deviation. For example, a mean hydration value of 2.5 microns could date to Late 1 Period, Middle/Late Transition or Middle 2 Period, a span of more than 900 years. While these results may be marginally improved by correcting for context-specific temperature differences, it is very unlikely that hydration studies will ever provide the same chronological resolution offered by radiocarbon dating or shell bead seriation. Nevertheless, the general utility of obsidian hydration as a dating technique is supported by these comparisons.

Period	Mean (microns)	Median	Range	Count	SD	CV
Historic	0.79	0.7	0.7 - 1.4	23	0.20	0.25
Late 2	1.71	1.7	1.1–2.4	10	0.45	0.26
Late 1	2.24	2.2	0.6–4.5	74	0.75	0.33
MLT	2.35	2.2	1.5–3.1	17	0.40	0.17
Middle 2–4	2.99	2.9	1.7–5.0	56	0.73	0.24
Middle 1	4.14	4.1	2.6–5.6	25	0.67	0.16
EMT	4.36	4.4	3.7–5.1	15	0.39	0.09
Early	5.19	5.1	3.0-6.9	37	0.74	0.14

Table 19. Napa Valley Obsidian Hydration Results Associated with Shell Beadsfrom Burial and Feature Contexts by Period.

Notes: MLT – Middle/Late Transition; EMT – Early/Middle Transition; SD – Standard deviation; CV – Coefficient of variation.

Data Requirements

Although significant refinements have been made in defining the age of long-recognized shell bead style horizons in central California (e.g., Groza et al. 2011), improvements to the common dating techniques used in the Bay-Delta Area can be made. Radiocarbon dates associated with different shell bead types will assist in improving the existing chronology, particularly dates from other kinds of organic material. As well, stable isotope information from shell beads and dated human remains will be important for resolving many of the issues discussed above. These studies will allow the Scheme D chronology to be continually evaluated and a refined reservoir correction developed. Of course, proper identification of each bead type is mandatory, and reliable contextual associations are required. Additionally, if hydration dating is to improve, these same kinds of paired dates should be developed from reliable contexts containing obsidian (see *Refining the Appropriate Use of Obsidian Hydration as a Chronological Tool*, page 7-9).



Figure 38. Napa Valley Obsidian Hydration Results from Burial and Feature Contexts Associated with Shell Beads by Period.

For a site to contribute to this research topic, it must contain *Olivella* shell beads that can be subjected to stable isotope analysis or radiocarbon dating, or beads found in association with obsidian and other organic material. Furthermore, an eligible site under this topic will contain beads that can be identified under Scheme D and has bead types that are known to have good temporal resolution (e.g., F and G Series). Sites that contain only bead types with poor temporal resolution (e.g., spire-lopped varieties) or those where beads cannot be confidently identified to type are unlikely to be eligible as contributing to this topic.

8. SETTLEMENTS IN SPATIAL CONTEXTS

This research domain is, by its very nature, broad and diverse in character. Investigations into settlement organization in the archaeological record are divided into five main research topics: (1) ideal free distribution modeling of diachronic trends in settlement; (2) reconstructing the nature of annual settlement patterning trends; (3) discerning the nature and function of Bay-Delta Area mounds; (4) exploring the causal factors and trajectory of Bay-Delta Area sedentism; and (5) the use of shellfish to infer seasonality of Bay Shore occupation.

SAN FRANCISCO ESTUARY ADAPTATIONS - A TEST OF IDEAL FREE DISTRIBUTION

The examination of settlement trends in the archaeological record can take many forms. Often these studies are synchronic, attempting to reconstruct patterns of site occupancy and transhumance in a given time period. Under such approaches, the focus of study is generally single sites, or a small local sample of sites that are thought to have been occupied simultaneously. Synthetic reviews of culture history aggregate these studies to discuss changes through time in the overall patterns of annual occupation, or relationships between central villages, resource procurement and processing sites, and other task-specific localities. These are all important contributions to our understanding of the archaeological record and we advocate for similar-such studies in the research issue discussions that follow. Initially, however, we widen the focus of study to look at broad-scale changes in settlement across the Bay-Delta Area before, during, and after the establishment of the San Francisco Bay estuary. The pattern of the bay-estuary development, and concomitant trajectory of human settlement and use of this rich habitat, offer a fruitful avenue for future research in District 4.

In this section, we offer a predictive model for the settlement of the Bay that is meant to serve as a null hypothesis against which to test new archaeological data. It relies on simple data available at nearly all bay shore sites, and incorporates both ecological and social pressures on pre-contact residents of the Bay-Delta Area. Reconstruction of Bay settlement is derived from the Ideal Free Distribution Model, which predicts that people will settle an area such that, all things being equal, each habitat has an equal average "suitability" for each individual within it (Fretwell 1972; Fretwell and Lucas 1970). In the standard ecological model, suitability is defined as evolutionary fitness, but for human populations it may take the form of resource availability, access to fresh water, access to marriage partners, or availability of certain key raw materials. If people are allowed to move about the environment as they choose (the free part of the model), then the ideal distribution would predict an equilibrium under which each individual was no better off than any other. The model assumes that, since individuals can continually reshuffle, the system as a whole maintains itself at an equilibrium. Thus at any point in time, we expect the relative density of people in two adjacent areas to reflect the two habitats' relative suitability.

The Ideal Free Distribution Model (Fretwell 1972; Fretwell and Lucas 1970) has recently become popular in archaeological explanation (e.g., Codding and Jones 2013; Hale 2010a, 2010b; Jazwa et al. 2013, 2015; Kennett 2005; Kennett et al. 2006; Winterhalder et al. 2010). Kennett, Winterhalder, and colleagues have used the model to predict the order of settlement of various island locations based on variability in habitats or between islands. These analyses have included not just environmental aspects of colonization but also technological and social mechanisms that affect perceived suitability. For instance, Kennett et al. (2006) argue that given the importance of mainland/island interactions, the availability of canoe landing areas on the Northern Channel Islands was an important factor in determining village locations. Jazwa et al. (2013) provide time-depth to examine shifting habitat suitability through time as a factor in an analysis of settlement patterns of a particular canyon on Santa Cruz Island in southern California, as the shoreline at the mouth of the drainage changed from estuary to rocky intertidal habitat. Codding and Jones (2013) found that the relative antiquity of linguistic groups in California was highly correlated with biological productivity, arguing that later groups settled in less suitable habitats, with the exception of Algic speakers in northwestern California, whose superior fishing technology and social organization may have allowed them to displace the previous occupants of the area (though these occupants have not been identified archaeologically) through a different, but related ideal despotic distribution. Implicit in these studies is a cultural ecological perspective that, rather than being environmentally deterministic, argues that environmental suitability is the product of the natural environment, tools used to extract resources from the environment (technology), and social organization (Steward 1936, 1938).

Modeling Suitability

There have been previous attempts to model suitability over a landscape. Most recently, Codding and Jones (2013) used net primary productivity as measured from satellite imagery to assess the overall environmental suitability of a region. Gmoser (1988, 1994) created suitability contours using modern vegetation maps, and examined the correlation between these and the antiquity of linguistic groups in California. Baumhoff (1963) focused on the relative abundance of key resources (acorns and "salmonmiles" of river) to predict carrying capacity in northern California. Site catchment models of the 1970s and 1980s used these data to examine the relative quality of the environment around particular sites (e.g., Simons in Hildebrandt and Hayes 1983). These early catchment approaches, however, focused on particular site foraging radii rather than examining broader patterns of suitability across the landscape. To examine the potential suitability of various portions of the Bay-Delta Area for settlement, we initially followed these previous efforts, and developed a model which combines the ecological make-up of units within the study area, defined by hydrological watershed boundaries, and the cultural significance of certain key plant and animal taxa. The steps for developing watershed suitability scores are discussed here and summarized in Figure 39.

The first step in developing a testable hypothesis under the Ideal Free Distribution model is to assign suitability scores to portions of the study area. There have been various ways this has been accomplished in the past. Codding and Jones (2013), for instance, used net primary productivity across California. Within the San Francisco Bay-Delta Area, this did not seem suitable since: (a) the area is generally similar in net productivity; and (b) the net primary productivity model fails to account for the abundance and diversity of estuarine, riverine, and coastal resources. An alternative tack would be to examine archaeological assemblages and identify key taxa. Focusing on the potential abundance of these taxa in a given habitat might provide suitability. This approach, however, biases against subsistence remains without regard for other culturally important aspects of site settlement decisions. As a result, we decided to use a method based on ethnographic accounts from the region, which cover subsistence and non-subsistence resources and provide a null hypothesis against which suitability can be tested.

Index of Cultural Significance

We began by distinguishing 34 distinct watersheds within the Bay-Delta Area using modern and historical mapping and hydrological data in GIS software. These watersheds were then assigned a suitability score based on the composition of watershed vegetation and suitability values calculated for each vegetation type based on an ICS. Vegetation data were obtained from the BayAtlas reconstruction of historic-era bay habitats⁷. These data derived from historical maps and other detailed historical information. We cannot account for change through time in various plant communities, but do assume

⁷ http://ecoatlas.org/



Figure 39. Schematic Overview of Suitability Model Construction.

that: (a) the bay itself was relatively stable for the period of interest; and (b) changes in the relative health of various vegetation communities would be reflected across the entire Bay-Delta Area uniformly. We recognize that there is currently no way to evaluate the latter assumption, but there is little way around it.

While traditional cultural ecology and human behavioral ecology models use caloric return rates to calculate the relative benefit of a given resource, indices of cultural significance (Stoffle et al. 1990; Turner 1988) calculate a significance score wherein the total number of uses per plant are multiplied by factors reflecting their quality, intensity, and exclusivity of use, and summed to produce numerical values—higher values indicate greater cultural significance. Scores for all plants and animals are provided in Appendix G.

Beckwith (1995) used Kelly's field notes for a detailed analysis of the cultural significance of Coast Miwok plants. Using this system, by far the most culturally significant plant is tule, with a value of 309 reflecting its multitude of uses, including roots as food and foliage for housing, boats, basketry, cordage, mats, and clothing. Tule is followed by bay, with a ranking of 170, with oak, willow, and hazel clustered at 142–146; buckeye and soaproot at 132–134; and sedge at 100. These eight plants were clearly the most, or among the most, significant plants according to Tom Smith and Maria Copa, who Isabel Kelly interviewed to collect information on Coast Miwok culture history (Kelly et al. 1991).

To provide similar data for animals, Beckwith's (1995) method was applied to ethnozoological data from various ethnographies, including Harrington's (1942) culture element distribution list for the Central Coast (including the San Francisco Bay-Delta Area, and a detailed Coast Miwok ethnography by Kelly et al. [1991]). Unfortunately, these sources lacked a great deal of information from people living around the Bay itself. As such, estuary resources may be under-represented in this record. Of course it is important to keep in mind that these ethnographic insights are the result of Kroeber's memory-culture technique. As a result, some resources (like sea otter) appear archaeologically (examined more below), but they are not discussed by Tom Smith and Maria Copa. This may reflect the absence of these species or changes in resource focus during their lifetimes (especially during the post-mission, post-Russian-American Company era) and might not necessarily be a comment on value per se.

The ICS model is necessarily limited by plant and animal taxa that were discussed by Tom Smith and Maria Copa, and therefore it does not account for all potential resources, and often lacks details as to the relative diversity of species available.

It is perhaps not surprising that deer are the animal with the highest ICS score since their meat was eaten, their pelts used for blankets and clothing, and their bones used for a variety of functional and ceremonial purposes. Similarly, elk and jackrabbit are near the top of the list. A number of estuarine animals, however, are also ranked highly, including smelt/surf fish, clam, mussel, and waterfowl. Given the vague nature of many descriptions, several taxa were grouped into family- or genus-level taxonomic groups (i.e., "ducks").

Community Score Calculations

The relative abundance of each animal resource with a suitability score in each vegetation community was calculated using the California Habitat Relationship files in GIS (California Fish and Wildlife 2015). These rank the quality of a given vegetation community for a given species by forage, cover, and reproduction (i.e., suitability as a place to give birth/lay eggs). The maximum value was used when grouped taxa, such as ducks or squirrels, had a number of individual species present within a given habitat. The maximum quality score was used under the logic that the suitability of a given habitat was marked by its most abundant taxa rather than an average of all individual species or genera. The California Habitat Relationship files are a terrestrial dataset, so estuarine and open coast species do not have habitat quality data. Therefore, somewhat subjective quality scores were assigned to estuary and

open coast species for a number of coastal habitats. Similar statistical data were not available for plants, but each plant was assigned a category for each vegetation community based on modern community composition. Plants were scored either as dominant (quality = 1.0), common (quality = 0.5), present (quality = 0.25), or absent (quality = 0.0)

A community-specific suitability score was calculated for each species by multiplying the species ICS value by the quality value for a given habitat. Species scores were then summed by resource type—terrestrial animals, estuary animals, and vegetation—and these values were standardized to generate a value of 0.0–1.0 for each of the three categories. The three standardized aggregate scores were averaged to obtain a community suitability score (Table 20).

HABITATS	SCORE			
Terrestrial				
Coastal Oak Woodland	0.63			
Valley Oak Woodland	0.56			
Blue Oak-Foothill Pine	0.56			
Blue Oak Woodland	0.55			
Montane Hardwood-Conifer	0.40			
Montane Hardwood	0.40			
Estuary				
Freshwater Emergent Wetland	0.46			
Tidal Marsh	0.36			
Coastal Marsh	0.32			
Lagoon	0.32			
Shallow Bay/Channel	0.20			
Saline Emergent Wetland	0.19			

Table 20. Suitability Score for the Top Six Highest-Scoring Bay-Delta Area Terrestrial and Estuary Habitats used to Calculate Watershed-Level Suitability.

Watershed-Level Suitability

The relative proportion of each vegetation or wetland community within each of the 34 watersheds was calculated. Watershed level suitability was calculated by using the relative percentage of the top six-scored terrestrial and top six-scored estuary habitats within each watershed (see Table 20). The percentage of each habitat was multiplied by the habitat suitability score, and the results standardized to obtain an overall terrestrial score for each watershed. A similar calculation was made to assign an estuary score for each watershed as well. These two statistics were combined, giving terrestrial vegetation a slightly greater weight (60%) than estuary (40%), though the standardized results change little. The resulting suitability is shown in Figure 40.

Discussion

Interestingly, Walnut Creek in the South Delta watershed has the highest suitability score despite a lack of bay-front territory. This is likely because it is the best habitat for terrestrial resources, with a high percentage of oak woodland within its rolling hills. After Walnut Creek (and Angel Island which, while certainly a location used pre-contact, is too small for further discussion), the Northwest Bay watersheds (most feed into San Pablo Bay) are four of the next five most highly ranked habitats—Novato, Napa River, San Rafael, and Petaluma River; the South Bay watershed of Palo Alto, drained by San Francisquito Creek, is also highly ranked. Notably, the Southwest Bay region bay shore and coastal watersheds, which were composed mainly of terrestrial dune habitat with some upland forests and estuary/open coast land, have very low scores. Finally, bay shore habitats of the East Bay region and the open plains and mudflats of the South Bay region give rise to average suitability scores. If the Ideal Free Distribution Model explains settlement of the Bay-Delta Area, and the general ranking of habitats is correct, then the relative quality of habitats should predict the order of settlement in the study area.

Measuring Settlement Trajectory

Spatial trends in radiocarbon-dated components were used to examine settlement trajectories. Because the San Francisco Bay Estuary was not established until approximately 6,000–5,500 years ago, the confidence in ranking Bay-Delta Area watersheds earlier than 6000 cal BP is tenuous at best. Furthermore, very few dated contexts are identified prior to 6000 cal BP, and many of these are isolated burials. We therefore used only those dates from 6000 cal BP onward, and examine the validity of the suitability model. We acknowledge that the San Francisco Bay margin was quite different 6,000 years ago than it is today, but offer the suitability model as a null hypothesis against which the record can be tested. Future work might identify local shifts in ecology that would allow refinement of this model.

We examined settlement trends using components defined on 500-year time scales, though they are plotted in 1,000-year intervals in Figure 40. Table 21 shows the results of the suitability score for each watershed with more than two component assemblages in it, as well as the earliest recorded radiocarbon date. The shaded cells are the earliest occupation which remained more or less constant (i.e., is not an outlier for the drainage settlement history). If the model perfectly predicted the order of settlement, and the archaeological sample perfectly reflected the order of settlement, then the shaded boxes would generate a diagonal line from top left to bottom right in the table. Obviously, neither of these conditions are met. Because the order of settlement is the topic of interest, however, both the earliest date of occupation and the order of sustained occupations are analyzed using Spearman's rank-order correlation (Rs). A Spearman's rank-order correlation between the habitat suitability rank and the rank of occupation using radiocarbon dates is not statistically significant (Rs=0.25; p-value=0.15), demonstrating that habitat suitability does not predict the earliest radiocarbon date (younger than 6,000 years old) in each watershed (Figure 41b). The correlation between the order of settlement and suitability, measured in stable occupations with components over multiple 500-year periods, is statistically significant (Rs=0.45; p-value=0.02), demonstrating an excellent fit between the modeled suitability and the order of sustained occupation (see Figure 41b).

Evaluating Potential Ecological/Environmental Factors Mediating Population Density

As noted in the introduction to this section, working under the assumption that Bay-Delta Area population at contact follows an ideal free distribution, the relative population density within watersheds should also correlate with habitat suitability. To examine this relationship, we turn to the extensively studied pre-contact population of various Bay groups based on mission records and other ethnographic evidence (Milliken 1995, 2010; Milliken and Johnson 2005). Milliken's population estimates are derived from careful study of the California Mission Database, a computer database consisting of records up through 1840 for 17 California Missions from San Fernando north to San Francisco Solano). The database includes 55,603 records representing 32,375 tribal converts, 13,696 mission-born California Indians, and 7,919 non-Indians (Milliken 2010:17). Death and marriage records are also included in the database, as is a column within each record assigning it to one of 663 year-round local group regions as defined by Milliken (see Milliken 2010 for a full explanation of methodology on determining these regions; see also Appendix B). These include 23 regions that border the San Francisco Bay and Delta Estuary and 50 that are within the District 4 San Francisco Bay study area.



Figure 40. Suitability by Watershed with Radiocarbon Component-Dated Sites in 1,000-Year Increments from 6000 to 150 cal BP.

WATERSHED	Suitability	PEOPLE/MI ²	Earliest ¹⁴ C Date	NUMBER OF COMPONENTS PER 500-YEAR INTERVAL											
				0- 500	500- 1000	1000- 1500	1500- 2000	2000- 2500	2500- 3000	3000- 3500	3500- 4000	4000- 4500	4500- 5000	5000- 5500	5500- 6000
Pacifica	0.04	1.58	984	2	3	-	-	-	-	-	-	-	-	-	-
San Francisco Bayside	0.11	1.28	1972	1	2	5	2	-	-	-	-	-	-	-	-
Fremont Bayside	0.23	2.99	1832	1	3	3	2	-	-	-	-	-	-	-	-
Coyote Creek	0.31	4.36	5677	6	10	8	7	5	4	1	1	-	1	-	1
Alameda Creek	0.32	4.52	3609	5	7	5	2	3	2	1	1	-	-	-	-
Berkeley	0.35	2.9	4932	4	6	4	2	3	5	5	2	3	2	-	-
Pinole	0.35	3.22	5093	2	3	6	7	4	3	-	-	-	-	1	-
Guadalupe River	0.41	4.67	5415	3	5	4	4	1	-	1	-	-	-	1	-
Marsh Creek	0.41	2.83	5948	8	5	5	8	2	4	2	3	2	3	3	2
San Mateo Bayside	0.43	2.29	5929	5	12	6	7	5	3	2	2	1	1	2	2
Delta Sloughs	0.46	2.62	1647	1	3	1	1	-	-	-	-	-	-	-	-
Benicia	0.46	3.65	4559	2	2	4	3	2	1	3	3	3	1	-	-
East Bay Cities	0.48	2.92	5165	2	5	4	5	4	2	1	2	-	-	1	-
Petaluma River	0.53	7.72	1578	3	2	-	1	-	-	-	-	-	-	-	-
San Rafael	0.54	3.66	4938	4	3	5	6	4	1	1	1	1	1	-	-
Palo Alto	0.57	4.14	5962	10	11	14	12	11	9	8	4	6	2	4	3
Napa River	0.58	4.78	4706	2	1	2	1	-	1	1	2	1	1	-	-
Novato	0.66	6.87	4042	5	3	3	1	-	1	1	1	1	-	-	-
Walnut Creek	1.00	4.08	5127	4	3	1	-	-	-	3	1	1	-	2	-

Table 21. Suitability Values and Radiocarbon-Dated Component Counts in 500-Year Intervals for all Watersheds with More than Two Components.

Note: mi² – Miles squared; Gray highlight indicates period of earliest consistent occupation that remained more-or-less constant.



Notes: Rs – Spearman's Rank-Order Correlation; p – Probability Value.

Figure 41. Comparison of Watershed Suitability to: (a) Date of First Occupation; (b) Date of First Lasting Occupation; and (c) Ethnographic Population Density.

Milliken (2010) acknowledges that his regional boundaries involve a good deal of guess work, particularly in the San Francisco Bay-Delta Area where ethnographic boundaries were obliterated early on by missionization. To match the watershed-level analysis used in this study, we generated a weighted population density based on the population density of all ethnographic regions encompassed by a given watershed. Weighted values were assigned based on the percentage of the total watershed comprised of a given ethnographic region.

The highest weighted values for population are in the Northwest Bay where populations in the Napa River and Petaluma River drainages are between 4.78 and 7.72 people per square mile (Figure 42). The lowest populations are in the coastal areas in the Southwest Bay, with between 1.28 and 1.58 people per square mile. The Spearman's rank order correlation between habitat suitability and population density is the most significant of any of the three comparisons ($R_s=0.52$; p-value=0.02; see Figure 41c).

Discussion

As comparisons with the first sustained occupation in each watershed and ethnographic population densities show, the ideal free distribution provides an excellent approximation of the relative suitability of different habitats around the San Francisco Bay-Delta Area and a null hypothesis for future work in the Bay-Delta Area. The lack of fit between the earliest radiocarbon date post-dating 6000 cal BP and suitability is likely due to the rapid settlement of the bay margin by existing peoples as the bay formed; the San Francisco Bay-Delta Area was not depopulated prior to this, but instead, settlement patterns were likely oriented around the more productive (and potentially now-flooded) "California" River (i.e., the river that emptied to the Pacific Ocean west of the Golden Gate). To avoid this being an environmentally deterministic model, we have used a cultural significance value to calculate the habitat suitability. With the exception of Walnut Creek in the South Delta, the majority of highly ranked habitats are found in the Northwest Bay where there would have been access to a variety of estuary habitats as well as extensive terrestrial resources in the surrounding hills. While these areas certainly had some of the highest recorded population densities at contact, radiocarbon evidence for occupation does not substantiate a priority of occupation in this region. In particular, the Petaluma River watershed is expected to have older occupations, as are sites along the Delta. Sites away from the Delta proper, namely Marsh Creek, (CCO-18/H) in the South Delta, demonstrate the potential to find old and lasting occupations adjacent to the Delta; Solano and Napa Counties might have evidence of older occupation stretching back into the Middle Period.

The converse is also true—some watersheds have older occupations than expected. Among these watersheds are Marsh Creek in the South Delta, Berkeley in the East Bay, and San Mateo Bayside in the Southwest Bay. There may be several possible explanations of these patterns, and these might be explored with site-specific studies in the future. For instance, site-specific data may demonstrate the importance of certain resources that are underrepresented in the ICS, and therefore provide a reduced score for the watershed as a whole. Feedback between data obtained from sites and the cultural significance values could prove valuable to recalibrating the model.

Correlation of the model with the current data set demonstrates that the ideal free distribution may be an excellent null hypothesis against which to test future syntheses of the region or subregions. It is possible that future studies will identify patterns that do not match the Ideal Free Distribution Model. In such cases, it is possible that the model is inappropriate to explain settlement patterns, but it is also possible that there are social pressures or other non-economic social mechanisms that are dictating the relative intensity and patterns of occupation. These may fall under the so-called ideal despotic distribution (Fretwell 1972; Fretwell and Lucas 1970), whereby groups that are already within a high-ranked habitat competitively exclude others, or it may elucidate variations on the model which have not been considered but can be proposed based on the wealth of non-subsistence data from the San Francisco Bay-Delta Area.



Figure 42. Suitability Results Compared to Ethnographic Population Densities by Watershed.

Data Requirements

This research issue is regional in scale but, as suggested, might be addressed and enhanced with site-specific data. These data can refine the ideal free distribution model, both in identifying important local resources that were exploited that may re-rank the various habitats in the Bay-Delta Area, and potentially by aiding archaeologists in reconstructing paleoenvironments and how they changed as the bay-estuary grew throughout the Middle and Late Holocene. As such, the first requirement to address this issue is well-dated site components. Beyond this, faunal and archaeobotanical data (including but not limited to plant macrofossils, starch grains, and pollen) can help gain insight into which local resources were exploited and, with consideration of cultural factors, gain insight into local habitats to aid in refining the model. At the same time, site-specific studies can also aim to collect nearby, off-site geomorphic or paleoenvironmental data that can provide direct evidence of localized changes in habitat.

Sites with paleoenvironmental data on bayshore habitats, particularly in the early Late Holocene (~4000 cal BP) might be eligible under this research topic, as might sites with good dietary data that might confirm or refute the ICS ratings proposed as part of the suitability ranking.

DISCERNING AND MODELING SETTLEMENT ORGANIZATION

Archaeological investigations of hunter-gatherer settlement organization invariably concentrate on discerning mobility, seasonal rounds, and the range of site types needed to maintain various settlement constructs (Binford 1980, 1982; Kelly 1983, 2013). These reconstructions, particularly in California, have tended to build logical linkages between a few residential sites (potentially occupied at different times of the year) and shorter-term, more specialized sites that typically functioned as procurement locales for key resources (such as hunting camps, bedrock milling stations, and lithic quarries). These selected, specific site types were then used to posit how annual systems functioned, and their areal extent and primary economic niches.

More recent research has begun to expand approaches to regional reconstructions (Kowalewski 2008), examining such topics as social boundaries and territoriality (Dortch 2002), exploring the social landscape (especially in relationship to symbolic behavior and ceremonial activities), and modeling transport costs for key commodities such as food resources and raw materials (Madsen et al. 2000; Zeanah 2000). Statistical analyses have also explored the use of hunter-gather ethnographic data to reconstruct the limits of daily and annual foraging ranges. For example, multiple regression analysis of world-wide ethnographic data by Grove (2009) demonstrates that residential moves are inversely correlated with group size—the larger the group, the shorter the relocation distance and the greater the number of moves made. Moreover, groups that relied largely on fishing tended to make fewer residential moves per year than gatherers or hunters. In contrast, Morgan (2007), focusing on southern Sierra Nevada groups, used ethnographic and archaeological data to conduct least-cost path, GIS-based spatial analyses, identifying the limits of caching locations and foraging ranges tied to seasonal movements.

There have been a number of prominent explanations of the spatial and organizational structure of the pre-contact annual round in the Bay-Delta Area, and several from different settings are highlighted below (see also Milliken et al. 2007:105–107). King (1974), for example, posited that sedentism emerged 2,000 years ago, initially along the northwest shore of the Bay as its rich and variable environment allowed groups to exploit multiple environmental zones from a sedentary central place. Alameda (near Oakland) and East Palo Alto were considered other potential early loci of sedentism. Initially, other portions of the Bay-Delta Area (notably along the Alameda and San Mateo County bay shores) were seasonally occupied, with groups spending the late fall and winter along the Bay, and spring to early fall in the uplands. Bocek (1991) argued for an annual round on the southwestern side of the Bay that included an upland and a lowland residential camp. Based on seasonal differences in resources

(productivity, diversity, and water availability), winter-spring occupation was concentrated in the lowlands (near grasslands and marshes), with summer-fall occupation in the uplands (within oak woodland, chaparral, and evergreen woodland vegetation communities). The San Francisquito Creek catchment was an exception to this pattern (Bocek 1991:Figure 3-4). Here, two different tribelets may have been present—one with an annual round in the foothills and one residing in the lowlands—with a gap in site distribution spatially correlated with petroglyph sites that served as boundary markers (i.e., Kroeber 1925:398). Bocek (1991) also observed that residential sites were almost always within 100 meters (330 feet) of drainages (also noted for the Santa Clara Valley by Bergthold [1982]), and that sites typically were highly clustered in a manner referred to as short-distance sedentism (see also Banks and Orlins 1981).

Along the southeast bay shore, Parkman (1994) envisioned three residential moves each year. This reconstruction was based on analysis of 58 sites in a 375-square-kilometer (1,230-square-mile) area, and placed considerable emphasis on the distribution of bedrock milling sites. In the winter, people living in large permanent villages on the bay shore consumed shellfish, fish, and migratory birds, along with stored acorns and grass seeds. Extended families or larger groups dispersed eastward to the plains/ foothills ecotone to collect bulbs, greens, and hard grass seeds in the spring and summer. Then in the fall, residences shifted into the hills for the acorn harvest and to hunt deer. Parkman (1994) argued that this semi-sedentary pattern, with seasons of dispersal and aggregation, was due to spatial incongruities in resource availability that precluded sedentism.

Turing to the northeast Bay margin, Banks and Orlins (1981:9.19–9.28) suggested a "periodically mobile living-site model." They distinguished two or three residential subgroups that "lived in the Richmond-San Pablo area on a virtually permanent, year-round basis" (Banks and Orlins 1981:9–22). This model aimed to reconcile a local ethno-historical reconstruction (indicating a population of 200 people [Milliken 1981]) with the presence of 28 major pre-contact middens, typically clustered in groups of three to six in their 100-square-kilometer study area. Therefore, they suggested that local populations shifted periodically between nearby residential locations due to minor, short-term declines in the local habitat (e.g., firewood and hygiene). These shifts were not seasonal, since there were no differences in intra-annual resource availability between these nearby localities. Banks and Orlins also offered an alternative reconstruction to explain this site distribution, suggesting that different extended families occupied different nearby mounds year-round, coalescing periodically for ceremonies. Recently, Finstad et al. (2013), drawing on shellfish seasonality data from two northeast bay shore mounds, found partial support of the Banks and Orlins short-term sedentism reconstruction, where multiple mounds in a general area were occupied by members of the same larger community.

These northeast shore reconstructions were then built upon in a series of articles by Lightfoot and Luby (Lightfoot 1997; Lightfoot and Luby 2002, 2012; Lightfoot et al. 2011; Luby and Gruber 1999; Luby et al. 2006). Those studies have typically entailed consideration of the larger context of settlement organization—focusing on mound clusters—as well as considering the function of individual bay shore mounds (as discussed elsewhere in this document). In doing so, they suggest that:

Most mounds are found in clusters of three to 14 sites distributed along the bay shore or adjacent freshwater streams. These site clusters may be composed of both large and small shell-bearing sites, an occasional earth mound, and petroglyphs; bedrock milling stations; lithic scatters; and nonmounded cemeteries (Luby et al. 2006). Two kinds of site clusters have been recently identified: "contained" (or "tight") clusters of sites grouped into geographically compact areas and "open" (or "dispersed") clusters in which associated sites are spread relatively far apart from one another; though at a larger scale they still possess spatial unity. Open clusters often span the shores of the bay, or reach across several drainages in the nearby hills, and tend to be arranged in a more linear fashion than sites associated with compact clusters [Lightfoot and Luby 2012:114–116].
Byrd and Petersen (2008) conducted a GIS-based spatial study of land use along the margins of the San Francisco Bay north of the Golden Gate, encompassing 360 square kilometers. The study gathered data on 322 sites drawn from Nelson's 1909 survey notes. The analysis revealed that Late Holocene settlement patterns differed significantly in this area. Notably, the east side had proportionally more extremely large sites clustered along small streams. In contrast, the west side had greater site densities and more varied site sizes, ranging from very-large mounds to small, temporary camps. Byrd and Petersen (2008) argue that these differences in settlement structure have implications for pre-contact shifts in social organization, political complexity, and land ownership. Northeast Bay social organization was more likely to stress political structures that best managed large communities as well as logistical organizational strategies to acquire resources from more distant patches. In contrast, pre-contact socio-political organizational development in the northwest Bay was more likely to have emphasized territoriality and private property ownership, and to have facilitated residential exploitation of nearby resource-rich uplands.

Recently, Eerkens et al. (2013b) presented a nuanced model of settlement organization drawing on shellfish isotope and plant seasonality data from two Late Period sites on the San Francisco Peninsula. This study contrasted a large shell mound (SMA-6) with an ephemeral camp (SFR-171), and examined isotopic data on clam (*Macoma* spp.) and mussel (*Mytilus* spp.) harvesting (Byrd and Kaijankoski 2011; Byrd et al. 2012). The results indicate that these two sites represent different parts of a single settlement pattern. They appear to represent typical end points of a single fission-fusion system that was practiced on the west side of San Francisco Bay. This settlement pattern included periods of dispersal during late winter through early summer (as exemplified by occupation of temporary camp SFR-171), and aggregation in late summer through early winter (as revealed by occupation of the major residential site SMA-6). The study demonstrated the utility of considering both small and large sites when reconstructing settlement systems.

In summary, settlement pattern models for the Bay-Delta Area have posited that residential sites near the bay shore were occupied year-round, in single seasons (such as the winter), or in multiple seasons (such as late summer through early winter). Moreover, it is possible that during the occupation span at a single site, the typical seasons of occupation changed. How the annual settlement pattern of specific groups interdigitated (particularly with respect to near-bay shore versus adjacent foothill populations) is potentially highly variable. In particular, the role of sedentary settlements needs to be considered in pre-contact settlement pattern modeling. Several significant questions remain unanswered. When did residentially stable settlements emerge in the region? Where were major residential communities situated on the landscape with respect to key environmental variables (such as perennial water sources and specific food resources)? What was the spatial distance between communities? What types of task-specific sites may be expected in bay shore settings versus inland or upland settings? What roles did ceremonial activities, ritual events, and periodic aggregations for social interaction play in the construction of the archaeological record and pre-contact annual settlement structure?

Data Requirements

Discerning the range of activities and seasons of occupation at individual sites in the Bay-Delta Area (including residential, short-term occupation, and specialized sites) requires construction of archaeological correlates (e.g., Monks 1981; Rafferty 1985). Archaeological data that can be used to address this topic include, but are not limited to, aspects of site structure, the range and nature of the resource base, and seasonality of resource exploitation. Attributes of site structure that need to be considered include site size, thickness of cultural deposits, residential versus non-residential architecture, food-processing and storage features, trash dumping episodes, and the presence of on-site cemeteries. Probably the most productive line of inquiry involves detailed studies of plant and animal remains that emphasize seasonality of availability. Such an investigation would benefit most profitably from the following analyses: season of plant collection (including small seeds, nuts, and fruits); presence of

seasonal birds (such as winter visitors or fall/spring migrants); seasonally migratory fish (spawning runs of salmonids); age profiles of faunal remains to identify young and juveniles, and isotopic analysis of shellfish remains. Notably, recent oxygen stable isotope studies demonstrate the analytical power of studying shellfish to determine season, if not month, of collection (see page 8-23). With multiple lines of seasonality evidence from discrete site components, more robust assessments of seasonality of occupation will be possible. These data can then be used to examine geospatial trends in settlement organization.

An eligible site will contain information on the duration and intensity of site use (i.e., seasonal versus year-round). This may be evident in subsistence remains, types and diversity of artifacts, and accretion of midden. This topic is best addressed through comparison of a site with other nearby or regional sites to reconstruct an overall pattern of occupation or seasonal rounds.

CONSTRUCTION, STRUCTURE, AND FUNCTION OF BAY-DELTA AREA MOUNDS AND MIDDENS

A diversity of perspectives has been offered regarding the construction, function, and structure of the major sites (notably mounds and shell middens) situated around the margins of the Bay and in adjacent inland areas. Notably, a number of scholars in recent years have suggested that major mounded archaeological sites functioned as key ceremonial centers, if not during early periods of occupation, then later on (Leventhal 1993; Lightfoot 1997; Lightfoot and Luby 2002, 2012; Lightfoot et al. 2011; Luby and Gruber 1999). Assertions have also been made that many of these sites were artificially constructed for ceremonial purposes, including mortuary ceremonies and as burial grounds, often primarily for those of high status and wealth (e.g., Leventhal 1993; Luby and Gruber 1999; Praetzellis 2015a:6–29). These perspectives, which deviate markedly from earlier assertions that the sites were kitchen middens, formed mainly by the residues of residential events (e.g., Uhle 1907), are summarized here.

Leventhal's (1993) reconstruction of the Ryan mound (ALA-328) as a non-habitation, ceremonial, and cemetery locality is undoubtedly the pioneering, seminal contribution to this topic. Leventhal (1993:256) argued that the site was not "the remnants of a sedentary village site built-up over time as a by-product of the accumulation of habitation refuse," but instead the site functioned "as specialized ceremonial sites which principally centered around both funerary and mourning related activities." Notably, the mound maintained its non-domestic function throughout it use (from the Middle 2 Period through the Late Period), and increased in size as fill was brought in to cover earlier burials. To support his argument, Leventhal's (1993) analysis stressed that the following site attributes were inconsistent with a habitation site: (1) dearth of house floors and features; (2) a low frequency of artifacts; (3) the site had only 10% shell by volume (Wilson 1993:4) and therefore was not a typical shell mound bay shore site, but rather an earthen mound; (4) its modern context-situated within a marsh that flooded annually, lacking readily available fresh water, was unsuitable for habitation; and (5) the presence of a large number of burial interments within the mound was inconsistent with ethnographic reports in California that indicated burials were almost always situated offsite. Although fauna and shellfish were present, Leventhal (1993:115) noted the challenge of discerning general habitation food residue from that generated by short-term major ceremonial events. Finally, he suggested that many other bay shore mounds also represent non-habitation localities, and drew support from Meighan's (1987) argument that many Windmiller sites/mounds in the Delta were not habitation sites (as classified previously), but instead functioned primarily as cemeteries.

Lightfoot (1997:131), in a subsequent analysis of Bay-Delta Area shell mounds, stressed the considerable variation in the structure and composition of mounded space. In doing so, he highlighted the large number of burials typically present, and spatial and temporal variation in their patterning (distinguishing the presence, often within a single mound, of a cemetery, smaller burial groups, and more isolated burials). Lightfoot (1997) compiled and noted the very low density, but high diversity, of artifacts

recovered from the major mound excavations (never more than 20 per cubic meter), lending credence to the perspective that some mounds "probably served as specialized cemeteries—sacred places, segregated some distance from residential places, where ritual activities venerating the dead were performed" (Lightfoot 1997:132–133). Their construction along the bay edge may have been, in part, purposive as material was dumped on them to intentionally raise them (Nelson 1909:335). This would have kept the site above the high tide, maintained ready access to the rich littoral zone, ensured continuity with ancestral generations through mortuary rituals and burial of community members, and served as visible markers of territorial rights across a wide landscape. Many of the most substantial mounds however "were used as both ceremonial locations and residential places" (Lightfoot 1997:134), and some may have been key local centers for political and ceremonial power. Lightfoot and Luby (2002:280), in a later study of Late Holocene settlement trends, argued for a strong decline/abandonment in occupation of major mounds at the start of the Late Period, and also asserted that the mounds continued to function as burial grounds and ceremonial centers.

Subsequently, Luby and Gruber (1999) argued that mortuary-related feasting and ceremonies were key factors in the creation of Bay-Delta Area shell mounds. They considered "shellmounds to be intentional cultural features rather than accidental aggregates of shell refuges that happen to contain artefacts..." (Luby and Gruber 1999:95). It should be noted that they referred to all shell middens as mounds (even if they were not mounds) to further stress the primacy of this non-subsistence perspective. It doing so, they embraced Hayden's (1995) views on social complexity and inequality among transegalitarian societies, and the importance of feasts and rituals (in this case mortuary) in allowing individuals to accumulate prestige and power. Although they recognized the mounds contained evidence of habitation, they assumed social inequality existed, and argued this "played a central role in mortuary ceremonialism" which was dominated by ritually sanctified feasts and surplus-driven exchange (Luby and Gruber 1999:100-101). One aspect of this argument that has direct relevance to site structure is the assertion (based on a study of ALA-328 burial) that most mounds are underlain by cemeteries with evidence of inequality (Luby 2004)-this argument, in turn, reinforces their perspective of the primacy of mounds as loci of ancestral celebration. In doing so, Luby and Gruber (1999:105) stress the sacred aspects of consumption-related residue, noting that "masses of shell should hardly be regarded as incidental wastage if people were buried therein," while at the same time chastising western archaeologists for their lack of perspective, stating: "As we have suggested, food and its non-edible matrix is homologous to life, as well as to death. A non-throw away culture does not necessarily see this non-edible matrix collected in one space as 'garbage' but as a condensed symbol. Some such cultures, therefore, 'build' up their mounds high, in an economy of symbolic conservation" (Luby and Gruber 1999:103).

Lightfoot et al. (2011:61) delve further into this topic by evaluating various mound site functional interpretations, including as kitchen middens, "specialized cemeteries, as aggregation sites for feasting and mortuary ceremonies, or as full-service mounded villages." Their focus is primarily on assessing the latter interpretation through a case study of Nelson's (1910a) excavation of the Ellis Landing mound (CCO-295). They state there is no strong evidence for the mounded village model given the dearth of house floors and low density of artifacts (especially those indicative of daily activities, such as debitage). Lightfoot et al. (2011:78) suggest that during the earlier phase of occupation, the site functioned as a burial ground and feasting locality, and perhaps as a "logistical base where coastal resources were bulk collected and processed, possibly for transportation elsewhere," and then in the later phase as a residential occupation (due in part to the presence of some 15 house pits observed by Nelson [1910a] on top of the mound), generally lacking burials. Overall, Lightfoot et al. (2011:74–75) envision bay shore shell mounds as key aggregation locales (to ensure coordination and to take part in ceremonies) within a "pyrodiversity collecting model" that required a flexible, varied organizational strategy, tied to mobility, small-patch burning, and associated terrestrial resource procurement. In a similar vein, Hylkema (2015)

suggests that bay-shore mounds may have represented maritime-based trade and ritualized reciprocity centers that capitalized on boat travel to enhance trade, subsistence, and broader territorial interaction.

As part of the overall reanalysis of the Ellis Landing mound, Schweikhardt et al. (2011) and Finstad et al. (2013) conducted shellfish isotope seasonality studies to assess if the site (and a nearby contemporary mound, CCO-290, on Brooks Island) functioned as "full service mounded villages" or were ceremonial centers where people aggregated only at certain times of the year for ritual events. Their basic premise was that if the mounds were ceremonial centers tied to a ritual calendar then "there should be a cyclical rhythm to the construction of the mound characterized by extensive deposits that were rapidly laid down in relatively short bursts of time" as documented in other mound construction localities in North America (Schweikhardt et al. 2011:2302). Both studies gathered systematic samples for a range of depositional contexts, and the results revealed that throughout their occupation sequences, both mounds were formed during all seasons except winter. Therefore, they concluded that "the results of our study do not appear to support the interpretation that the Ellis Landing shell mound served as a vacant ceremony center, with people dispersed out to smaller satellite sites for the remainder of the year" (Finstad et al. 2013:2656) Moreover, there is no indication for reduced annual intensity of occupation during the latter portion of the sequence at either site (during the Late Period), as had been suggested previously.

More recently, Lightfoot and Luby (2012) delve further into Bay-Delta Area mound building reconstructions, stress the singular importance of mounded space in the regional landscape, and place them in broader context with comparisons to mounds of the nearby Delta and elsewhere in North America. They assert that bay mounds were complex and intentionally constructed, and also that most "are accretional midden deposits built up over hundreds or even thousands of years" (Lightfoot and Luby 2012:219). They do, however, suggest that some bay mounds may have been made by intentionally moving material. As a result, they reject the use of arbitrary categories (such as earthen versus midden or shell mounds) to infer function, noting, for example, that the amount of shell in bay mounds declines in a gradient from north to south. Bay mounds also do not appear to be on the scale of specialization seen elsewhere (especially compared to the Midwest and Southeast), and the use of mounded space in the nearby Delta is considered more varied in terms of function and size (including temporal changes between emphasis on cemeteries versus habitation), and are also typically constructed on high points on the landscape to avoid flooding. Overall, Lightfoot and Luby (2012:218) stress the need for nuanced interpretations of mounded space, stating that "mound uses, construction methods, and meanings changed across generations."

By stressing the vital role non-subsistence activities played in Bay-Delta Area Native American occupation, these recent studies have been provocative and stimulating. Moreover, they have provided a counter balance to the earlier economic focus of California midden-constituent studies, as well as current human behavioral ecology subsistence modeling. They have also broadened the context in which the local archaeological record is interpreted (via comparison with mounded spaces in central and eastern North American and Near East tells), and place new interpretive emphasis on topics such as the social landscape, territorial markers, and the impact of pyrodiversity collecting.

These fresh perspectives are in turn raising new archaeological questions regarding how Bay-Delta Area settlement was structured. For example, if Native groups were primarily using the roughly 500 largest sites around the margins of San Francisco Bay as ceremonial centers for periodic aggregations and rituals, then where did people live most of their lives, and why, at least at first glance, does archaeological evidence of habitation appear much sparser? And why, if the bay littoral zone was the most productive setting in the region (and also the reason settlement became focused here initially), were neither subsistence strategies nor settlement positioning concentrated adjacent to the estuary? Why would local groups eschew daily foraging of this habitat, with its predictably successful yields of fish and shellfish throughout the year, for more seasonally varied and potentially less productive interior/upland settings? Should we also be concerned that such a focus on ceremonies, feasts, aggrandizing, and elites appears to minimize the daily efforts and lives of everyday Native people working upon and living off their lands? Might such an emphasis take away from a multi-millennial success story that should be celebrated in the same way Americans admire and construct mythical narratives of Euro-American farmers and ranchers who worked tracks of land for only the last 100 to 150 years?

It is also worthwhile briefly assessing two lines of archaeological evidence already raised in interpreting whether the Bay-Delta Area mounds can be best viewed as habitations sites, cemeteries, loci of annual feasting and mortuary ceremonies, or localities where habitation, mortuary, and other aspects of social interaction took place. One line of evidence is the dearth of residential house floors documented during excavation. Where such evidence is preserved, it is mainly represented by house pit depressions on the top of a mound or as occasional subsurface burned floors/surfaces. This negative evidence argument does not appear to be a strong one given the similar scarcity of house floors recorded during excavations at sites that are widely considered habitation sites elsewhere in central and western California. Three factors undoubtedly contribute to the lack of consistent preservation of houses: (1) the use of a building construction technique that entail digging a pit into the underlying sediment, thereby destroying the underlying stratigraphy; (2) the lack of formally prepared floors or non-perishable structural features which would increase the likelihood of archaeological identification; and (3) bioturbation, especially by burrowing rodents, blurring site stratigraphy. A second line of evidence is that the low artifact density of artifacts recovered from mounds is incompatible with daily habitation. In assessing this assertion, we compare the pre-1980 archaeological excavation data previously compiled and used (Lightfoot 1997; Lightfoot et al. 2011), with some readily available data from more recent excavations of bay shore mounds. Figure 43 reveals that mean recovery rates are almost 25 times greater for the select projects completed after 1985 than those completed prior to 1980 (of course, the sampled sites and contexts may play a role in these trends too, given the small sample size discussed here). This trend is consistent with changes in archaeological methods and recovery efforts (including the use of screens, and the consistent use of 1/8-inch screen, and, most recently, regular sampling with 1/16-inch mesh), and increased archaeological interest in recovering the debris of artifact manufacturing (such as debitage and small fragments of formal tools). As such, it appears that the recovery rates and range of material present within the mounds sampled using modern methods reveal presence of manufacturing debris and broken/discarded tool fragments consistent with habitation sites.

Data Requirements

Several lines of investigations can advance our insight into whether mounded spaces and middens can be considered habitations sites, cemeteries, loci of annual feasting and mortuary ceremonies, or localities where the full range of social interaction took place. Archaeological correlates need to be developed by which we can logically derive inferences regarding site function and on-site activities from empirical data. For example, what archaeological attributes can be used to distinguish an artificially constructed mound from one that grew accretionally through a broad range of anthropogenic events associated with village life? Or what archaeological evidence can be used to distinguish when food remains are the residue of feasting or just a prosaic meal? Similarly, if bay shore mounds were used briefly for bulk resource processing for transport elsewhere, then what are the archaeological expectations? Note that DeGeorgey's (2013, 2016) study of fish remains at Late Period site CCO-297 is an important example of such an effort, which now needs to be tested at inland sites.

These questions require detailed research into site formation processes aimed at unraveling a well-dated sequence of occupation periods; how deposits built up and whether they can actually be considered a mound or not; consideration of the development of cultural norms tied to waste disposal; and linking site function and settlement intensity attributes to shifts in occupational history. Any such analysis is both a geoarchaeological assessment and cultural formation process study that takes into account



Figure 43. Mean Artifact Recovery Rates at Bay-Delta Area Shell Mounds by Archaeological Study Date.

studies of local mounds (e.g., Finstad et al. 2013; Leventhal 1993; Meyer 2014a, 2014b), and an extensive body of international literature on the topic (Goldberg and Macphail 2006; Rosen 1985; Stein et al. 2003; Villagran 2014; Villagran et al. 2011). The objective should be to generate material correlate expectations of how evidence of feasting or ceremonial mound building events should differ from other types of formation events, examining how site deposits were created, assessing aspects of residential discard, and distinguishing various forms of secondary or primary deposits. Such studies need to be structured to gather the types of small-sized evidence/residues expected to be created during habitation events versus other type of activities and would be greatly aided by microconstituent analyses (such as microdebitage, carbonized plant remains, small fish remains, and small fragments of bone tools), drawing also on micromorphology, phytoliths and starch grain analysis to better understand site formation processes.

An eligible site will be a mounded midden deposit with intact strata that can be studied by a geomorphologist to examine site formation processes. The site should also have a suite of features and/or artifacts that provide evidence of the activities that occurred on-site and aid in the discernment of ceremonial and prosaic uses of the site. For instance, a mounded site with evidence of mainly artificially constructed deposits and ceremonial features and burials, but lacking debitage or other manufacturing evidence indicative of daily activities, would be eligible by demonstrating a purely ceremonial use of a mounded space. Conversely, a mound with abundant and varied dietary remains and evidence for tool manufacture (e.g., debitage and discarded tools) would provide evidence for use of the site as a habitation location.

BAY-DELTA AREA SEDENTISM-CAUSAL FACTORS AND TRAJECTORY

The onset of sedentary life—living in one community for most of the year—is a research topic of enduring interest to archaeologists and other scholars. Globally, archaeological investigation has concentrated on settings, such as the Near East and Mesoamerica, where the earliest known sedentary communities have been found (e.g., Byrd 1989; Flannery 1976). As a consensus has emerged in much of the archaeological community that sedentism first appeared in the context of hunting and gathering economies (rather than, as initially posited, with the emergence of agriculture [Price and Brown 1985; Price and Feinman 1995]), investigators have begun to examine a broader range of contexts in which hunter-gatherers became sedentary. Moreover, an earlier tendency to dismiss coastal hunter-gatherers as marginal is giving way to a recognition of the highly productive nature of marine and aquatic settings and their pivotal role in long-term developments with respect to population movement, population growth, and social interaction (e.g., Bailey and Milner 2002, 2003). Recent research has examined ethnographic and archaeological settings, and aimed at unraveling cross-cultural trends underlying the emergence of sedentary life, and determining whether or not, once established, this was a stable, adaptive strategy (e.g., Kelly 1992; Kent 1991; Rocek and Bar-Yosef 1998).

Elucidating the conditions under which hunter-gatherers become sedentary is a complex process. The fundamental question is, how and under what conditions will this happen? A persistent debate in theoretical discussions has been whether such change occurred in stressful or non-stressful conditions. That is, did these events occur in contexts of resource abundance (Byrd 2005) or resource shortage (Binford 1968)? Clearly, both internal and external factors must be considered to fully understand the dynamics of such a fundamental reorganization in hunter-gather settlement patterns.

It is also necessary to consider the social dynamics and organizational structure that underlie initial sedentism, as well as attendant changes in resource exploitation. This draws us explicitly into theoretical discussions on the correlation between sedentism, resource intensification, and the emergence of social complexity (e.g., Byrd 2005; Hayden 2001; Matson 1985). Such a research orientation is useful as it provides a basis for stepping beyond more prosaic aspects of initial sedentism—the what, where, and when questions—and for addressing the more vexing "how and why" aspects of this fundamental transition.

Although many scholars have studied Bay-Delta Area mounds and major shell middens, and provided varying interpretations of their function and formation (e.g., Leventhal 1993; Lightfoot 1997; Lightfoot and Luby 2002; Luby and Gruber 1999; Nelson 1909:335), few have explicitly addressed whether or not they were sedentary settlements. King (1974) asserted that sedentism first began 2,000 years ago along the northwest side of the Bay. Using catchment analysis and Nelson's (1909) site distribution information, he argued for social circumcision in the Middle Period as populations were packed in tighter than the maximum possible daily foraging extent. Sedentism then led to increased population, budding off, and the creation of new sedentary settlements, warfare and/or exchange, and ultimately greatly increased social complexity in the Late Period. Although why sedentism first began is not explicitly addressed, King (1974) considers it a necessary precondition for subsequent socio-political developments, including a ranked society. It is also clear that he saw a 2,000-year upward trajectory of increased population and social complexity, halted only by European contact.

In discussing Richmond-San Pablo area sedentism, Banks and Orlins (1981) did not address causality. They assumed that, once established 2,500–3,000 years ago, it was a stable adaptive pattern (although with precise settlement locations shifting over time, with some upstream repositioning in response to sea level rise). In a similar vein, Parkman (1994) argued that a semi-sedentary adaptive pattern emerged around 1,600 years ago along the southeast Bay margin and persisted until Spanish contact. No explanation, however, was offered for its origins.

Banks and Orlins (1981) did observe that the majority of their 28 Richmond-San Pablo area midden sites dated to the Middle Period, while fewer dated to the Late Period. This observation formed the basis for later assertions that population densities and social complexity declined in the Late Period (e.g., Lightfoot 1997; Lightfoot and Luby 2002). In this context, Lightfoot and Luby (2002:279) implicitly suggest Middle Period occupation was sedentary, while Late Period occupation was seasonal.

The Middle Period cultural climax and Late Period decline have received considerable support, with some scholars linking it to a shift in Bay-Delta Area mound site function from village to cemetery/ ceremonial center (e.g., Cartier et al. 1993:54; Lightfoot and Luby 2002). It should be noted that Leventhal's (1993) reconstruction of the Ryan mound (ALA-328) as a non-habitation, ceremonial, and cemetery locality greatly influenced these arguments. Some mounds (especially in the Richmond-San Pablo and Coyote Hills areas) became unsuitable for year-round occupation as Late Period sea level rise seasonally inundated the adjacent landscape. Settlements were relocated farther inland and, according to some, a dispersed settlement pattern and marginal use of the Bay-Delta Area ensued.

In contrast, Hylkema (2002:237) suggests that South Bay Early Period populations were mobile, while Middle Period populations "expanded their resource base and aggregated into semi-sedentary residential communities." Sedentism emerged later in the Middle Period and presumably persisted into the Late Period (Hylkema 2002:250). Similarly, Wilson (1999) argued for more intensive use of marshlands of southern Alameda County in the Late Period.

In summary, delineating the timing and causal factors for the onset and persistence of Bay-Delta Area sedentism has not been an explicit focus of research. Assertions offered regarding initial sedentism have tended to make an implicit environmental argument to this effect—with the establishment of Bay-Delta Area marshes in the middle Holocene, the resulting productive environment was a necessary and sufficient condition for major residential sites to be established in select locales during the Early Period (e.g., Milliken et al. 2007:115). Whether these sites were sedentary or seasonally occupied is open to varied interpretations, since previous archaeological investigations were rarely, if ever, designed to address this question.

Recent reconstructions have also tended to suggest that sedentism was not a stable adaptive strategy. Although it may have had its origins in the Early Period, sedentary village life, with an attendant increased social complexity, reached its zenith in the Middle Period, and then may have declined in the Late Period. It should be noted that Hylkema (2002:258–261) argues for increased social complexity in the Late Period, including greater evidence for exclusive memberships in social organizations, possibly including the *Kuksu*). Although causal links are rarely articulated, environmental conditions appear to have played a primary role in disrupting Middle Period settlement permanence, as a benign environment gave way to a poor environment (associated with the Medieval Climatic Anomaly) in the Late Period. The instability of Bay-Delta Area adaptive patterns is best exemplified by Milliken et al. (2007:115–188), who identify four cultural climaxes during the last 2,200 years (in the Middle 1, Middle 3, Middle/Late Transition, and at the end of the Late 2 Periods), with intervening downturns. These fluctuations in social complexity have implications for settlement organization, site permanence, village size, and economic strategies; they are also considered to be tied to population movements and increases that overtaxed local resources and led to stress and conflict.

Data Requirements

Despite assertions that portions of the Bay-Delta Area were occupied by sedentary hunter-gatherers during the late Holocene, archaeological research has rarely gathered independent data to assess whether or not specific sites were sedentary habitations (yet see Byrd and Berg 2009). As such, there is limited insight into when, where, and in what context sedentary communities emerged and how long they lasted, and even more-restricted perceptions with respect to precisely how and why the transition took place. Key unresolved aspects of this topic include whether or not Bay-Delta Area mounds and major shell middens were sedentary settlements; when sedentism first emerged in the Bay-Delta Area; whether this was a stable adaptive pattern; whether some mounds functioned as habitations, trash discard localities, ceremonial centers or cemeteries; and if mound function changed over time. These questions require detailed research into site formation processes aimed at unraveling the precise date of site establishment; a well-dated sequence of occupation; consideration of the development of cultural norms tied to waste disposal; and the ability to link site function and settlement permanence attributes to shifts in occupational history.

An eligible site under this topic is expected to contain data evincing year-round settlement. This might include seasonality data, but also structural features such as house floors and cemeteries. Older sites with such evidence are more likely to contribute to the research topic than sites occupied closer to contact, when it is clear that sedentism was the norm.

SEASONALITY OF OCCUPATION – INSIGHTS FROM SHELLFISH HARVESTING

Integral to our understanding of site settlement and sedentism is the ability to identify the seasonality and duration of site occupation. Previous approaches have relied on biological traits of various plants and animals, generating charts of seasonal availability/abundance of various fish, waterfowl, and mammals, and seasonal ripening of small seeded plants (generally spring/summer), berries (summer), and nuts (fall; e.g., DeGeorgey 2013, 2016; Simons 1981; Simons and Carpenter 2007; Simons et al. 2000, 2008). These studies provide seasonal information and can sometimes be associated with a more direct time span based on birthing patterns, but rarely yield specific timing for season-of-occupation. These methods are further hampered as they provide season-of-death or season-of-harvest information but, due to pervasive storage regimes, may not provide season-of-consumption and therefore season-of-site use. DeGeorgey (2013, 2016), for example, argue that fish was processed at the Stege Mound (CCO-297) for trade to the interior. Therefore, while the run of herring may have been harvested in January and February, they may not have been consumed until September.

Unlike these more general studies, stable oxygen isotope analysis of shellfish remains provides an important new tool for reconstructing trends in the annual tempo of shellfish harvesting, and in the seasonality of site occupation. This is because shells are generally discarded at the time of processing, even

if shellfish are being prepared for storage. Recent studies in the San Francisco Bay-Delta Area demonstrate the analytical power and potential of studying shellfish to determine season, if not month, of collection (Eerkens et al. 2013b, 2014; Finstad et al. 2013; Schneider 2015a; Schweikhardt et al. 2011). To date, all of these studies have been conducted either on bent nose clams or bay mussels, two of the four main species in the bay. No studies of oysters or horn snails—the other two key shellfish in the bay—have been conducted. Oysters should be well-suited to isotope seasonality studies given documented seasonal variance in oxygen isotopes (Goodwin et al. 2010; Harding et al. 2010). Horn snail, however, may be more challenging as they inhabit such a wide range of environments (from saline to almost freshwater), the rapidity of their growth, and their possible lack of a cyclical pattern of growth (Jelmer Eerkens, personal communication 11/20/2013). Most recent site-specific studies have tended to focus only on a single species. Although useful, they provide only a partial picture of shellfish gathering strategies. A more robust approach is exemplified by investigations at SFR-171 and SMA-6, where both clam and mussel isotopes were studied for seasonality, providing a more comprehensive perspective on the timing of shellfish harvesting and site occupation (Byrd and Kaijankoski 2011; Byrd et al. 2012; Eerkens et al. 2013b).

Two main methods have been used for estimating seasonality (see Veldhuizen 1981 for an earlier attempt to study shellfish seasonality by visually examining growth bands), each designed for somewhat different research objectives. Both examine changes in biogenic carbonates due primarily to annual changes in water temperature and salinity. The first method provides more general insight and estimations of a seasonal emphasis of collection (Finstad et al. 2013; Schneider 2015a; Schweikhardt et al. 2011). It should be kept in mind that in these studies, the months assigned each season are offset one month later than standard meteorological seasons.

To date, this seasonality method has been used at three sites (CCO-290, CCO-295, and MRN-114) and with only bay mussels. The method involves plotting the ratio of magnesium to calcium (to track changes in water temperature) against oxygen isotope (¹⁸O/¹⁶O) ratios (to track changes in salinity). The actual shellfish sampling method involves taking a single sample from the edge of a series of shells to estimate seasonality of a particular site deposit or level, supplemented by a single, larger sample for a random location on a similar number of shells from the same context to estimate the range of values present. The goal is to obtain "tentative inferences of season of deposition of fossil carbonate" (Schweikhardt et al. 2011:2304), and gain general insight into whether all collecting occurred during one season or over a wider seasonal range. This approach was then used to assess research questions related to timing of mound building (whether it was represented by a single seasonal event or not) and whether nearby mounds were occupied at different seasons or not. The results are effectively coarse-grained site assessments; they are not aimed at obtaining empirical data to assess annual variation. Rather, it is effectively a qualitative assessment of seasonality, and it does not lend itself at present to rigorous quantitative comparisons between contexts or sites; see for example the considerable seasonal differences between contexts observed by Schweikhardt et al. (2011:2308–2309) but not delved into in their broader discussion.

The second method entails determining a month of death estimate for individual shells (Culleton et al. 2009; Eerkens et al. 2013b, 2014), and has been used on both bay clams and mussels. Four sites (ALA-17, CCO-297, SFR-171, and SMA-6) have been studied, along with a two-shell pilot study at SFR-175 (Praetzellis 2015). This method focusses on oxygen isotope ratios (¹⁸O/¹⁶O), with multiple data points (typically four) taken on a single shell, starting with the last, outer growth ring, and proceeding inward. Then the results are curve-fitted to ascertain where the last growth ring should be placed on the annual curve to estimate the month of death (with a plus or minus of approximately one month; though Culleton et al. 2009 identified six-week time segments). The ability to more precisely control for decade or larger-scale changes in salinity and temperature is an important advantage of this method.

The month-of-death method results from both shellfish species are assembled and presented in Figure 44. This graph shows six data sets (four for clams and two for mussels) from four sites (three Late Period sites and Early Period site ALA-17). It is important to keep in mind that these are modest-sized samples; a total of 191 shells have been studied with the sample size typically 31–36 per data set (except the small sample of 13 clams from SMA-6). These results, provide a useful primary assessment of annual trends in shellfish collection by species and site. One also would anticipate some difference between sites of varied function, such as SFR-171 versus SMA-6—the latter have a much more even distribution of monthly collection data indicative of a major residence rather than a temporary camp. The graph illustrates considerable monthly variation in individual data sets, with notable upswings, particularly in the winter and summer, and downturns in the spring and fall. There does not, however, appear to be strong differences between Early Period clam harvesting at ALA-17 and Late Period harvesting trends.

Figure 45 aggregates these data by presenting the mean of all samples for each shellfish species. The results reveal a series of trends. First, some shellfish collection occurs throughout all months of the year, consistent with sedentary occupation. There are also two peaks and two valleys in both the clam and mussel collection. Moreover, the time span of collection emphasis and minimization co-vary for the two species—peak collection for each occurred circa December-February and June-August, with downturns in procurement around March-May and September-November. These results are broadly consistent with summary observations noted using the more generalized method. Finstad et al. (2013:2655) suggested a June/July through December mussel collection emphasis at CCO-290 (Brooks Island) and CCO-295 (Ellis Landing), a trend also reiterated by Schneider (2015a:521) for MRN-114. These more general interpretations largely encapsulate the two main collection peaks noted in the monthly studies, although they lack the resolution to track finer-grained shifts in procurement.

These initial studies of the seasonality of shellfish collecting have several implications for our understanding of settlement trends and land use. First, the monthly reconstruction method is clearly more broadly applicable to a variety of archaeological research topics, including site seasonality and settlement pattern reconstructions, as demonstrated elsewhere on other species, including California mussel (*Mytilus californianus*), bean clam (*Donax gouldii*), and surf clam (*Mesodesma donacium*; Byrd et al. ms; Carré et al. 2009; Jones et al. 2008). Therefore, this method should be preferred in the future. Second, some collection of mussels and clams during most months of the year reveals that most of the studied sites were effectively sedentary settlements. Third, peaks in collection are present, and these times of shellfish collecting emphasis do not vary between these two species, despite differences in their habitats. Fourth, these fluctuations are relatively modest in scale rather that strong signals of time spans of site abandonment. Fifth, downturns in shellfish collection correlate with period of greater seasonal plant collection, and may reflect scheduling conflicts and choices. Finally, the December through February peak in clam and mussel collecting conflicts with Schneider's (2015:526) suggestion that there is an inverse correlation between mussel harvesting seasonality and the main months of Spanish mission baptism of Coast Miwok.

Data Requirements

Analysis of shellfish seasonality requires isotopic data. It is recommended that sampling protocol, sample sizes, and interpretation follow that developed for mussels and clams (Eerkens et al. 2013b). Ideally, samples should be from well-controlled and dated context so that temporal trends in shellfish collection can be derived.

An eligible site under this topic will contain a large assemblage of well-preserved whole shells of the same species (mussel or clam) from well-dated contexts. A site with multiple components containing shell would be of particular interest since it would provide a diachronic view of seasonal occupation.



Figure 44. Shellfish Procurement by Month of Clams and Mussels at Bay-Delta Area Sites.



Figure 45. Summary of Monthly Shellfish Procurement Patterns by Species.

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9. EXPLORING CHANGES IN DIET AND HEALTH

As with many other regions that were home to hunter-gatherers, perhaps the most robust dataset available to archaeologists in the San Francisco Bay-Delta Area is direct evidence of diet and the resulting health of pre-contact populations. Dietary remains are ubiquitous in the archaeological record, particularly along the bay margin where large shell mounds and dense middens have developed, containing literally tens of thousands of fish, mammal, and bird bones; thousands of kilograms of invertebrate shell; and tens of thousands of charred plant remains. Large numbers of human interments, which offer more direct evidence of dietary and health information, are typically documented at major shell mounds. A long history of studies on human bone paleopathology has recently been supplemented by advances in archaeological science. Overall trends in diet can now be measured directly using the inherent bone chemistry of individuals as measured through stable isotopes encased in bone collagen. Taken together, these studies provide interesting information on the day-to-day subsistence activities of pre-contact occupants of the Bay-Delta Area.

Beyond simply reconstructing the diet of past people in the Bay-Delta Area, however, the same data which have been used to track diet can also be framed in a greater ecological context providing valuable data on the interplay between pre-contact occupants along the bay shore and the broad and complex ecosystem around them. Some studies measure the effects of humans on particular prey taxa, while others have demonstrated the ways in which traditional practices fostered greater growth and diversity of plant species through practices such as burning. Past studies have provided myriad questions that data recovered from recent projects can address.

A total of 142 archaeological sites within the study area provides faunal data, identifying more than 500,000 total specimens (Figure 46; see also Appendix D), typically as number of identified specimens (NISP) with varying levels of taxonomic precision varying from size-sorted class level (i.e., medium mammal) to species-specific identifications. Of the 142 sites in the sample, 117 have at least one identification to order or lower taxonomic level; the sample from these sites totals an NISP of almost 180,000 and encompasses the identification of more than 300 distinct taxa.

RESOURCE INTENSIFICATION AND PRE-CONTACT SUBSISTENCE REGIMES

Over time, several explanations have been offered to account for patterned variation in subsistence practices in the Bay-Delta Area archaeological record, with scholars emphasizing resource intensification, differences in resource availability, over-exploitation, and changes in technology and environment (e.g., Bickel 1978; Gifford 1916; Hildebrandt and Jones 1992; Hylkema 2002; Milliken et al. 2007; Simons 1992). Studies typically have been regional in orientation, comparing a variety of sites; rarely have they examined diachronic trends at a single site (though see Broughton 1999, 2002, 2004; Wake 2012).

Resource intensification explanations have received a great deal of attention in California and the Great Basin. They generally suggest that human population-resource imbalances during the Late Holocene fostered more labor-intensive subsistence practices and declines in overall foraging efficiency (e.g., Basgall 1987; Broughton 1997). These ecologically oriented models have been used to study floral and faunal assemblages from throughout the San Francisco Bay-Delta Area and elsewhere (see Morgan 2015 for a review of such studies worldwide).

Resource intensification can be defined in various ways, but Broughton (1997:846) defines it as "a process by which the total productivity or yield per areal unit of land is increased at the expense of declines in overall caloric return rates or foraging efficiency." Under this definition, Broughton adheres to



Figure 46. Sites with Faunal Data in the Study Area.

what Morgan (2015) categorizes as an "explanatory" application of the term. A secondary use, particularly common in the gray literature of California is a "descriptive" use of intensification, where the term is applied to evidence of increased subsistence efforts. Under Broughton's application, resource intensification occurs when lower-ranked, less-productive food species are consumed in increasing quantities. Most researchers in central California explain resource intensification as a result of population growth, territorial circumscription, and/or a declining abundance of higher-ranked resources brought about by overexploitation or worsening environmental conditions. As discussed by White et al. (2002:59), such models predict "a specific sequence of archaeological signatures: (1) reduced foraging efficiency (increased diet breadth); (2) intensification (new tools and organization); and (3) inter-group trade and exchange (extensification)." In a general critique of these models, White et al. (2002), in a study of Clear Lake area archaeology, presents an alternative theory regarding the relationship between human adaptation and the distribution of resources. He sees social complexity arising out of the natural abundance of resources, rather than resulting from some precipitous decline in resources. Under this view, areas of natural resource abundance (such as the Central Valley and Bay-Delta regions) are expected to foster the development of social complexity, because access to resources in a competitive environment would require some sort of management. Specifically, "Exogenous competitive relationships are experienced more frequently by groups located near resource surplus, and in these locations positions of authority are further enhanced for individuals who successfully mediate conflict by converting it into wealth and political and ceremonial power" (White et al. 2002:61). The set of archaeological expectations based on this view include: (1) intergroup trade and exchange (signaling social differentiation); followed by (2) intensification and specialization; and subsequently (3) reduced foraging efficiency (White et al. 2002:62).

The processes which drove dietary patterns in the San Francisco Bay-Delta Area provide a wealth of possibility in terms of future research as dietary remains are abundant within bay shore sites and can be readily identified within distinct stratigraphic contexts, and therefore provide information on spatial and temporal shifts in human subsistence practices throughout the Late Holocene.

Broughton's Vertebrate Faunal Resource Intensification Trends

Broughton (1997, 1999, 2002, 2004; Broughton et al. 2007, 2015) has undoubtedly conducted the most detailed and problem-oriented study of subsistence change in the Bay-Delta Area, analyzing more than 25,000 identified faunal remains from the long habitation sequence at Emeryville (2700–650 cal BP) along the east-central bay shore. Broughton argues that steady human population growth during the Late Holocene (3800 cal BP onward) caused resource depression, which in turn led to resource intensification and greater reliance on lower-ranked foods. This manifested itself in higher frequencies of smaller resources and more emphasis on resources that took more effort to acquire, notably by traveling to more distant resource patches.

Broughton identifies three major procurement trends (Figure 47). First, the highest-ranked resources available locally (elk [*Cervus* spp.], sturgeon [*Acipenser* spp.], and larger birds) steadily declined during the Emeryville sequence in relationship to other resources from the same niche. For birds, these included geese (*Anserinae*) versus ducks (*Aythya*), large geese versus smaller geese, estuarine versus marine ducks, and large versus smaller shorebirds (Broughton 2004:32–44). Second, sea otters (*Enhydra lutris*) and cormorants (Phalacrocoracidae) increased steadily until around 2100–1900 cal BP (Stratum 7– start of the Middle Period) and then gradually declined. Their initial increase was correlated with high numbers of juveniles and babies, while the decline was associated with more adults and fewer juveniles/infants. A similar pattern was noted at MRN-67 in Larkspur, with juveniles more abundant during the late Early and Middle Periods, followed by a Late Period collapse in cormorant population (Schwitalla and Powell 2014). Broughton (2002) argues that intensified use of these two species caused breeder colony suppression. Finally, deer (*Odocoileus* spp.) declined in abundance until around 2100–1900 cal BP (Stratum 7), associated with a steadily increasing number of adults, along with younger



(Broughton 1994, 1997, 1999, 2002, 2004; Broughton et al. 2007)

Figure 47. Summary of Broughton's Resource Intensification Trends at the Emeryville Site (CA-ALA-309).

individuals, until site abandonment. Broughton asserts that these trends in deer exploitation initially entailed local resource depression, and then involved exploitation of more-distant patches that contained deer herds previously subjected to less intensive exploitation.

In two regional studies, both drew heavily on data from sites in the northern San Francisco peninsula, Broughton found support for the resource intensification trends identified at Emeryville (Broughton 1994; Broughton et al. 2007). Sea otters increased in importance in relationship to artiodactyls over time at SFR-114, and avian resource depression was discerned in a diachronic analysis of seven sites (SFR-7, -29, -30, -31, -113, -112, -114). Notably, the frequency of geese, large geese, and cormorants declined over time.

Cautious Use of Prey Abundance Indices

Since its introduction to archaeology (Bayham 1979; Bettinger 1982, 1987; Winterhalder and Smith 1981), optimal foraging theory has been eagerly embraced by faunal analysts as a framework within which faunal remains could be interpreted. To fit the data to optimal foraging theory models, namely the prey choice model, zooarchaeologists have adopted *abundance indices* to measure changes through time in the contribution of various taxa to the Native American diet (Bayham 1979; Broughton 1994, 1997, 1999, 2000, 2004). More specifically, these indices are often used to track the fate of large mammal populations as a result of human hunting. Indices are calculated as the ratio of a chosen large taxon (e.g., deer) to small taxa (e.g., rabbits) and are standardized to a value between 0 and 1, calculated as $\Sigma(\text{large taxon})/\Sigma(\text{small taxon} + \text{large taxon})$. A smaller index value shows a reduction in the large taxon relative to the small taxon. Unfortunately, it is impossible to demonstrate, based on the index alone, whether this is due to a reduction in the absolute number of large taxon, or an increase in the absolute number of small taxon. Furthermore, because the NISP is used to calculate the statistic, changes in the preservation, processing, or identification procedures of bone can affect the index.

Broughton (1999) supports his Emeryville resource intensification conclusions gleaned from abundance indices, with supplemental data on processing and age composition of hunted individuals. The index, which demonstrates the most profound change in the record at Emeryville shell mound, is the artiodactyl-sea otter index which ranges between 0.6 and 0.8 in the early strata at the site (Strata 10 and 9) but dramatically decreases to fewer than 0.4 in Strata 8–6. The relative proportion of artiodactyls begins to increase thereafter to values close to 1.0 in Strata 3, 2, and 1. These data form the basis of Broughton's resource depression interpretation (either through behavioral changes in the prey or an overall reduction in their population) and subsequent rebound due to use of more-distant resource patches.

There are several issues, however, that Broughton fails to account for and that require further study. Two issues in particular merit further review—the roles of habitat, and non-caloric foraging goals in changes in hunting patterns through time. These two issues are particularly pertinent to the artiodactyl-sea otter index. Broughton acknowledges that the ratio "includes prey types that now occur in separate habitat types, [so] the fine-grained search assumption may be more seriously violated" (Broughton 1999:53). In other words, the trade-offs between hunting deer and hunting sea otters are not so much a decision of which prey type to hunt, but in which habitat to hunt. The conclusion that deer populations have been depressed is less convincing when the orientation of hunting may simply have changed to emphasize offshore rather than terrestrial hunting.

A larger issue with the use of this comparison is the assumption that humans are motivated to hunt prey exclusively for meat. Sea otter pelts are likely to have been highly sought-after as trade goods in pre-contact contexts. The Bay-Delta Area was a socio-politically and economically complex place during occupation of the Emeryville site. Lightfoot and Luby (2002), in fact, believe that mounded sites rimming the East Bay represented nexuses of trade during the Middle Period. If sea otter pelts were highly prized as trade items, the relative increase in the abundance of sea otters represented in the middle

strata at Emeryville may in fact represent an increased hunting of sea otters for trade rather than a gastrically driven foraging decision. As sea otters are significantly more prone to population declines as a result of human hunting (e.g., Whitaker 2008a:Table 2-1), the increase in artiodactyls relative to sea otter remains in the latest occupational deposits at Emeryville might represent the resource depression of sea otters rather than the distant hunting of deer proposed by Broughton. Resolution of these issues requires further analyses of time-transgressive, fine-grained faunal data from Bay-Delta Area sites.

Alternative Vertebrate Reconstructions

Milliken et al. (2007:109) suggest that "problems of limited and anomalous component samples" may be affecting Broughton's results. If this is correct, then Broughton's index-based trends probably will not be replicated in data from other occupational sequences in the region. To date, explicit, rigorous attempts to test Broughton's temporal patterns with other vertebrate data sets in the Bay-Delta Area have been rare (although, see Simons and Carpenter 2007). At SFR-4/H, subsistence patterns show mixed results when compared with Broughton's faunal exploitation trends at Emeryville (Byrd 2008). Notably, trends in otter exploitation at SFR-4/H are not consistent with the Emeryville results, as otters decline with respect to other marine mammals from the Middle to Late Periods (artiodactyls are too infrequent to calculate an artiodactyl-sea otter index). Trends in the exploitation of birds at SFR-4/H are, however, consistent with the Emeryville results-cormorants decline over time in relation to all birds, and also with respect to anatids (geese and ducks [Byrd 2008:Figures 43 and 44]). Finally, SFR-4/H results were used to extend Broughton's intensification argument to the exploitation of different-sized birds that form island breeding colonies. Murres (Uria spp.), a small-island-colony-bird, increased steadily at SFR-4/H in relation to cormorants (a larger island colony bird; Byrd 2008:Figure 45). These results are consistent predictions of resource intensification models and provide a further line of evidence in support of Broughton's reconstruction of pre-contact exploitation of island bird colonies.

Milliken et al. (2007:107–110) outline general Bay-Delta Area trends in pre-contact vertebrate exploitation. These include a focus on large sea mammals in the Early/Middle Transition Period (Hildebrandt and Jones 1992); followed by a rise in deer and a decline in sea otters in the Middle 1 Period; a rise in sea otter exploitation and a decline in deer from the Middle 2 through the Middle/Late Transition Periods; and a re-emphasis on deer in the Late Period. Hylkema's (2002:252–254) South Bay synthesis highlights additional trends. He notes deer were more abundant than elk in the Early and Late Periods; canids, elk, and deer were common during the Early through Middle Periods, while sea otter were not; and there were clear decreases in canids and elk, and an increase in deer and sea otters, during the Late Period (Hildebrandt 1983; Simons 1992).

Both syntheses give as much, if not more, credibility to the explanatory power of environmental shifts and social decisions as to resource intensification models. For example, Hylkema (2002:257) suggests that the Meganos desire for pelts may have been the primary reason for the upswing in sea otter exploitation at the start of the Middle 2. Simons' (1992, 2008) reconstructions that stress differences in local resource potential, environmental change, inter-annual fluctuations, and co-harvesting (with its rejection of the predictive explanatory strength of foraging theory) are also given considerable credence.

Further Tests of the Resource Depression Model

Perhaps as a result of Broughton's thorough studies, few subsequent examinations of faunal records from Bay-Delta Area sites have tested the patterns of resource depression identified at Emeryville and other east bay localities. As discussed below, much recent research has focused on ways in which the prehistoric inhabitants of the San Francisco Bay-Delta Area enhanced their habitat through such practices as selective harvesting and burning (Diekman et al. 2007; Kearns 2010; Lightfoot et al. 2013). The impression of these studies is that people in the Bay-Delta Area had a deep understanding of ecological

processes and the effects of their actions on future ecosystem health. This notion stands at odds with the picture presented by the faunal record as viewed by Broughton. While the truth is likely somewhere inbetween these two extremes, a more thorough examination of the history of human-prey interactions in the Bay-Delta Area could serve to bridge the gap or demonstrate a dichotomous pattern of environmental use—on the one hand conservationist in the management of plant remains, and on the other hand deleterious in the management of game populations. Furthermore, these patterns may have shifted through time as population-resource balances shifted due to intrinsic population growth and changes in the natural environment (i.e., droughts and the growth of the San Francisco Bay Estuary).

Research outside the Bay-Delta Area has recently suggested several possible alternative explanations for the patterns observed by Broughton. Confirmation in other portions of the Bay-Delta Area and at different time periods would substantiate his findings and provide valuable information regarding Bay-Delta Area-wide population resource imbalance. Perhaps more interesting will be instances when trends do not support Broughton's conclusions. In these instances, it may be possible to argue that non-subsistence-related foraging goals drove hunting. For instance, as noted in regards to sea otter pelts, the rich literature surrounding so-called "prestige hunting" could very well apply to the Bay-Delta Area (Broughton and Bayham 2003; Hildebrandt and McGuire 2002, 2012; McGuire and Hildebrandt 2004, 2005; McGuire et al. 2007; Whitaker and Hildebrandt 2011). Furthermore, instances where the hunting of high-ranked prey are seen to be stable through time might provide evidence of sustainable hunting practices to match the trends in plant harvesting and burning which appear to have increased yields on plant remains.

Data Requirements

Large assemblages (>100 NISP/cubic meter) of vertebrate fauna identifiable to family or better from chronologically well-defined contexts are required to examine changes in resource exploitation through time and test models of resource depression. In general, species-specific identifications are needed since the population dynamics of individual species vary greatly. Those species that have already been the subject of Broughton's investigations—deer, elk, geese, sea otters, sturgeon, and cormorants are the best candidates for such analyses, but any large-bodied animal might be just as suitable. Although resource depression cannot be examined at sites with only a single identified chronological component, these sites can meet the data requirements for this research issue since assemblages from single component sites within a nearby area can be combined to examine regional trends in exploitation.

FISHING TRAJECTORIES

The importance of fishing as a keystone subsistence practice generally has been underplayed in the Bay-Delta Area, and this is unfortunate, because fishing-based economies can support large, sedentary populations. This is due to a variety of factors, including the richness or density of the resource, the year-round availability of many species, the ability to acquire these resources from varied contexts (near-shore, off-shore, marshes and tidal flats), the diversity of techniques that can be used to acquire fish, and that acquisition in some contexts can be done by the young and elderly.

In a synthesis of fish remains from the Bay-Delta Area, Gobalet et al. (2004:821) note strong variation across different portions of the region; unfortunately, this study does not take into account temporal trends, treating the pre-contact record as a single chronological unit. Sturgeons (*Acipenser* spp.), salmonids, and bat rays (*Myliobatis californica*) are the most frequent remains (72%) at sites along the east-central Bay margin, while sturgeons dominate (50%) at sites along the northeast bay shore; Byrd (2008:121) also notes that fish remains are ubiquitous at Native American sites on Bay-Delta Area islands. The principal species recovered varies greatly between sites: topsmelt (*Atherinops affinis*)/jacksmelt (*Atherinopsis californiensis*) on de Silva Island (MRN-17), salmon (*Oncorhynchus* spp.) on Angel Island (MRN-44/H), and

topsmelt/jacksmelt, surfperch (*Embiotica* spp.), and rockfish (*Sebastes* spp.) on Yerba Buena Island (SFR-4/H). Moreover, Clupeidae (herring/sardine/anchovy) declined over time in two of these contexts.

Gobalet et al. (2004:821), lumping all northern San Francisco peninsula sites together, notes the importance of embiotocids (surfperch, 55%), atherinopsids (smelts, 30%), and the low frequency of salmonids (7%). More detailed examination of the record (adding new sites and comparing percentages between sites, thereby reducing the effect of sample-size differences between sites) has revealed complex patterns tied to ecological settings and temporal trends (Figure 48; Byrd et al. 2010; Byrd and Kaijankoski 2011). First, site setting (island, north shore, or east shore) plays a strong role in determining the first species to be exploited. For example, the assemblage on Yerba Buena Island has near equal representation by Sebastidae (rockfish), Ambiotocidae (serfperch), and Atherinidae (smelts), whereas anadromous fish join Embiotocidae and Atheriniadae as major contributors to sites on the north shore. Anadromous taxa (salmon, steelhead, and sturgeon), however, were heavily exploited (contra Gobalet et al. 2004) at most sites on the peninsula, except during the Late Period. In addition, sturgeon and rays—typically bat rays—are well-represented at only two sites on the east shore (both occupied relatively early in the occupation sequence). This is in notable contrast to the Emeryville site (ALA-309) and Stege Mound (CCO-297) where bat rays were the primary resource (DeGeorgey 2013, 2016; Gobalet et al. 2004:819–820). Finally, Elasmobranchiomorphi (sharks) are well-represented only at SFR-114 (perhaps reflecting sampling bias toward larger remains).

A recent study by Byrd et al. (2012) examined fishing trends along the northern peninsula. They noted some broader temporal trends through time (Figure 49). First, Atherinidae (smelts) are prominent throughout the sequence. Second, the Early and Late sample are most similar; both also include sizable samples of Embiotocidae (surfperch) and moderate quantities of Clupeidae (herring/sardines). Third, Salmonidae (salmon/steelhead) and Rajiformes (sturgeon/rays) are minimally represented in the Early and Late Period samples; interestingly, Salmonidae are well-represented during the Middle Period. Overall, northern peninsula fishing activities appear to have been focused on smelts, anadromous fish, and surf perch. These trends reveal an emphasis on near-shore fishing with nets rather than offshore fishing in boats or with the use of spears.

Fish exploitation in the South Bay, however, appears to have been very different. Based on small samples from sites such as SCL-690, -478, and -605 in Santa Clara County, freshwater species dominate (Gobalet 1992; Gobalet et al. 2004). In contrast, recent investigations at South Bay site SCL-12/H have yielded a robust sample (n=1,760) dominated by saline-adapted ray-finned fish (*Actinopterygii*; 97.7%), with only infrequent cartilaginous fish (Gobalet 2009). With respect to individual species, longjaw mudsucker (18.7%) and northern anchovy (6.6%) are the most common. This sample —dominated by small fishes — documents heavy exploitation of nearby South Bay and estuary contexts, including migratory species.

In the lone published diachronic study on fish from the Bay-Delta Area, Broughton (1997; Broughton et al. 2015) create a sturgeon index and see a very significant trend toward decreased sturgeon in the archaeological record relative to other fishes. They also identify a decrease in the size of individual sturgeon through time, and attribute both patterns to resource depression resulting from over-exploitation. While the data they present is compelling, they fail to account for a key innovation—fish nets—which might produce the same patterns without over-exploitation playing a role. The introduction and increased use of fish nets in the San Francisco Bay-Delta Area would have increased the capture of smaller-bodied fish and led to the capture of all sizes of sturgeon (not just large individuals typically caught using spears). While the pattern of declining relative abundance of fish through time may signal resource depression, it may also signal an increase in the return rate of smaller fishes using a new technology akin to the increased returns garnered by the bow and arrow (Bettinger 2013) or diving from tule boats rather than the shore (Whitaker and Byrd 2012).



Overall, it appears that local ecological settings played an important role in shaping adaptations, but the presence of divergent procurement strategies suggests that very different social dynamics shaped historical trajectories. An important future goal should be to unravel scheduling tradeoffs, particularly with respect to seasonality (notably for salmon procurement), and explore the technological and social infrastructures of fishing strategies from a diachronic perspective.

Data Requirements

There are myriad topics that are little understood in terms of fishing methods, patterns, and technologies in the San Francisco Bay-Delta Area. Micro-constituent sampling is requisite if these issues are to be further explored. If fish bone can be recovered from well-dated contexts it can provide valuable dietary information germane to exploring these broader patterns of fishing trajectories in the Bay-Delta Area. Additional types of data may also be explored including bone and stone tools associated with fishing (e.g., harpoons, leisters, and net sinkers) or evidence for the origins of boating technology that may have changed payoffs associated with fishing. Sites with abundant fish bone recovered using 1/16-inch mesh are likely to be eligible under this topic, as are sites with bone and stone tools associated with fishing.

SPECIES-SPECIFIC EXPLOITATION HISTORIES

As discussed, faunal data represent perhaps the most abundant and commonly recovered class of archaeological data in Bay-Delta Area sites. Some specific research topics have been proposed here that relate to broad changes in diet, and human impacts on large-bodied prey species. This approach differs from those that have used faunal data either to examine seasonality (see *Seasonality of Occupation*, page 8-23) or human-induced resource depression, and concomitant expansions of the diet breadth, as described in the previous two research topics. Certainly other taxa have been examined and identified as important dietary contributors, but many studies treat the vast majority of identified specimens as simply the "everything else" against which to compare the large-bodied species of interest (e.g., deer, elk, cormorants, salmon, sturgeon). This perhaps undersells the importance of these other species in the archaeological record, and may lead researchers to overlook the importance of such taxa in archaeological assemblages.

As DeGeorgey (2013, 2016) has recently shown, sites with high abundances of a particular taxon (herring in this case) offer an excellent opportunity to explore the role of potentially less common but still important species in the diet and overall economy. DeGeorgey (2013, 2016) cites the abundance of fish head bones relative to tails in arguing for the mass processing of herring, which were likely caught as they schooled near to shore and close to the Stege mound (CCO-297). Close examination of this single species leads DeGeorgey (2013) to explore the potential role of herring as a trade item or as a stored food. In addition, this frames the occupation of the Stege mound in a new light; rather than a location where a group of people lived and slowly accumulated debris as a result of their day to day foraging, it is possible that the site also was used as a locale for the exploitation of a seasonally abundant food source and subsequent processing for trade, or to dry and store fish for later consumption. Under the more commonly applied resource depression models, these smaller-bodied fish would contribute to the denominator in the calculation of a salmon or sturgeon index. Examining the species-specific procurement and processing practices, in this case, illuminated the complex settlement, subsistence, and trade patterns that may have played an important role in the development of bay shore mounds.

We briefly review two other candidates for species-specific examinations: bat ray and sea otter.

Bat Ray

Bat rays (*Myliobatis californica*) are a common constituent of shallow waters along the margins of bays and estuaries in northern California where they forage for invertebrates, such as bivalves, mollusks,

shrimps, and crabs, by generating suction in the sand with their bodies as they "fly" through the water (Marinebio.org 2015). Adult bat rays have been recorded to live up to 23 years and can grow up to 1.2–1.85 meters (six feet) in length and can weigh up to 90 kilograms, though individuals found along the bay shore are rarely this large (Marinebio.org 2015). The ease of access of bat rays in the shallow waters of the bay, their association with other important dietary items (i.e., invertebrates), and their long life-history and large size, indicate that they may have also been a species prone to over-exploitation by pre-contact hunters. As such, it is possible that future research could identify bat ray faunal elements that track the size of individuals (e.g., vertebrae or mandibular elements) through time and the ratio of bat rays to other species in the intertidal. Little is known about extractive techniques used for bat rays, though based on their shallow habitat and invertebrates as food of choice, it is likely that they were speared. If this is true, there may be shifts apparent in the relative frequency of bat rays through time as netting technology and other fishing techniques were increasingly employed within the bay. Gobalet et al. (2004:819–820) suggest that bat rays may have been taken in weirs along the bay shore. Such techniques may have allowed for fairly passive capture of rays with limited effort once a weir was built.

A review of faunal data from the study area identifies 47 sites with evidence of bat rays, and a total of 3,781 identified specimens. Geographic distributions of bat ray remains show a circum-bay pattern of exploitation (Figure 50; Table 22). Remains are focused in the Northwest Bay, the north edge of the Southwest Bay, and the northern third of the East Bay region. Interestingly, more than 2,600 of these are from three sites—MRN-67, CCO-297, and CCO-269. The first site is located in Tiburon in the Northwest Region while the other two are along the Richmond shoreline of the East Bay Region. Given the habitats preferred by bat rays, it is perhaps not surprising that their remains are infrequent in the southern half of the bay. Notably, only 45 bat ray elements have been identified in sites in the South Bay, and only one element has been identified at a single site in the Delta. This could point to some inconsistencies in the identification of bat ray, or it may signal a true signature of north versus south bay exploitation patterns. Transport or trade of bat rays are indicated by presence of elements in a few inland settings in the East Bay and South Bay.

Archaeologists working in the northern half of San Francisco Bay (including the northern San Francisco Peninsula) should be aware of the potential for high numbers of bat ray remains, and the possibility of pursuing research issues related to them.

Sea Otters

Sea otters provide a very interesting avenue for research for a number of reasons, both ecological and anthropological. A total of 59 sites in the study area has sea otter remains, totaling more than 10,000 elements (Table 22; Figure 51). Unlike bat rays, these remains are found throughout the Bay-Delta Area, though well over half (NISP=6,323) have been identified in the East Bay. Interestingly, the Southwest Bay has far more sea otter remains than either the Northwest Bay or the South Bay. The dearth of sea otter bones in the South Bay makes sense from a biogeographical standpoint as the South Bay lacks good sea otter habitat within the mud flats that make up most of the southern portion of the San Francisco Bay. The shoreline along the Northwest Bay, however, would be expected to have a much higher number of sea otters than are present archaeologically. Simons (in DeGeorgey 2013, 2016) comments upon the importance of tidal marshes for sea otter birthing and nursing habitat.

The increase through time of sea otter relative to other large-bodied taxa is well documented at the Emeryville shell mound (Broughton 1997, 2002) and elsewhere in the Bay-Delta Area. This increase is identified in the Middle Period, when exchange networks of all sorts flourished in the Bay-Delta Area (Hughes and Milliken 2007), with shell beads being exchanged liberally, obsidian flow from eastern Sierra sources at its peak, and population growth at some of its highest rates in the Late Holocene. It



Figure 50. Distribution of Sites with Bat Rays in the Study Area.



Figure 51. Distribution of Sites with Sea Otter in the Study Area.

SUBREGION	BATRAY		SEA OTTER	
	NO. Sites	NISP	NO. Sites	NISP
Northwest Bay	14	1,574	8	373
North Delta	1	1	-	-
South Delta	-	-	-	-
East Bay	13	1,687	17	6,323
South Bay	5	45	11	97
Southwest Bay	13	485	23	3,294
Total	46	3,792	59	10,087

Table 22. Number of Sites and Number of Identified Specimens of Bat Ray and Sea Otter by County within the Study Area.

Notes: NISP - Number of Identified Specimens.

seems likely that hunting sea otters increased as part of this pattern of trade, as sea otter pelts would have been a valuable trade commodity and were likely much more important than the meat sea otters would have provided. Support for the notion of sea otter pelt exchange is provided by the number of interior sites, particularly in the South Bay, that have sea otter remains. In his synthesis of hunting patterns at Emeryville, Broughton (1997) does not address the non-dietary importance of sea otters, and therefore considers them a lower-ranked species than artiodactyls. If non-dietary value is incorporated into prey rank, an unanswered question may be why sea otters were not hunted earlier.

Identifying loci where sea otter butchering occurred may provide valuable information regarding loci of trade, as Lightfoot and Luby (2002) have suggested. The presence of other trade items at sites with high numbers of sea otter bones may provide circumstantial evidence of trade supporting these assertions (see also Hylkema 2002; Milliken et al. 2007). Sea otter butchering has been identified by Cope (1984) at Emeryville, at Stege by Simons (in DeGeorgey 2013:189–195, 2016), and SFR-4/H (Simons et al. 2008:E-13 to E-18). Simons (in DeGeorgey 2013, 2016) argues that during the Late Period, sea otter pelts were being produced as exchange commodities at CCO-297.

Along with trade, the study of the pattern and distribution of sea otter remains in the San Francisco Bay may prove valuable to addressing several other pre-contact questions in Bay-Delta Area. Among these are sea otter population history and the origins of tule balsa use on the bay. Recent advances in genetics have provided methods that rely on archaeological bone to reconstruct the genetic histories of animals. The most notable recent study is by Broughton et al. (2013) on elk DNA from the Emeryville shell mound. Sea otter aDNA could be used to provide modern conservation mangers with valuable baseline genetic information on the relationship between sea otters in the San Francisco Bay and other areas of northern California where they have been extirpated.

As the historical record demonstrates, sea otters are much more easily captured from boats than from shore. Whitaker and Byrd (2012) argued that in Monterey Bay, the intensive procurement of abalone in the Late Period may have been preceded by the use of boats to both procure abalone, but also to hunt sea otters, initiating trophic cascade (Erlandson and Rick 2010) through which reduced sea otter populations allowed abalone populations to flourish. If similar processes were at work in the Bay-Delta Area, the onset of sea otter hunting may be equated with intensive use of tule balsas. While there is little data currently to substantiate this association, future research may be able to identify patterns that support or refute the theory.

Data Requirements

Addressing species-specific research questions will obviously require the presence of a large number of faunal elements from the species in question. While two species in particular are identified here, future research might identify other species of interest that are found in large numbers at a given site. Just as Simons (in DeGeorgey 2013; Schwitalla et al. 2014) was able to address issues related to bat ray exploitation, similar studies might identify bird or fish species that were important at a particular place and in a particular time. The presence of bone collagen within samples would allow for the extraction of aDNA and may allow for the reconstruction of individual-species life histories.

DOGS AS WALKING LARDER FOR FEASTING OR TOUGH TIMES

Dogs were domesticated throughout the world at various points in the past, assisting hunters; serving as pack animals, guards, and companions; and providing a source of food. In addition, dogs and their wild counterparts—coyotes and wolves—played an important role in the spiritual lives of many North American cultures. A recent study by Byrd et al. (2013) examined the cultural processes through which canid (dog, wolf, and coyote) remains enter the archaeological record in the San Francisco Bay-Delta Area. It is apparent that canid remains are found in both ritual and prosaic contexts throughout the study area. Dog remains are found in ceremonial interments, often with associated offerings, but also appear as disarticulated remains in general midden contexts. Identification of coyotes versus wolves versus dogs has often limited the ability of faunal analysts to conclusively identify these remains to species. Byrd et al.'s study, however, used aDNA analysis to identify remains from five Bay-Delta Area sites (ALA-329, MRN-5/H, SCL-134, -287, -732, and SFR-4/H) as domesticated dogs (as opposed to coyotes or wild wolves).

Early work concerning canids began with a synthesis of canid remains in Bay-Delta Area sites by Heizer and Hewes (1940), who classified 13 interments from five Bay-Delta Area sites as coyotes. Of these 13 interments, Heizer and Hewes (1940:589–590) report that nearly half (42%) lacked hind quarters, and that over three-fourths (77%) had associated cultural materials, including abalone pendants and shell beads. Additional canid remains have been reported from sites in the subsequent 75 years in a variety of contexts (Cambra et al. 1996; Haag and Heizer 1953; Jones 2010; Langenwalter 1996; Simons 2004). A reanalysis by Langenwalter (1996) reveals that the coyotes identified by Heizer and Hewes (1940) are more likely dogs.

The ethnographic record for dogs was rich in California, but coyotes played a larger role in the ethnographically recorded spiritual and totemic practices of central California groups. For instance, coyotes were totemic symbols for moieties among the Miwok and Yokuts (Driver 1937; Gayton 1948), and coyote is portrayed as a trickster in many central California myths, but there are fewer references to dogs and wolves specifically. Although wolves are little mentioned in myths or totemic rituals, nearly all California Native American languages have distinct words for each of the three canid species.

In addition to aDNA analysis, Byrd et al. (2013) obtained stable nitrogen and carbon isotope values on the dog bones to examine their diet relative to human burials at some of the same sites. They found that dogs had diets very similar to humans and conclude that the dogs were being fed by humans. This conclusion matches similar studies conducted throughout the world.

Byrd et al. (2013) summarize a number of ethnographic accounts of rituals involving the ceremonial killing of dogs followed by interment in most cases and ritual consumption in others and conclude that "these activities would then have been followed by ceremonial disposal as an interment" (Byrd et al. 2013:2186). Overall, the ethnographic record provides a somewhat clouded picture of both ceremonial and consumptive behavior with respect to dogs, indicating that ceremonial and subsistence practices are not always separated.

Beyond the ceremonial aspect involving canid interments, it is also likely that dogs were an important food item along the San Francisco Bay margin. Simons (1992:Table 4.5), for instance, documents that five of the 11 assemblages he examined had *Canis* remains representing 20–32% of identifiable large- and medium-sized mammals. If these are dogs, then it is apparent that dogs were an important food source, at least during the Late Holocene in the Bay-Delta Area. Wake (2012) identified a number of dogs in the assemblage at Emeryville shell mound, and found that they contribute approximately 5% to 15% of the assemblage throughout the site's occupation.

As an initial assessment of the relative importance of canids in the Bay region (assumed to be mainly represented by dogs), we synthesized data from Bay-Delta Area sites. To gain an initial impression if there is the potential to assess if canids were associated with rituals and ceremonial feasting or were consumed for more prosaic economic reasons, we explore if there is a correlation between relative frequency and human burials (as a proxy for ceremonial events). Canid remains are present in 57 of 71 (80%) sites in the study area that have 20 or more genus-or-better identifications on dog-sized or larger mammals. These sites have 23,934 total elements identified to genus or better, and 14% of these (NISP=3,452) are canid remains. Eighteen of the 57 sites have more than 20% canid remains by identification (Figure 52).

Although the data are irrespective of time, there are some intriguing patterns that emerge when the Bay-Delta Area record as a whole is examined. With the exception of one site (SFR-114), all other sites with canid remains in the Southwest Bay (including those adjacent to it along San Francisquito creek), lack human burials. In contrast, those sites to the south and up the east side of the bay and out into Livermore Valley all have both dogs and burials, as do sites in eastern Contra Costa County. A more mixed pattern is evident in northern Alameda and Marin Counties where the majority of sites with canid remains also have burials, but not all do. Overall, these trends may indicate that differential patterning in canid remains are tied to varied emphases in on-site activities.

Snyder (1991:370–374) and Cail (2011), in studies of Plains and Canadian plateau Indians, have pointed out that dogs have a high relative fat content compared to wild animals and, since they scavenge the remains of human meals or are fed by humans, maintain this fat throughout the year. As such, dogs would have offered a source of excellent fatty meat during the lean winter times when other resources were scarce. In a way, dogs serve as another form of storage—banking reserves of fat and calories from otherwise wasted food for a time when it is needed. In this context, it is the sites where no burials are present but dog bones are common that merit further investigation in terms of dietary significance. Additional data could further elucidate the relationship between ceremonial and prosaic aspects of human-canine relationships. It is also possible that this correlation could be further explored to examine the development of social boundaries in the pre-contact Bay-Delta Area.

Data Requirements

Identifying dog remains in archaeological sites is not sufficient to address this research issue. Instead, dog bones must be found in contexts that identify either consumption or interment of the dog within ceremonial versus prosaic settings. Dog interments are an obvious sign of ceremonial activity, and the presence of dog bone in generalized midden may be taken as a sign of non-ceremonial consumption. The association of dog remains with other ceremonial signatures provides the best avenue for addressing this research issue.

Before the relationship between dog remains and other activities can be examined, however, positive identifications of domestic dog versus coyotes versus wolves must be made. The best way to do this is through DNA analysis, though bone collagen stable isotope analysis may also be able to provide valuable identifying data as baselines of domestic versus wild canid dietary isotopes are established.



Figure 52. Summary of Canid Remains by Percentage within Study Area Sites.

Analysis of cut marks on dogs may identify patterns of butchering on ceremonial versus purely dietary processing of dog carcasses, and body part representation studies may reveal patterns in ceremonial interment versus discard. Aggregated spatial data, such as those presented here, can provide valuable insights into the relationship of dogs and humans at important ceremonial sites and at general occupation sites/villages.

SOCIAL AND BEHAVIORAL CONTEXTS OF SHELLFISH GATHERING

Shellfish occupy an interesting middle-ground on the continuum of resources available to precontact Californians-offering the benefits of an animal (i.e., high protein value) with the growth potential and behavior of a plant (i.e., they are sessile, fast growing, and available in large patches). Despite their mixed nature, shellfish have been typically studied as if they were larger-bodied vertebrates (yet see Whitaker 2008; Whitaker and Byrd 2014). Studies worldwide have noted a reduction in average shell size and changes in the relative frequencies of high-ranked invertebrates in the archaeological record as indications of increased predation pressure, reduced foraging returns, and resource depression, either by humans or as the result of environmental change (Klein et al. 2004; Rudolf 1985; Spennemann 1987; Steele and Klein 2006; Stiner et al. 2000; Sullivan 1987; Swadling 1976, 1977). In California, studies have demonstrated a similar diminution in mussel, cited as evidence of reduced foraging returns on outer-coast species (Botkin 1980; Colton et al. 1999; Moore 1988; Serena 1984). The tacit assumption, based on population structure and immediate return rates, in these and other studies is that smaller shells provide lower returns for the forager than larger ones. This includes the assumption that small shells indicate younger individuals; in mammalian populations, this generally indicates that a population is stressed and, in some cases, may be at risk of local extinction leading to collapse of that portion of the subsistence economy for the forager. This also includes an assumption that small shells have less meat in them and, all things being equal, returns are poorer with small shells than with larger ones, both within and across species.

The behavioral uniqueness of shellfish is demonstrated by the fact that several species are currently farmed successfully using modern aquacultural techniques (Hickman 1991; Van Ginkel 1990; Yamada and Peters 1988). In contexts where pre-contact coastal foragers intensified subsistence economies, pseudo-aquaculture could have been practiced by harvesting shellfish beds such that long-term yields were maximized without detriment to the mussel population itself. For this practice to be successful, the maximization of immediate returns would have to be sacrificed to increase long-term productivity.

Only through an understanding of the biology of prey species is it possible to fully examine the intricate relationship between humans and their prey (Stiner et al. 2000). Several methods have been used to monitor changes in exploitation pressure. All rely on some form of shell measurement on non-repetitive portions of the shell (e.g., the umbones of bivalves). Many follow the lead of White (1989) in using a template which breaks shell size into two- to three-centimeter-length classes. Umbones are grouped into classes by comparison, with typical shapes of each given size (Whitaker 2008a, 2008b; White 1989). Recently, two independent studies have developed a more refined and reliable method for measuring fragmentary shells using the width of the umbone (Cambell and Braje 2015; Singh and McKechnie 2015). These studies independently developed a method found to be more effective at placing individual shells within the correct category and it is recommended that they be used rather than the White (1989) template. In either case, the results of these analyses are presented as cumulative percentage graphs that allow samples to be compared to one another (see Whitaker 2008a for further justification). Although these methods have been developed to deal with California mussel, they could as easily be used to create templates and profiles of mussel, oyster, and clam populations through time in the Bay-Delta Area. In fact, given the nature of cumulative percentage curves, population profiles for complimentary or competing species could be compared without using standard indices with all the problems inherent to them.

Normative and New Perspectives on Bay-Delta Area Temporal Trends in Shellfish Exploitation

Two major patterns in pre-contact shellfish exploitation have long been asserted for the Bay-Delta Area – a predominance of three species and a shift in reliance over time from oysters to mussels to clams (e.g., Bickel 1978; Gifford 1916; Greengo 1951; Hylkema 2002:252, 2007:349–352; Milliken et al. 2007:109; Uhle 1907:16–17). Milliken et al. (2007:109) state that the transition from Olympia oysters (*Ostrea lurida*) to bay mussels (*Mytilus edulis*) occurred at the start of the Middle 2 Period and the shift to bent-nose clams (*Macoma nasuta*) took place at the start of the Middle 4 Period—except on the San Francisco peninsula, where clams predominated earlier, at the start of the Middle 1 Period. In addition, the diminutive California horn snail (*Cerethidea californica*) is stated to have been intensively collected only from the start of the Late Period in the south Bay-Delta Area (Hylkema 2002, 2007). These changes in species emphasis have typically been interpreted as due to either environmental change (notably sedimentation) or overexploitation (see review in Bickel 1978:14), although Milliken et al. (2007:109) suggest that horn snail may have been a prestige or luxury item, reflecting local social intensification trends. Milliken et al. (2007:108) further stress the potential importance of non-economic issues in noting that the sudden shift from oysters to mussels and from deer to sea otters at the start of the Middle 2 Period is correlated with the hypothesized Meganos Intrusion.

Despite this long standing perspective on the temporal trajectory in shellfish exploitation, a series of studies has found exploitation patterns were highly divergent across time and space in the Bay-Delta Area, deviating from expectations that shifts in shellfish use were uniformly linked in tight temporal fashion across the region (Byrd 2008; Byrd and Berg 2009; Byrd et al. 2010; Norton 2007; Waechter et al. 1992; Whitaker and Byrd 2014). Examples from two Bay-Delta Area settings are highlighted below. Additional research into this topic can be carried out by focusing on the 135 sites in the study area that present shellfish data (Figure 53; Appendix D).

In the northern San Francisco peninsula (including SFR-4 on Yerba Buena Island), 19 radiocarbon-dated site components from 12 sites reveal temporal and very localized spatial patterns in shellfish exploitation trends (Byrd and Kaijankoski 2011; Byrd et al. 2010). Oysters are a relatively minor contributor in all site components – despite a Bay-wide trend of being the predominate shellfish exploited until the Middle 2 Period – with most of the variability tied to the relative frequency of clams to mussels (Figure 54). Mussels predominated into the Middle 1 Period at all site components except SFR-148, which lies farther from the Bay and farther south than the other sites. During the Middle 2 to Middle 4 Periods (after 1,500 years ago), clams were typically more ubiquitous than mussels; this trend is reversed in the Middle/Late Transition Period. Then in the Late Period, clams were once again more common, although the reliance on clams or mussels varies widely between sites. The sudden uptick in mussel exploitation during the Middle/Late Transition Period (reversing a general downward trend) raises the question of whether it was driven by environmental change. This time span falls within the Medieval Climatic Anomaly, a time span dominated by two major drought intervals terminated by major flooding events (Malamud-Roam et al. 2007:12). These flood events may have led to increased erosion of bay mud (the habitat of clams) especially in the central bay (the area closest to the Golden Gate), and potentially exposed areas of mussel habitat that had formerly silted in.

There are also several distinctive local variations to these general trends. For example, California horn snail (*Cerithedia californica*) represents 16% of the shellfish assemblage from Late Period site SFR-129 on the north shore of the peninsula; it is essentially absent everywhere else. In addition, the open-coast California mussel (*Mytilus californianus*) is the prevalent mussel species at all sites along the northern shore of the peninsula, and also dominates (at 65%) the sample from the historic-era Native American occupation at Mission Delores (Ambro 2003). Mussels at sites along the eastern bay side of the peninsula are, not surprisingly, dominated by Bay mussel (*Mytilus edulis*).



Figure 53. Distribution of Sites with Reported Shellfish Remains in the Study Area.



Figure 54. Temporal Trends in Exploitation of Major Shellfish Resources at Sites in the Northern End of the Southwest Region.

Very different trends in shellfish exploitation are revealed at 21 dated components from 19 sites within 6.5 kilometers of the Bay south of Coyote Point (Byrd and Berg 2009; Whitaker and Byrd 2014). In this area, bay mussel was an insignificant resource at most sites owing to the species' rarity in the South Bay tidal areas (Skinner 1962:Table 32). In contrast, oysters were clearly an abundant South Bay resource, depending on site setting, and also considered of high-value, targeted for collection by logistical procurement throughout the pre-contact sequence (Figure 55). The rich oyster beds north of Ravenswood Point appear to have been the most likely procurement locality, requiring boat transport and subsurface diving. The presence of auditory exostosis (small bony growths in the posterior of the wall of the ear opening), primarily in male burials from a variety of sites in the Bay-Delta Area (including ALA-328 and ALA-329 in the South Bay), indicates considerable time spent in cold water, possibly gathering oysters (Brooks and Brooks 1993:419; Evans 2014). There is also no supporting evidence for a purported mass extinction of large pre-contact oyster beds that flourished in the South Bay between 1700 and 1850 cal BP (Story et al. 1966).

California horn shell, on the other hand, appears to have been a key South Bay resource only when its habitat—the upper tidal mud flats—was situated within the daily foraging range of a site. During the Early Period (circa 4000–2500 cal BP), the diminutive Cerithidea was heavily exploited at some but not all South Bay sites (Byrd and Berg 2009 and references therein). The relative importance of Cerithidea appears to have varied based on whether oysters, a higher value shellfish, were in the daily foraging range or not. If they were, as documented at sites within 10 kilometers (6.2 feet) of the oyster beds along the east and west edges of the South Bay, then the smaller California horn snail was largely ignored (Whitaker and Byrd 2014:Figure 5). When oysters were outside the daily foraging range (as depicted for the southern-most bay shore sites, those beyond 10 kilometers [6.2 feet]), then both horn snail and oysters were collected. The relative importance of Cerithidea increased during the Late Holocene, and by 700 cal BP, this was the dominant shellfish recovered at south bay shore sites, and was also documented at sites outside the daily foraging range of the bay (Hylkema 2007 and references therein). As stated by Whitaker and Byrd (2014), these trends are driven by population packing and territoriality-groups that did not have daily foraging access to oyster beds did have the option of foraging for lower-ranked shellfish (i.e., Cerithidea) readily available within the extensive brackish marshes. A lack of access to the best habitats required people to intensify their foraging efforts in smaller, and potentially more marginal, foraging ranges.

Overall, these results demonstrate that the old bay-wide model, where shifts in shellfish use were uniformly linked in tight temporal fashion, should be discarded. These two examples of Late Holocene trends in shellfish exploitation demonstrate that we need to account for a variety of environmental and social factors in interpreting shellfish exploitation patterns. These include: (1) the location of natural habitat zones for individual species; (2) whether or not a resource was within the daily foraging range of a settlement; (3) whether or not other species were targeted via longer range logistical procurement; and (4) whether resources were acquired via trade and exchange or were brought by others participating in ceremonial events. The latter aspect is particularly relevant to sites both outside the daily foraging range of the bay or the outer coast (where California mussels are present), and in contexts where other groups occupied/controlled the intervening territory (Byrd and Berg 2009; Hildebrandt et al. 2009).

Changes in the relative abundance of shellfish species over time must consider a variety of factors, including the ranking of shellfish resources, resource availability within the daily foraging range, the willingness of site inhabitants to procure shellfish on more distant logistical forays, the role of environmental change, and the possible impact of overexploitation. We argue that long-term trends arealso heavily influenced by social choices regarding how and in what manner efforts were placed on obtaining more costly resources. A fruitful avenue for future research will be to explore the social dynamics of procurement strategies and model how such strategies in turn impacted various species, including the potential for the planned management of specific species.


Note: Oyster constitutes the bulk of the non-Cerithidea shellfish at most sites.

Figure 55. Percentage of Cerithidea Californica in Shell Assemblages in the Southern Portion of the Bay (after Whitaker and Byrd 2014:Figure 6).

Data Requirements

All that is required to address these and related research issues is the presence of quantifiable shellfish within well-dated component assemblages. While weights are commonly used in the Bay-Delta Area to compare the relative contribution of invertebrate species to the diet, minimum number of individual (MNI) statistics are favored in southern California and can be calculated easily for bivalves (number of hinges or hinge fragments divided by two) and for other taxa with non-repeated elements.

An eligible site under this topic will have a large assemblage of shell that can be quantified through MNI and weight statistics. The presence of whole shells allows for measurements to examine the effects of human predation or climatic shifts on shell populations. When whole shells are noted at a site, it is important under this research issue to collect them from all screens, even if shell is being analyzed only from smaller subsamples. Shell measurement data require dozens of shells per provenience, though cumulative datasets are also valuable, and shell measurements should be taken and reported on smaller assemblages as well.

TRENDS IN PLANT RESOURCE EXPLOITATION (by Eric Wohlgemuth)

Central California archaeobotanical research has been most intensive within the San Francisco Bay region. In the last three decades, charred plant remains have been recovered and documented from nearly 1,100 sediment samples from at least 77 archaeological sites (Figure 56). More importantly, multisite longitudinal data spanning the last 4,500 to 5,000 years have been assembled and interpreted from six localities within the region. These key data permit evaluation of temporal trends in plant use by controlling for habitat diversity in the highly variable environments of the region. The longitudinal data sets are notable for their discrete, securely dated contexts and for robust charred plant assemblages. The 25 sites comprising the multi-period data sets encompass slightly more than half the analyzed samples, and their collective NISP exceeds 100,000 (Table 23).

Three of these key localities are in interior settings with little or no access to productive marine or brackish faunal resources of the San Francisco-San Pablo-Suisun Bay wetlands. Two are in the South Delta region, one in the interior valleys in Pleasanton and Lafayette east of the Berkeley Hills (overlapping into sites of the East Bay region), and the second in the Marsh Creek drainage basin in the drier country east of Mount Diablo. The third interior locality is in Green Valley, at the foot of the North Coast Ranges in the North Delta region (Wohlgemuth 1996, 1997, 2002, 2004, 2010a; Wohlgemuth and Scher 2015). Two localities with longitudinal plant data are along the Bay shoreline, in East Marin of the Northwest Bay region, and in Emeryville of the East Bay region (Wohlgemuth 2014a, 2014b; Wohlgemuth and Tingey 2012). The last locality is a mix of near-shore and interior zones in the Santa Clara Valley portion of the South Bay region (Arpaia 2015). Longitudinal data also may have been produced from research on the Stanford campus in the Southwest Bay region, but have not been published.

The longitudinal data from these six areas provide a context for evaluating spatial variation as well as temporal models of plant use and intensification. Here we focus on three problems that can help guide archaeobotanical research in the San Francisco Bay Region. Data requirements for the three issues are presented in a combined section at the conclusion.

Regional Variation in Antiquity of Intensive Acorn and Small Seed Use

As archaeologists and ethnographers have long stressed, California Indians were noted for their subsistence focus on acorns, with attendant storage facilities and intensive processing practices that have been termed a "spectacular investment of female labor" (Bettinger and Wohlgemuth 2011:116). In the following discussion, acorn intensification is measured by marked increases in the ratio of acorn nutshell versus small seeds and wood charcoal, and by the increased proportion of acorn in the dietary nutshell



Figure 56. Distribution of Sites with Analyzed Carbonized Plant Remains in the Study Area.

		5	1 0					5 0							
SETTING			INTERIOR				BAYSHORE				HORE AND	Interior			
REGION	North	I DELTA		EAST BAY	NORTHWEST BAY EAST BA			NORTHWEST BAY			Northwest Bay			SOUTH BA	Y
Locality	GREEN	VALLEY	PLEASANTON	MARSH CI	REEK BASIN	EAST MARIN			EAST MARIN EMERYVILLE		SANTA CLARA VALLEY				
LATE PHASE 2															
Site	-	-	ALA-555	CCO-458	CCO-755	MRN-327	MRN-254	-	ALA-310	SCL-919	-	-			
No. Analyzed Samples	-	-	13	8	7	5	4	-	36	30	-	-			
NISP	-	-	6,239	1,444	2,815	2,417	253	-	18,095	20,475	-	-			
LATE PHASE 1															
Site	SOL-356	-	CCO-235	-	-	MRN-150	MRN-254	-	-	-	-	-			
No. Analyzed Samples	12	-	15	-	-	8	6	-	-	-	-	-			
NISP	3,111	-	4,260	-	-	1,254	968	-	-	-	-	-			
MIDDLE/LATE TRANSITION	T														
Site	-	-	ALA-42	-	-	MRN-254	-	-	-	-	-	-			
No. Analyzed Samples	-	-	13	-	-	1	-	-	-	-	-	-			
NISP	-	-	4,646	-	-	93	-	-	-	-	-	-			
Middle															
Site	SOL-355	SOL-364	ALA-555	CCO-459	CCO-696	MRN-254	MRN-67 Str. 3	MRN-67 Str. 4	ALA-309	SCL-12	SCL-478	SCL-674			
No. Analyzed Samples	10	10	3	8	17	8	18	10	110	13	25	22			
NISP	2,591	1,584	357	1,380	1,884	436	827	395	1,524	Nd	nd	3,761			
EARLY															
Site	SOL-315	-	CCO-309	CCO-637	CCO-548	MRN-67 Str. 1	MRN-67 Str. 2	-	ALA-312	SCL-12	-	-			
No. Analyzed Samples	10	-	17	11	38	9	15	-	24	33	-	-			
NISP	1,617	-	5,317	1,198	5,255	890	1,539	-	2,707	3,435	-	-			
EARLY HOLOCENE															
Site	-	-	-	CCO-696	-	-	-	-	-	-	-	-			
No. Analyzed Samples	-	-	-	10	-	-	-	-	-	-	-	-			
NISP	-	-	-	148	-	-	-	-	-	-	-	-			

Table 23. Key Sites and Sampling Information for Plant Data from Six San Francisco Bay Region Localities.

Notes: NISP – Number of Identified Specimens; Str – Stratum; nd – No data available, only small seed counts from Emeryville, no data available for counts of nutshell and berry pits.

assemblage, where applicable (if there are other nut resources present). Similarly, small seed intensification is measured by marked increases in the frequency of small seeds and the ratio of small seeds to wood charcoal, and by marked declines in the acorn:small seed ratio (Wohlgemuth 1996, 2004). It is important to stress that these indices are long-term trends that are relative to particular suites of plant resources at specific localities; there are no absolute numbers that can be fixed as thresholds for intensification for any index. For example, an acorn proportion of 70% of total dietary nutshell in Late Period contexts may be an increase signifying acorn intensification in one locality, but reflects the base level of Early Period acorn use in another, depending on the presence and abundance of other nut resources in that locality.

Attempts to document the time depth of intensive acorn use have long suggested variability in the age of these practices in different central California regions. It may date to as early 3000 to 4000 cal BP in interior central California (the San Francisco Bay and Central Valley regions, more than 10 kilometers from the ocean or Bay), to only about 600 cal BP in the central Sierra Nevada foothills (Rosenthal et al. 2011), and apparently never arose in the interior South Coast Ranges (Wohlgemuth 2004, 2010b). The recent emergence of longitudinal plant use data now allows assessment of variability between and within subregions in the advent and degree of intensive use of acorns within the Bay region.

Our present understanding suggests intensive acorn use in the Early Period (circa 4000–3000 cal BP) in the Marsh Creek basin, near the start of the Early/Middle Transition Period (circa 2500 cal BP) in Green Valley in the North Delta and in the South Bay Region, by the end of the Middle 4 Period (circa 1000 cal BP) along the east Marin shoreline, but never in the Emeryville sequence (Wohlgemuth 2004, 2010a, 2014b). It should be noted that the absence of robust Middle Period data from the Amador-Livermore Valley in inland East Bay obscures the advent of acorn intensification there, but it clearly post-dates the mid-Holocene component at other inland settings—CCO-309 dating to ca. 5000 BP—and antedates the Middle/Late Transition at ALA-42 (Wohlgemuth 2002, 2006). The data at hand suggest that acorn intensification arose substantially earlier in the interior than along the bay shoreline (Wohlgemuth 2014b).

In contrast to acorns, intensive use of small seeds occurs later in time. The earliest known case of small seed intensification is at the Middle/Late Transition Period site ALA-42 in inland East Bay, although there are hints that small seeds were targeted in late Middle Period (in a feature radiocarbon-dated to 1265 cal BP) at bedrock mortar plant-processing site CCO-459 at Los Vaqueros Reservoir (Wohlgemuth 2002; Wohlgemuth and Scher 2015). Small seed intensification is well-documented in Green Valley, Pleasanton, the Marsh Creek basin, and Santa Clara Valley after ca. 1000 BP (Arpaia 2015; Wohlgemuth 1996, 2002, 2010a; Wohlgemuth and Scher 2015). But intensive small seed use has not been documented at East Bay shoreline Late Period components at Emeryville, and while some Northwest Bay shoreline site Late components display it (e.g., MRN-327), others do not (MRN-150 and MRN-254; Wohlgemuth 2014b).

While patterns in the six localities provide important baseline data for future investigations, additional research within or adjacent to them should target verifying and clarifying the antiquity of acorn and small seed intensification. Future research in other Bay region localities also should explore this topic to see temporal patterns in different locations; e.g., is there evidence for acorn or small seed intensification on the Pacific Ocean shoreline of the Northwest and Southwest Bay regions?Variability in the presence and timing of the initiation of acorn and small seed intensification points to an important distinction in plant use at interior and shoreline localities, the second research issue.

Interior versus Bay Shore Plant Use

It is probably no coincidence that interior localities have earlier and more complex records of plant food intensification than shoreline sites around San Francisco and San Pablo Bays. This appears at least partially due to poorer plant resources around the shoreline than in the interior, especially for Emeryville, which has minimally productive plant foods within six kilometers of the shoreline, and an archaeobotanical record with no evidence of intensification of acorns or small seeds. In the Northwest Bay, however, productive stands of oaks and bay nut extend to the historical shoreline in many places, so the distribution of plant foods alone does not explain the delayed record of acorn intensification and the mixed record of Late Period small seed intensification (Wohlgemuth 2014b). What may be at play is the hypothesis that aquatic faunal abundance tended to reduce hunter-gatherer reliance on plant foods (Keeley 1999:11).

Interior localities not only display early and multiple stages of plant food intensification, but are marked by steadily, occasionally rapidly increasing densities of plant remains in more recent time periods. In contrast, longitudinal data from shoreline localities show a distinctly different pattern. The earliest known components—Strata 1 and 2 at MRN-67 in the Northwest Bay and ALA-312 in the East Bay, both dated to the Early Period—exhibit robust plant remains assemblages. Subsequent components (starting around 2800 BP) at MRN-67 and East Bay ALA-309 (the Emeryville shell mound) are notable for substantial declines in the density of plant remains; this drop has not been documented anywhere else in central California (Wohlgemuth 2014b). In contrast, robust Early and Middle Period data from near-shoreline site SCL-12/H in the South Bay suggest acorn intensification at around 2500 cal BP, more consistent with interior localities than the shoreline data. Further, densities of plant remains, notably acorn nutshell, increase dramatically from Early to Middle Period times at SCL-12/H (Arpaia 2015; Byrd and Berg 2009).

The decline in density of plant remains in studies from Northwest Bay and East Bay shoreline contexts may be interpreted as a de-emphasis of plant foods that occurred with the advent of intensive shellfish or possibly fish collection at around 2800 BP. In this view, the labor of women and children was allocated to shellfish at the expense of plant foods, regardless of whether productive plant patches were easily available (East Marin) or not (Emeryville; Wohlgemuth 2014b). This distinctive pattern, however, is at odds with the interior-like findings from SCL-12/H in the South Bay. The SCL-12/H case may differ due to lack of or more costly access to productive beds of mussel and oyster, such as those available farther to the north. The South Bay record shows a heavy emphasis on horn shell (*Cerithidea californica*), a small, low-meat yield, and low-ranked species, along with varied oyster exploitation (Whitaker and Byrd 2014). People living near the South Bay shoreline appear not to have always had the option of heavily exploiting productive shellfish species over plant foods, and appear to have made choices like interior groups in intensifying acorn production after the Early Period (Arpaia 2015). Keeley's (1999) hypothesis of the priority of aquatic fauna may be the key factor in the delay of plant food intensification in East Marin versus interior localities (Wohlgemuth 2014b).

This interpretation is intriguing as it attempts to integrate patterning in plant food debris with shellfish remains, and appears worthy of additional research. For now, it needs to be verified with more data on pre-contact plant use, especially in sites along the bay shoreline. Equally important is to amass appropriate shellfish data from sites with analyzed plant remains, and integrate both data sets with terrestrial and fish faunal data, and data from isotopic studies of human remains (e.g., Bartelink 2006). Further, the focus to date has been on large sites, but data from smaller sites also need to be incorporated.

Identifying Mission Period Contexts from Plant Remains

Plant remains of invasive Eurasian plants have been useful in dating Native American archaeological deposits to the contact period and occasionally historic periods (Wohlgemuth 2004). Perhaps the most compelling case is from SCL-628 in the South Bay, where use of Feature 2 during the historic period is confirmed by abundant seeds of at least three introduced Eurasian plants (hairy brome (*Bromus ramosus*), filaree (Erodium), and bur clover (*Medicago polymorpha*), along with abundant acorn debris (Waechter 2013). Filaree was probably the earliest Eurasian plant to invade California (Minnich 2008); it has been found in high-resolution, offshore varved deposits in the Santa Barbara Basin in strata dating to AD 1755–1760 (Mensing and Byrne 2000), nine to 14 years prior to Spanish colonization. Consistent with the hypothesis of an early, pre-colonization introduction, filaree has been documented in

more than 20 archaeological sites in central California, virtually always without other Eurasian plant seeds and predominately in sites lacking European or other exotic goods (Wohlgemuth 2004).

While filaree has been found in many other California sites, Feature 2 at SCL-628 is unique in the abundant seeds of other Eurasian plants like hairy brome and bur clover. These latter plants have not been identified in any of the thousands of flotation samples processed from central California. Their presence suggests that Feature 2 dates to a later time, considerably after colonization, when other Eurasian plants had invaded and perhaps largely replaced the native herbaceous plants in the region. The abundance of these seeds suggests that they were eaten, along with acorns, during this early historic-era occupation.

Feature 2, and indeed the entire deposit excavated at SCL-628, lacks any artifacts diagnostic of the Mission Period. Without collection and analysis of charred plant remains, this deposit would not be recognizable as dating to the Mission Period, as it consisted of fire-affected rock resting on a thin layer of fire-reddened soil, and contained only a cobble tool and small amounts of bone and shell (Waechter 2013). It is uncertain as to how many other excavated sites or features in the Bay region are unrecognized Mission Period contexts, but careful study of charred plant remains have the potential to increase the number.

Data Requirements

Archaeobotanical remains from securely dated contexts provide data applicable to the above and other topics, and their presence in robust samples almost invariably contributes to site eligibility. This is particularly the case for sites of little-known time periods, notably pre-5000 cal BP. Sites along the bayshore with plant remains (or evidence that such remains are lacking due to dietary rather than preservation issues) would also be eligible, as there is little evidence for plant use along the east bayshore. Evidence for plant use is highly variable by time period along the northwest shoreline, and stronger along the southern shoreline. To ensure that plant remains continue to be relevant to regional research issues, it is critical that methodological standards of sampling and analysis, discussed in Section 3, are followed to guarantee that sufficient archaeobotanical remains are collected, and that data are presented consistent with recent efforts.

INSIGHT INTO DIET AND HEALTH FROM HUMAN REMAINS

A series of studies has been carried out in central California during the last decade exploring dietary and health trends based on human skeletal data. Some studies have explored health and diet based on macro-analysis of human remains from a bioarchaeological perspective, exploring evidence of dietary stress and disease (e.g., Bartelink 2006; Griffin 2014). For example, Evans (2014), in a study of auditory exostosis (abnormal growth of bone within the ear canal) in the Bay-Delta Area, argues that an uptick in its frequency mainly among males during the Middle Period indicated increased cold water foraging for subtidal shellfish (oysters and mussels).

Most notably, considerable analysis of stable nitrogen and oxygen isotopes of human remains has been undertaken along the bay shore, especially in the East and South Bay regions, near the Delta, and in the adjacent lower Sacramento Valley (e.g., Bartelink 2006, 2009; Beasley et al. 2013; Eerkens et al. 2014; Gardner 2013; Graham 2006; Greenwald and Burns 2016; Leventhal et al. 2010, 2011; Morgan and Dexter 2008; Van Bueren and Love 2008). Such studies provide a new and complementary line of evidence for understanding subsistence practices by gathering aggregate data on diet from radiocarbon-dated individuals that can be very precisely placed in time. Such studies are providing insight into temporal and localized trends in diet, and the relative reliance on terrestrial versus marine, fresh water, and marsh resources (rather than the specific foods exploited).

In a comprehensive study, Bartelink's (2006, 2009) synthesis of central California dietary and health trends based on human skeletal data contrasts Late Holocene trends in the Central Valley and Bay-

Delta Area. He argues that overall health was poorer in the Bay-Delta Area than in the valley, and that dietary stress and health-related diseases trended downward in the valley but remained stable in the East Bay. These trends were considered to support resource intensification models for the Central Valley but not for the Bay-Delta Area. The East Bay sample (from ALA-307, West Berkeley village; ALA-309, Emeryville; and ALA-328, Ryan mound) revealed high marine resource reliance in the Early Period and a significantly greater reliance on terrestrial resources in the Middle and Late Periods (Bartelink 2006:Table 5.4; note these periods use the Scheme B chronology). Subsequent isotopic results from the Ellis Landing site (CCO-295), largely focusing on the end of the Middle Period into the Late Period, provide additional results consistent with the initial study (Beasley 2008). In contrast, isotopic research at SFR-4 on Yerba Buena Island showed an even greater reliance on maritime resources in the Early Period and no increase in terrestrial resources in the Middle and Middle/Late Transition Periods (Morgan and Dexter 2008). Studies of South Bay human isotope data reveal, not surprisingly, a much heavier reliance on terrestrial resources in the Middle and Late Periods than farther north along the bay shore (Gardner 2013: Figure 38; Graham 2006). These in turn can be distinguished from populations near the Delta. For example, Eerkens et al.'s (2014) study of populations from two Middle Period sites (SOL-11 and SOL-69), just north of Suisun Marsh, reveal that brackish marsh resources (both plants and animals) were important components of the diet that can be distinguished isotopically.

Recently, studies of stable isotopes have also been used to explore childhood diets and the timing of weaning (Eerkens and Bartelink 2013; Gardner et al. 2011). Temporal trends in the timing of childhood weaning have the potential to provide insight into changes in fertility and the timing of sedentism, since a reduction in mobility is generally considered to encourage reduction in the social controls on fertility (Kelly 1995). Similarly, sex-based differences in weaning, in association with diet, can provide insight into potential differences in child rearing norms between sexes.

Data Requirements

These research topics are outlined for sites that contain human remains, even if intact interments are found in otherwise mixed deposits. Of course, permission must be granted by the MLD to analyze the remains. Basic osteological analyses of observable bone traits and measurements can provide some information on diet and health (dental caries, enamel hypoplasia, harris lines, cribra orbitalia). Stable isotope studies provide an excellent window into the diets of individuals, and can be carried out with minimally invasive sampling techniques on well-preserved bone.

CONSTRUCTION OF ANTHROPOGENIC LANDSCAPES

In stark contrast to the picture of resource depression and overexploitation painted by Broughton (1997, 1999) in regards to hunting in the study area, those studying plant remains take an opposite view. Lightfoot and Parish (2009) have offered a novel model of Native California adaptive strategies that has applicability to subsistence trends in the Bay-Delta Area (see also Lightfoot and Lopez 2013; Lightfoot et al. 2011). They argue that hunter-gatherers throughout the western portion of the state developed a "rotational system of prescribed burns" every 10 years or so to "stimulate the growth of a broad spectrum of resources" (Lightfoot and Parish 2009:99). This pyrodiversity strategy entailed regularly conducting small, controlled burns in a manner akin to swidden agriculturalists. Such fire management strategies are believed to have greatly increased food resources for deer and other animals, with subsequent higher population densities, enhanced habitat for plant resources such as bunchgrass, and greater quantities of suitable firewood. In particular, these studies posit the maintenance of productive grassland habitats from 950 cal BP (Middle/Late Transition Period) to Spanish contact (Lightfoot and Lopez 2013). They suggest this adaptive strategy effectively led down a novel diachronic path away from agriculture and large nucleated villages

that characterized the Southwest, Midwest, and Eastern North America (Lightfoot 1993). Instead, emphasis was placed on flexibility in resources orientation, research breadth rather than concentrating on a few keystone resources, and inter-annual variability in the location of residential bases depending on pyrodiversity-based resource abundance tied to burning rotations. Lightfoot and Parish (2009:136–140) argue that this strategy allowed for better and more balanced diets, spread resource procurement efforts evenly throughout the year, created a buffer against inter-annual climatic variation, and facilitated larger overall populations while village size and territorial extent remained relatively small. The onset and underlying causal explanations for the pyrodiversity adaptation, however, remain uncertain.

An interest in burning as a plant management tool was first brought to the attention of California anthropologists by Lewis (1973), but did not capture their interest until Blackburn and Anderson (1993) detailed the ecological benefits of various tillage, pruning, weeding, and prescribed burning, particularly around oak groves. More recently, Anderson (2005) describes a myriad of management practices designed to encourage the growth of basketry materials and food crops alike. Studies up to and including Anderson (2005) relied heavily on post-hoc ecological explanations for how the practices identified by modern tribal consultants benefited the plants. Until very recently, however, archaeologists had not rigorously investigated the antiquity of such practices.

A series of studies by a research group led by Kent Lightfoot, Rob Cuthrell and others has provided a model of how to identify burning in the archaeological record (see also Diekman et al. 2007; Kearns 2010). They argue that, while the proximate causes of pre-contact burning cannot be ascertained (i.e., we do not know if people were consciously managing plants for future benefit), the ignition of small and regular fires led to a patchy mosaic of vegetation communities that maximized biodiversity and habitat diversity within small areas:

The creation of patchworks of recently burned plots that placed young herbaceous plants adjacent to 'islands' of more mature shrubs and trees would have enhanced the availability of seeds, nuts, greens, fruits, and tubers for exploitation. The patchy distribution of habitats would also have facilitated hunting by attracting game to succulent young forage following burns and by providing shelter to birds, rabbits, deer, and other creatures in more established vegetation stands (Lightfoot and Parish 2009:94–102) [Lightfoot and Lopez 2013:210–211].

Cuthrell et al. (2013) and Lightfoot et al. (2013) have modeled fire frequencies based on natural ignitions (i.e., lightning strikes) and believe that these can be used as a null hypothesis to test predicted vegetation cover and fire frequency indicators. If it can be demonstrated convincingly that anthropogenic burning did, indeed, play a large role in the development of Western California ecosystems, it would constitute a major breakthrough for both anthropological analysis and modern fire management and vegetation restoration practices.

The Quirsote Valley project (which also included data from Pinnacles National Park on the interior of the Central Coast south of Monterey) provides an example of how the question of anthropogenic burning should be investigated (Cowart and Byrne 2013; Cuthrell 2013; Evett and Cuthrell 2013; Gifford-Gonzalez et al. 2013; Lightfoot and Lopez 2013; Lightfoot et al. 2013). Quirsote Valley is located on the San Mateo Coast, outside the current study area, but in similar habitat. The multi-disciplinary project brought together methodological specialists who all examined the archaeological and ecological records for signs of landscape modification due to anthropogenic burning.

Cuthrell (2013; Cuthrell et al. 2013) examined geomorphological and archaeobotanical data from site SMA-113, which was occupied between 950 and 175 cal BP. He found that site inhabitants relied heavily on grassland seed foods that included fire-associated plants. Furthermore, analysis of charcoal at the site revealed that the plants being burned as firewood were more compatible with regimes associated with low-

intensity fires rather than the highly fire-susceptible trees that dominate the modern communities in the study area. Phytolith analysis by Evett and Cuthrell (2013) found that there was a higher-than expected prevalence of phytoliths in the samples from the valley, indicating hundreds of thousands of years of grassland vegetation, supporting the macrobotanical findings. Staying with microbotanical evidence, Cowart and Byrne (2013) analyzed pollen samples from a 3,000-year depositional record from nearby Skylark Pond. They found that there was increased fire activity from the fifteenth century until contact, indicating an increase in high-intensity fire activity following the arrival of the Spanish. Gifford-Gonzalez et al. (2013) found that mammalian taxa at the site were reflective of more open communities than are found today within the valley. In particular, they found a prevalence of California voles, which are rarely identified in closed vegetation. This again implies the maintenance of open grasslands.

The implications for myriad other research issues are astounding if the findings of this study are more broadly applicable to the entire Bay-Delta Area. For example, the rebound in artiodactyls that Broughton observed at the Emeryville shell mound may have had less to do with distant hunting than with the initiation of anthropogenic burning that fostered growth in game populations. Areas that may seem to have been poor habitats based on the modern dominance of dense vegetation may have been maintained as open parklands, making them ideal locations. Perhaps more importantly, with the everpresent threat of catastrophic fires such as in the Oakland Hills in 1991, modern urban foresters around the Bay-Delta Area could learn valuable ecological lessons from such studies.

Data Requirements

Obviously, Lightfoot and colleagues' long-term multi-disciplinary study is well beyond the scope of a single CRM project (Cuthrell et al. 2013; Lightfoot et al. 2013a). The methods used, however, are mainly those employed by modern archaeological projects (i.e., faunal analysis, archaeobotanical analysis, geomorphology), and some that could easily be implemented (pollen and phytolith studies, charcoal identification). Certainly, not all of these datasets are required to make an argument for anthropogenic burning, though the more analyses conducted, the more convincing the argument will be. The collection of such data within and adjacent to project areas could be banked for future comparative studies (e.g., along various highways) which might create meaningful data corridors (or transects) for long-term assessment of landscape management at local and interregional scales.

The Quirsote Valley study provides baselines that can be used by others to test the null hypothesis that all burning was natural. Therefore, to address this topic requires the availability of both micro- and macro-botanical constituents (i.e., soil samples for pollen or phytolith analysis and archaeobotanical identification) or faunal remains. Because all of these types of data are organic, direct dating from these contexts can help pin-point the onset of such practices, and grow the database to support widespread use of fire as a plant management tool.

An eligible site will have well-preserved micro- and macro-botanical and faunal assemblages that provide evidence for habitats that are no longer present. This may be difficult in urbanized settings, but may perhaps be profitably implemented in the Northwest Bay or East Bay hills.

GENERAL SUBSISTENCE DATA REQUIREMENT CONSIDERATIONS AND GUIDANCE FOR FUTURE RESEARCH

As the preceding discussion makes apparent, there is a wealth of data potential in the subsistence remains recovered from sites in the San Francisco Bay-Delta Area. Clearly, detailed studies of intra- and inter-site trends within regions of the Bay-Delta Area are needed to refine temporal trajectories and to test models explaining changes in resource reliance. With insights from multiple data sets (vertebrates,

invertebrates, macrobotanical remains, and human skeletal material), the efficacy of these competing models can be examined.

Although archaeological investigations into subsistence practices clearly have a long history in the Bay-Delta Area, prior investigations have been very uneven with respect to which data sets have been investigated. Analysis of invertebrates has been most consistently presented, and vertebrates have been subject to more varied recovery and analytical methods, with many studies lacking rigorous sampling of fish remains or detailed identification of birds. Only recently has any effort been placed on understanding plant foods, with only limited sampling for macrobotanical remains. Moreover, these three data sets are rarely integrated to create comprehensive reconstructions of Bay-Delta Area subsistence trends.

Estimating the relative reliance on particular food resources can be particularly challenging when comparing dietary remains obtained using varied recovery methods (plants from flotation light fraction, small fish from flotation heavy fraction, shellfish from column samples or dry-sieving, and vertebrate remains from dry-sieving). Moreover, comparing overall assemblages recovered with different techniques poses considerable challenges, particularly where different types of field screening have been used: dry-screened 1/4-inch, dry-screened 1/8-inch, wet-screened 1/8-inch, and wet-screened 1/16-inch. In addition, the size and number of samples taken for analysis of fish and macrobotanical remains are highly variable, typically too small, and occasionally lacking entirely.

Prior research indicates that vertebrate, invertebrate, and plant remains should be well-preserved at Late Holocene sites, and potentially at some Early and Middle Holocene sites as well. It is also possible that human burials will be encountered. Rigorous flotation and light-fraction sampling is needed to ensure that sufficient data sets of carbonized plant remains and small vertebrates (notably fish) are recovered. This should include collecting flotation samples of 12–20 liters in size, both as column samples and as samples within and adjacent to features. Carbon and nitrogen isotope ratios obtained from dated human bone collagen could provide an independent test of these observations.

Changes in technology (such as the introduction of the bow and arrow, and new processing technologies such as the replacement of millingslabs and handstones with mortars and pestles) also have the potential to provide insights into the causal factors behind new subsistence strategies. Of course, inferences regarding plant reliance based on ground stone tool types must be tested with independent data (e.g., associated macrobotanical remains or protein residues, notably lipids, obtained from ground stone artifacts [Burton 2003; Reddy 1999]). In addition, paleoenvironmental studies, including pollen from natural sequences near the study area (such as cores from buried marshy areas), can provide an important environmental context.

With sufficient samples, behaviors such as variation in faunal procurement, shellfish collection, and plant exploitation can be tracked within the broader regional context. Although invertebrate remains are regularly identified in CRM reports, shellfish-size studies are rarely conducted on whole-shell specimens. Addressing issues of overexploitation or pseudo-aquacultural practices requires such data to be collected form a variety of sites in different places and dating to different time periods. MNI values can be converted to calories by using previously estimated values for each species, and these data can greatly aid in understanding the relative dietary importance of various food classes. Where applicable, regional analyses should place emphasis on archaeological results from sites with multiple data sets (cf. Lightfoot et al. 2013). These results may provide important tests of the efficacy of various prominent explanatory models, particularly the timing of resource intensification developments in relation to social and technological changes and paleoenvironmental fluctuations.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

10. THE IMPORTANCE OF TECHNOLOGICAL CHANGE

Archaeologists have traditionally viewed technological change as signifying important transitions—ethnic migrations, diffusion of ideas, local economic innovations, restructuring settlement systems. This is certainly true in the Bay-Delta Area archaeological record. Yet, as radiocarbon dating has become more common over the last 60 years, it is now apparent that traditional estimates for the introduction of important technologies, such as the mortar and pestle or bow and arrow, need to be re-evaluated. It is also clear that some of the most important technological and economic changes did not occur everywhere or at the rapid pace often envisioned. Further, as the study of dietary remains has become a focal point of archaeological research in the Bay-Delta Area, the assumed functional relationships between certain technologies and associated resources require consideration.

In this section, we focus on two interrelated topics to better understand the importance and implications of technological change in the Bay-Delta Area: (1) the timing of two major technological developments; and (2) what those developments might mean from a culture-historical, economic, and/or socio-political standpoint. We first discuss milling tools, focusing on adaptive strategies, plant values and productivity, and archaeological data in the form of archaeobotanical evidence and the millingslab/ handstone-mortar/pestle dichotomy. For the bow and arrow, we discuss the timing and circumstances of the introduction of the Stockton serrated arrow point, cultural transmission, cultural and ethnic continuity, and social and economic organization.

MILLING TOOLS, PLANT FOODS, AND ADAPTIVE STRATEGIES

Review of milling tool and plant macrofossil assemblages from the Early and Middle Holocene demonstrates that nuts and small seeds were both commonly processed with the handstone and millingslab and mortar and pestle. It is also evident that there is considerable variability in the timing and geographic distribution of these different types of milling tools in central California. The adoption of the mortar and pestle is often related to a shift to the dominance of acorn processing, but the handstone and millingslab persist in some areas, and the mortar and pestle are adopted early in others. Basgall (1987) has suggested that population-resource imbalances mandating more intensive regional subsistence strategies occurred differentially across central California, resulting in considerable temporal discontinuity in the persistence or adoption of these contrasting milling technologies. If correct, use of the mortar and pestle signals not simply a reliance on acorns, but a significant structural transformation in the organization of production related to a greater seasonal dependence on plant foods and increasing storage (Basgall 1987; Jackson 1991; McGuire and Hildebrandt 1994; Testart 1982), along with a significant change in patterns of settlement mobility and land use. Therefore, the design of different types of plant processing implements should be seen in terms of maximizing functionality given constraints imposed by the environment, mobility, and the broader economic system (Nelson 1991; Nelson and Lippmeier 1993). Consideration should be given to functional efficiency and the energetic costs of material acquisition, manufacture, and transport, and the planned period of use (Buonasera 2015; Horsfall 1987; Nelson 1991; Nelson and Lippmeier 1993; Ugan et al. 2003).

From this perspective, handstones and millingslabs represent a comparatively expedient technology that functioned well within a settlement-subsistence system organized around frequent residential moves. This type of adaptive system is consonant with what Woodburn (1980, 1982) describes as immediate-return, whereby labor expenditures result in direct, near-term economic benefits. Such systems are also consonant with what Bettinger (2001) describes as time-minimizing adaptive strategies. Under such systems, storage is minimal and technology is comparatively simple (Bettinger 1991:69;

Woodburn 1982). Because of the low initial investment in millingslabs and handstones, more available labor can be directed toward collection and processing targeted resources. Abandonment of these tools upon moving to new foraging locations sacrificed little in the way of overall time/labor expenditures. In addition, handstones and millingslabs appear to be a very flexible technology, another hallmark of immediate return systems featuring time-minimizing strategies (Bettinger 1991:69). Presumably there is no morphological impediment to either pounding or grinding with these tools and therefore a single tool can capably perform a variety of tasks (Hale 2001; Mikkelsen 1985).

In contrast, use of mortar and pestle likely signals a more residentially stable pattern of land use-referred to variously as a collector or processor strategy (Binford 1980; Bettinger and Baumhoff 1982)—in which energy-maximizing goals result in high degrees of storage, territorialism, and greater social complexity (Bettinger 2001). Such an adaptive strategy emphasizes a delayed-return, whereby benefits of labor are not immediate, and storage and technological investment are high (Bettinger 1991; Woodburn 1980, 1982). In this respect, use of the mortar and pestle constitutes a substantially greater technological investment than use of the handstone and millingslab. To achieve a functional bowl mortar, a significant amount of time/energy must be invested. For example, experimental studies by Leventhal and Seitz (1989:156–165) and Schneider and Osborne (1996) have shown that it takes between about 17.2 and eight hours of labor (depending on technique) to create a single functional mortar cup in various types of material, including granite, basalt, and sandstone. This is not an unreasonable commitment if the expected period of use is long and the technology confers a sufficient benefit in terms of increased efficiency in processing (Bettinger et al. 2006; Ugan et al. 2003). That is, given that residentially tethered adaptations engender a high degree of transport and handling costs, processing methods that reduce unnecessary waste and processing time will, by definition, significantly enhance overall return rates (Bettinger 1991; Bettinger et al. 1997). As foraging efficiency declines, labor is simply redirected to more productive resources (Bettinger 1991; Binford 1979).

While it is likely that bowl mortar and pestle use would be minimal in contexts of high residential mobility, there is no reason to believe handstones and millingslabs would be totally excluded from situations of low residential mobility, particularly if they continue to convey some advantage when processing certain types of resources (e.g., small seeds) or are only marginally less efficient than mortars and pestles (Bettinger et al. 2006). Also, seasonal variability in the degree of residential stability within settlement-subsistence systems could result in the use of handstones and millingslabs during one part of the year (e.g., spring and summer), and mortars and pestles during another (e.g., fall and winter). However, as residential mobility decreases and logistical procurement increases, reliance on the bowl mortar and pestle or, eventually, the hopper mortar, is expected to increase, as well.

To go beyond the strict equation of mortar and pestle equal acorn use and handstone and millingslab equal small seed use, these tools need to be analyzed in relation to design and adaptive strategies. Important data sets include resource value and productivity, the relationship between these milling tools in time and space, and associated archaeobotanical assemblages from central California.

Resource Values and Productivity

The Mediterranean climate of California has a strong influence on plant food productivity, as peak rainfall is directly out of phase with the growing season. As a result, cold winter temperatures and summer drought both constrain the period of plant-food ripening. When warm temperatures converge with adequate water supply in spring, a variety of seed-bearing plants, geophytes, and leafy greens are widely available. In summer, native plant foods consist mainly of small seeds and various fruits (e.g., manzanita berries, elderberry, blackberry, grape), whereas in the fall, a variety of nut crops ripen, including acorn, pine, bay, and buckeye. With the exception of a few types of roots (e.g., cattail and tule) and greens, virtually no plant foods are available during winter months in central California. This latter characteristic is important for understanding prehistoric economies, as use of plant foods in winter either relied on stored resources or focused on relatively un-productive and geographically restricted species of wetland plants (e.g., cattail and tule). Another important characteristic of this seasonal succession is that nut crops (e.g., pine nuts, acorns) came at an entirely different time of year than small seeds. This means that collection of acorns and other nuts would not interfere with the collection of seeds; they are sequential and thus complimentary resources.

Early studies of acorn use among aboriginal groups in central California assumed a high value for this resource, largely due to its ubiquity in ethnographically documented native California diets (Basgall 1987; Gifford 1936; Glassow 1996; Kroeber 1925; Schulz 1981). This led many archaeologists to believe that the only significant impediment to intensive acorn use was "unavailability, induced by either environmental factors (an absence of suitable oak tracts) or technological limitations (ignorance of the leaching process)," but not the productivity of the resource itself (Basgall 1987:23). Basgall (1987) later argued that neither of these alternatives seemed to be a substantial impediment to intensive acorn use, prompting him to reconsider evidence for the timing and role of acorn use in pre-contact Native subsistence economies.

Although Basgall (1987) went to great lengths to describe the labor-intensive process of pounding and leaching acorns, the true profitability of this resource can only be evaluated in relation to other potential food sources (i.e., opportunity costs). The most common way of measuring resource profitability is through post-encounter return rates (i.e., the net gain in food energy divided by the time required to procure and process the item; see e.g., Simms 1987). Although return rates have not been calculated for many plant foods in central California, this information now exists for some of the most important individual species, including acorns (i.e., Quercus kelloggii, Q. douglasii, Q. lobata, Q. chrysolepis, Lipocarpus desilora). Using the common index of kilocalories per hour, several estimates have been generated for various types of acorns, small seeds, and roots (see Table 24). Contrary to prevailing assumptions, however, acorns rank among the most profitable plant foods available in central California. Return rate estimates for five different species of acorn far exceed those calculated for small seeds like chenopods, maygrass, and Indian rice grass. Cattail roots and bulrush roots are substantially less productive than both acorns and small seeds, whereas pine nuts—in this case pinyon pine—provide return rates similar to or higher than acorns. Although we lack return-rate estimates for pine species common to central California (e.g., gray or foothill pine, coulter pine), the value of these foods is presumably equal to or perhaps slightly less than pinyon pine found in eastern California and throughout the Great Basin.

Because the availability of different plant foods in central California is also bound by the period of ripening, acquisition could not continue beyond the period of availability, regardless of its energetic profitability. Thus, return rate estimates also indicate that plant food productivity fluctuated substantially throughout the year. It is probably significant that fall-ripening nut crops are among the most profitable plant foods available throughout the annual cycle, and these came just prior to the most deficient period—winter. As pine nuts and acorns can last for a year or more in the shell without spoilage, it follows that these should have been among the first types of plant foods to be stored in prehistoric central California (Basgall 1987).

It is also true, as Bettinger et al. (1997) point out, that delaying the actual processing of acorns until winter incurs very few opportunity costs, simply because few other plant foods are available at that time; and those that are (e.g., cattail and bulrush roots), have substantially lower energetic returns, even factoring in processing costs. And while existing return-rate estimates suggest pine nuts may have been more productive than acorns, pine trees are not as widely distributed in central California as oak trees, and do not grow in valley floodplains where pre-contact human populations appear to have been the highest.

		Kcal/F	Iour	D
COMMON NAME	SCIENTIFIC NAME -	Low	High	KEFERENCE
Bitteroot	Lewisia rediviva	1,237	2,305	Simms (1987)
Pinyon Pine	Pinus monophylla	841	1,408	Simms (1987)
Black Oak	Quercus kelloggii	1,166	1,276	Barlow and Heck (2002)
Salina Wild Rye	Elymus salinas	921	1,238	Simms (1987)
Nuttal Shadscale	Atriplex nuttalli	1,200	1,200	Simms (1987)
Black Oak	Quercus kelloggii	1,091	1,194	Barlow and Heck (2002)
Valley Oak	Quercus lobata	1,135	1,138	Barlow and Heck (2002)
Black Oak	Quercus kelloggii	1,070	1,070	Basgall (1987)
Shadscale	Atriplex confertiflora	1,033	1,033	Simms (1987)
Golden Cup Oak	Quercus chrysolepis	979	979	Barlow and Heck (2002)
Blue Oak	Quercus douglasii	915	919	Barlow and Heck (2002)
Bulrush Seeds	Scirpus spp.	900	900	Simms (1987)
Tanbark Oak	Lipocarpus desiflora	866	866	Barlow and Heck (2002)
Black Oak	Quercus kelloggii	848	848	Talaley and Keller (1984)
Black Oak	Quercus kelloggii	793	793	Bettinger et al. (1997)
Sunflower	Helianthus annus	467	504	Simms (1987)
Bluegrass	Poa spp.	418	491	Simms (1987)
Great Basin Wild Rye	Elymus cinereus	266	473	Simms (1987)
Maygrass	-	457	457	Gremillion (2004)
Chenopod	-	433	433	Gremillion (2004)
Indian Rice Grass	Oryzopsis hymenoides	301	392	Simms (1987)
Cattail Roots	Typha latifolia	128	267	Simms (1987)
Bulrush roots	Scirpus spp.	146	160	Simms (1987)

Table 24. Return Rates on Various Plant Foods in Central California.

Archaeobotanical Evidence

Given the comparatively high energetic return rate estimates for acorns, we expect this food to have been used at least seasonally throughout the prehistoric sequence, particularly in regions like the Bay-Delta Area valleys, where pine trees cannot grow. Acorn use during the late Holocene (i.e., after 3,000 cal BP) in this region is well documented (e.g., Wohlgemuth 1996, 2004), but there are now sufficient archaeobotanical assemblages from the early and middle Holocene to demonstrate use of acorns for nearly 10,000 years.

Wohlgemuth (1996, 2004) amassed a substantial record of plant food use from pre-contact central California, particularly for the late Holocene. Based on nearly 1,000 archaeobotanical samples collected from throughout central California, Wohlgemuth (2004) demonstrated that the relative abundance of acorn residues in regional archaeological sites increased during the Middle Period (i.e., 2500 to ~1000 cal BP), consistent with Basgall's (1987) predictions. However, at sites located in interior central California, this increase was followed during the Late Period by an almost ten-fold rise in the abundance of small seeds (see Chapter 9). Wohlgemuth (2004) attributed this development to more labor-intensive subsistence practices in this region, spurred by increasing human population densities—i.e., resource intensification. However, how do we account for the upswing in small seed consumption late in the prehistoric sequence when mortars and pestles were used almost exclusively (see Chapter 9).

Comparison of the ubiquity of the four most common large seeded taxa (acorn, gray pine, wild cucumber [*Marah* spp.], and bay [*Umbellularia californica*]) found in central California sites is presented in Table 25. This summary includes 366 archaeobotanical samples from 27 stratified or single component

Site	Reference	# OF SAMPLES	Acorn (%)	Gray Pine (%)	Wild Cucumber (%)	Bay (%)	¹⁴ C Range Cal BP	Count
EARLY HOLOCENE								
Coast								
SON-348	Schwaderer (1992)	2	-	-	50	100	8000-7210	2
SLO-832	Jones et al. (2002)	6	83	-	100	-	9313-6066	11
SLO-1797	Fitzgerald (2000)	8	-	-	-	-	10,295–4780	16
Northern Coast Ran	ges							
P-01-011556	Meyer 2015	4	-	-	100	-	8200-9560	6
CCO-696D	Meyer and Rosenthal (1997)	10	90	-	70	10	9870-7400	3
P-48-000897	Hildebrandt et al. 2012	1	100	-	100	-	8865	1
SOL-468	Rosenthal and Whitaker (2016)	7	100	-	100	29	8100-6700	4
Sierra Nevada Footh	uills							
CAL-629/630	Rosenthal and McGuire (2004)	10	70	60	100	10	10,200–7765	7
TUO-2797/H	Whitaker and Rosenthal (2010)	10	100	100	80	-	8850-4850	3
Middle Holocene								
Southern North Coa	st Ranges							
LAK-72E-A	White et al. (2002)	1	100	100	100	-	4494	1
LAK-510W-C	White et al. (2002)	2	100	100	100	100	7820–3000	2
LAK-509/881	Compas et al. (1994)	1	100	100	100	100	6880	1
SON-2098	Origer (1993)	5	100	20	100	80	5590-5130	2
Northern Diablo Ra	nge							
CCO-637	Meyer and Rosenthal (1998)	10	100	80	100	100	5797-2585	4
CCO-309	Price et al. (2006)	4	100	-	100	100	5050-4420	3
CCO-18/548, Upper	Wiberg 2010	17	100	24	100	70	5555-3213	188
CCO-18/548, Lower	Rosenthal (2010)	7	100	71	57	71	7060-5025	9
SCR-313	Jones et al. (2000)	15	33	-	7	60	5935-4985	2
Coast								
SBA-54	Levulett et al. (2002)	3	33	-	100	-	6155–4810	15
Sacramento Valley								
COL-247	White (2003)	9	100	-	100	22	4385-3575	3
GLE-701	Hildebrandt and Kaijankoski (2011)	6	67	50	100	-	6600–6075	4
SAC-1142	Wohlgemuth (personal communication 2009)	3	100	-	100	-	7470–5215	2
Sierra Nevada Footh	nills							
CAL-789	Rosenthal and McGuire (2004)	11	90.9	100	9.1	-	5390-2720	8
FRE-61	McGuire (1995)	3	67	-	33	-	6760–3010	2
TUO-4559	Meyer 2008	13	92	92	54	-	6510-4415	23

Table 25. Ubiquity of Nut Crops in Stratified and Single Component Early and Middle Holocene Sites.

sites in the Bay-Delta Area and elsewhere in central California (Table 25), and clearly demonstrates that acorn use was ubiquitous, as charred acorn nutshell occurs in 67% of early Holocene samples and 85% of all middle Holocene samples containing dietary remains. Likewise, pine nuts were widely used in habitats such as the foothills of the Sierra Nevada and Coast Ranges, where pine species were common, but are virtually non-existent in the earliest samples from lowland valleys of the Bay-Delta Area.

Milling Tool Evidence

Handstones and millingslabs occur in 87% of the 23 archaeological sites in mainland California dated between 9,000 and 12,600 cal BP (Rosenthal and Fitzgerald 2012). To better identify the initial introduction of the mortar and pestle in the Bay-Delta Area and the wider central California region, information was compiled on ground stone tools from 35 early and middle Holocene deposits, including 20 sites with archaeobotanical assemblages presented in Table 25, as well as 15 other radiocarbon-dated and stratified or single component sites. For comparative purposes, milling tools reported from late Holocene strata at these sites are also provided (Table 26). In total, the 35 site assemblages included 4,354 pieces of ground stone: 717 mortars (bowl and hopper mortars), 1,861 pestles, 1,043 handstones, and 733 millingslabs.

The stratigraphic distribution of mortars and pestles clearly indicates that these milling tools were not widely used in most regions of central California, including the Bay-Delta Area, until after about 5500 cal BP, but could have been introduced as early as 7770-6700 cal BP (e.g., LAK-380/381, CCO-696, SOL-468). In the Bay-Delta Area, handstones and millingslabs are the only plant processing tools from early Holocene deposits dated more than 7400 cal BP. These tools were found exclusively in the early Holocene Kellogg paleosol, dated between 7400 and 10,000 cal BP, at the buried Laguna Creek site dated 8865 cal BP, and the buried Fremont Site (P-01-011556) dated 9560-8200 cal BP (Hildebrandt et al. 2012; Meyer 2015; Meyer and Rosenthal 1997). At Los Vaqueros, overlying strata in the valley floodplain younger than 7210 cal BP included only mortars and pestles. That these latter tools were used exclusively at Los Vaqueros during the middle Holocene is clearly indicated at CCO-637, where mortars and pestles are the singular plant processing tools found in deposits dated between 5700 and 2600 cal BP. At the Marsh House site (CCO-18/548) in the watershed adjacent to Los Vagueros, buried deposits dated between 7060 and 5025 contained only handstones and millingslabs, whereas of the 162 milling tools from the overlying deposit, dated between 5555 and 3215 cal BP, mortars and pestles dominate by a ratio of 8.5:1. This pattern appears to prevail throughout the valleys of the northern Diablo Range, as mortars and pestles are virtually the only milling tools reported in middle and late Holocene strata at the Stone Valley site (CCO-308) and Laguna Oaks site (ALA-483), and outnumber handstones and millingslabs at the Rossmoor Site (CCO-309) by a ratio of four to one. In all subsequent (well-dated) Late Holocene sites after about 4000 cal BP in the Livermore Valley and San Ramon-Walnut Creek Valleys, mortars and pestles occur almost exclusively (Fredrickson 1966; Rosenthal and Byrd 2005).

Discussion

In central California, adoption of the mortar and pestle marks a significant economic transformation that began in parts of the Bay-Delta Area and other lowland regions at different times during the middle Holocene. Although archaeobotanical evidence does not suggest a difference in the types of plant foods associated with diachronic changes in milling technologies, it seems certain that the proportions of specific plant foods in the diet changed, especially acorns and small seeds, reflecting increasing storage and use of off-season resources (Basgall 1987; Wohlgemuth 1996, 2004). This transformation appears to track with evolving patterns of labor organization, increasing residential stability, and the overall intensity of plant use (Basgall 1987; McGuire and Hildebrandt 1994; White et al. 2002:536–537; Wohlgemuth 2004).

As population-resource imbalances increased (i.e., population pressure), labor throughout the entire year shifted towards surplus production of foods for use during winter and early spring, when all types of plant foods were scarce. Previously, the storage of acorns, pine nuts, and other fall-ripening nuts was sufficient to bridge seasonal deficits in productivity. As population-resource imbalances increased during the Holocene, and foraging territories decreased (i.e., increasing territorial circumscription), it was

		BM	PES	HND	MLG	CAL BP	Count
Sierra Nevada, Lower Foothills							
Skyrocket (CAL-629/630) LaJeunesse and Pryor (1996) Green, Black, and Gray Clay	-	-	-	61	206	10,200–7765	7
Tan-gravelly Clay	-	6	20	43	5	7500–5980	5
Olive Silt and Black Clay	-	4	2	13	16	4470	1
Brown Clayey Silt	-	12	8	38	10	4415-2720	3
Surface Loam	-	11	48	179	26	1965-465	5
Clarks Flat (CAL-342) Peak and Crew (1990) Spit B	-	-	-	134	104	7470-1940	6ª
Spit A	-	-	-	9	8	610–355	3
Black Creek (CAL-789) Rosenthal and McGuire (2004) Stratum II	-	-	1	2	3	5390-2720	8
Stratum III	-	5	7	18	26	1210	1
Taylors Bar (CAL-1180/H)Milliken et al. (1997)Stratum III	-	-	1	1	-	10,715–1905	2
Stratum II	7	11	5	31	11	970–390	3
Edgemont Knoll (TUO-4559) Meyer (2008) Stratum II	-	8	4	133	107	6510-4415	23
Wahtoke Creek (FRE-61)McGuire (1995)Stratum II	-	-	-	17	8	6760-3010	2
Stratum I	-	-	2	14	-	2420	1
Poppy Hills (TUO-2797/H Whitaker and Rosenthal (2010) Stratum II	-	1	3	10	1	3635–530	4
Stratum I	-	-	-	5	6	8850-4850	3
North Coast Ranges							
SHA-1169Basgall and Hildebrandt (1989)Stratum 1b, Feature 6	-	-	-	29	20	5830-3570	2
Mostin (LAK-380/381) White and King (1993) Buried midden	-	1	1	5	2	13,262–7770	3 ^b
LAK-509/881 Compas et al. (1994) above Buried soil	-	-	-	1	1	>6880	1
Creager (LAK-510) White et al. (2002) WC-2	-	-	-	-	-	7820	1
WC-1	-	-	-	4	8	3005	1
Anderson Ranch (LAK-72) White et al. (2002) EA-2	-	-	-	4	8	4494	1
EA-1	-	2	17	1	-	1735–1214	3
Memorial Hospital (SON-2098) Origer (1993) Layer 3	-	3	1	4	2	5590-5130	2
Laguna Creek (P-48-000897) Hildebrandt et al. (2012) 2Ab	-	-	-	1	-	8865	1
Alamo Basin (SOL-468) Rosenthal and Whitaker 2017) Stratum II	-	1	-	1	-	8100-6700	4

Table 26. Radiocarbon-Dated Early and Middle Holocene Ground Stone Assemblages from Stratified and Single Component Sites in California.

SITE	Reference	STRATUM	HM	BM P	ES I	HND	MLG	¹⁴ C RANGE CAL BP	Count
Northern Diablo Range									
Los Vaqueros (CCO-696, -458)	Meyer and Rosenthal (1997)	Kellogg Paleosol	-	-	-	6	3	10,355–7400	6
		Vaqueros Paleosol	-	25	37	-	-	7210-690	14
		Brentwood Alluvium	1	1	15	-	-	665–250	5
Los Vaqueros (CCO-637)	Meyer and Rosenthal (1997, 1998)	Stratum I	-	5	18	-	-	5795-2585	4
Marsh House (CCO-18/548)	Wiberg (2010)	Upper Component	-	50	95	9	8	5555-3215	188
	Rosenthal (2010)	Lower Component	-	-	-	2	3	7060–5025	9
Stone Valley (CCO-308)	Fredrickson (1966)	Stratum C	-	5	1	-	-	5030-2990	2
		Stratum B	-	5	6	1	-	2955-1160	3
		Stratum A	-	3	1	-	-	950-470	4
Rossmoor (CCO-309)	Price et al. (2006)	Stratum I		6	7	2	1	5050-4420	3
Laguna Oaks (ALA-483)	Bard et al. (1992); Wiberg (1996)	-	-	4	8	-	-	6180–2830	4
Fremont Site (P-01-011556)	Meyer (2015)	2Ab Horizon	-	-	1	-	-	9560-8200	6
Santa Clara Valley									
Classic Residence (SCL-623/H)	Morley (2004)	2Ab horizon	-	1	1	-	-	4030-5160	5
Saratoga Site (SCL-65)	Fitzgerald (1993)	-						7350-6850	2
CENTRAL COAST RANGES									
Scotts Valley (SCR-313)	Jones et al. (2000)	Stratum III	-	-	-	3	5	5935-4985	2
Cross Creek (SLO-1797)	Fitzgerald (2000)	Stratum 3Ab	-	-	-	21	21	10,297-4781	16 ^c
CENTRAL VALLEY									
Reservation Road (COL-247)	White (2003)	Stratum 3	-	-	1	3	-	4385-3575	3
× ,		Stratum 2	-	-	-	14	2	3205-2755	2
		Stratum 1	-	-	3	2	-	2755-1675	3
Hamilton City (GLE-701)	Hildebrandt and Kaijankoski (2011)	Stratum I	-	-	-	1	1	6600–6075	4
Blossom Mound (SIO-68)	Ragir (1972): Schulz (1981)	-	-	31	3	1	4	5000-3195	7

Table 26. Radiocarbon-Dated Early and Middle Holocene Ground Stone Assemblages from Stratified and Single Component Sites in California *continued*.

Site	Reference	STRATUM	HM	BM	PES 1	HND	MLG	¹⁴ C Range cal BP	Count
Coastal/Bay									
Duncans Landing (SON-348/H)	Schwaderer (1992)	Stratum VI	-	-	-	2	1	8000-7210	2
Nursey Site (MRN-67)	Schwitalla and Powell (2014)	Undifferentiated	-	379	1,426	110	24	4905-1010	36
West Berkeley (ALA-307)	Wallace and Lathrap (1975)	>300 cm	-	37	56	-	-	4960-2880	24
Pismo Beach (SLO-832)	Jones et al. (2002)	Stratum II	-	-	-	2	2	9313-6066	11
Corona Del Mar (SBA-54)	Levulett et al. (2002)	Stratum II/III	-	23	5	38	20	6155-4810	15 ^d
Aero Physics (SBA-53)	Levulett et al. (2002)	-	-	69	57	68	60	6103-5580	6

Table 26. Radiocarbon-Dated Early and Middle Holocene Ground Stone Assemblages from Stratified and Single Component Sites in California *continued*.

Notes: ^a Excludes one intrusive date of 505 cal BP; ^b Charcoal dates only; ^c Excludes one date of 1910 cal BP; ^d Excludes one date of 8905 cal BP; HM – Hopper mortar; BM – Bowl mortar; PES – Pestle; HND – Handstone; MLG – Millingslab.

necessary to extend the period of surplus production throughout the year, emphasizing the extent to which storage of off-season resources became an important component of pre-contact economies. It is also likely that surplus foods, like small seeds, also served as barter with neighbors, as regional economic integration increased through the Late Period (e.g., DeGeorgey 2016; Rosenthal 2011a). The shift identified in milling technologies, therefore, represents a transition from time-minimizing to energy-maximizing adaptations, a development which did not occur in all regions of central California at the same time. Instead, this transition appears to be a response to local thresholds in population density and resource productivity.

Data Requirements

The previous discussion makes two fundamental predictions: (1) that there is a direct link between milling tools and residential mobility and permanence; and (2) that use of the bowl mortar and pestle occurs in the context of increasing residential permanence, economic intensification, and greater reliance on stored foods. Conversely, handstones and millingslabs should occur in contexts of high residential mobility, seasonal site use, low investment in storage, and few specialized tools. To test these hypotheses, it will be necessary to better establish the timing of the introduction of the mortar and pestle in all subregions of the Bay-Delta Area and then determine if this technological transition correlates with other economic developments and changes in settlement systems. Of course, this will require a broad range of archaeological information, including milling tools and full technological assemblages, as well as archaeobotanical remains. Insights into settlement permanence might be monitored through the plant remains, isotope studies of shellfish or human bone, or identification of house remains, storage features, and other evidence for seasonality of site use (e.g., increment analysis of artiodactyl teeth; faunal remains). Likewise, changes in the proportion of cooking stones through time may also correlate with intensive acorn processing and sand-basin leaching, as described ethnographically.

SOCIAL AND ECONOMIC IMPLICATIONS OF THE BOW AND ARROW

Among the more important technological advancements documented in the archaeological record of the Bay-Delta Area is the widespread adoption of the bow and arrow late in the pre-contact sequence, completely replacing the older technology of dart and atlatl. As Bettinger (2013:118; 2015:44–48) clearly demonstrates, the bow is an immensely better weapon, as hunting success was likely two to three times greater than with an atlatl (Bettinger 2013:118). Of course, this has long been suspected, leading to the traditional assumption that the bow and arrow was immediately adopted throughout central California when it was first introduced. (e.g., Beardsley 1954; Fredrickson 1974a; Lillard et al. 1939). However, recent refinements to regional chronologies throughout the Bay-Delta Area and adjacent regions of central California suggest that the bow and arrow was not adopted simultaneously across this broad region (e.g., Groza et al. 2011; Kennett et al. 2013; Rosenthal 2011b). Furthermore, morphological similarities and differences in arrow point styles across different subregions of central California suggest that bow and arrow technology was initially introduced from different directions and by alternate forms of cultural transmission. Perhaps as importantly, Bettinger (2015:149–152) has argued that the adoption of this new technology ultimately leads to smaller economic and political groups.

Introduction of the Bow and Arrow

In contrast to the Great Basin, where projectile point typology and chronology have been an integral part of archaeological research for more than 50 years, no formal projectile point chronology has been established for the Bay-Delta Area. Typologies exist, to be sure (e.g., Beardsley 1954; Gerow 1968; Lillard et al. 1939), but discriminate metrical criteria establishing different point styles (e.g., Thomas 1981) have not been established. This is a major problem in need of remedy, since formal typologies are the

primary means by which archaeologists convey morphological information. More importantly, standardized typologies allow for the identification of spatial and chronological patterns necessary for examining a wide range of cultural phenomena (Bettinger and Eerkens 1999:231). Despite the lack of a well-established point typology for the Bay-Delta Area, a reduction in projectile point size, in combination with a distinctive new point style, is widely regarded as representing the introduction of the bow and arrow around the beginning of the Late Period, originally estimated at about 1650–1450 BP (Bennyhoff and Hughes 1987:Figure 10; Elsasser 1978; Fredrickson 1974; Heizer 1958).

Throughout most of the Bay-Delta study area, the earliest recognized arrow point is a unique, deeply serrated type with variable basal morphology grouped into the Stockton Series (e.g., Dougherty 1990; Johnson 1940; see also temporal charts by Bennyhoff in Elsasser 1978). So-called Stockton serrated points range from straight-stemmed with flat bases to side- or corner-notched with convex bases; all, however, share the distinctive, deep, square serrations and are made of obsidian. In most regions, Stockton Series points are Napa Valley obsidian, except in Marin and Sonoma Counties where Annadel obsidian is common (e.g., Fredrickson and Origer 1995; Origer 1982). Bennyhoff's seriation of mortuary assemblages from throughout the Bay-Delta Area suggests that Stockton Series points were widely used beginning in the Late 1 Period (e.g., see temporal charts in Elsasser 1978), which is currently estimated to have begun about 685 cal BP (Groza et al. 2011), almost 1,000 years later than initial estimates.

Remarkably, there are few radiocarbon dates which relate directly to the initial timing of the Stockton serrated arrow point in the Bay-Delta Area (Table 27). And while numerous hydration readings are available for Stockton series points, hydration age estimates are of such coarse temporal resolution that they are unlikely to be helpful in refining the age of introduction for this point style (see Reporting Obsidian Hydration Data and Definition of Cohesive Temporal Components, page 6-6, and Refining the Accuracy of Scheme D, page 7-13). The earliest radiocarbon-dated example is 745 cal BP from Burial 239 at ALA-329 (Table 27; Groza et al. 2011; Kennett et al. 2013). A slightly later date of 715 cal BP was obtained from charred wood associated with a partial cremation, Burial 157 at CCO-696 North (Meyer and Rosenthal 1997). Both of these dates suggest that the bow and arrow was introduced by at least the end of the Middle/Late Transition Period (930-685 cal BP) in the East Bay/South Delta. Additional dated burial contexts from ALA-329, ALA-555, and CCO-235 in the East Bay and YOL-187 in the North Delta, confirm continued use of the Stockton serrated arrow point through the Late 1 and 2 Periods, with dates ranging between 675 and 370 cal BP. This limited information confirms Bennyhoff's initial conclusion that the bow and arrow was introduced by Late 1 Period, although he placed that introduction several hundred years earlier than is indicated by the revised Scheme D chronology and the radiocarbon information compiled in Table 27 (cf., Bennyhoff and Hughes 1987: Figure 10; Groza et al. 2011). In the South Delta, however, Bennyhoff identified Stockton Serrated arrow points in the Middle/Late Transition Period at CCO-150 (Veale Facies in Elsasser 1978; see also Groza et al. 2011). Based on this and other information, Groza et al. (2011) suggested that introduction of the bow and arrow in the Bay-Delta Area may have progressed from north to south and east to west. If so, this technology should be later in the South Bay and Southwest Bay regions. To our knowledge, no directly dated arrow points are documented from these areas, although Bennyhoff identifies Stockton Serrated points in the undated Late 1 Period assemblage at SFR-7 on the western side of San Francisco Bay (Bayshore Facies; Bennyhoff in Elsasser 1978: Figure 6).

That arrow points were not widely used in the earlier portion of the Middle/Late Transition Period is indicated at ALA-42 in the Livermore Valley and at SCL-690 in the Santa Clara Valley, where Middle/Late Transition components do not include arrow points. However, radiocarbon information from the southern Sacramento Valley clearly demonstrates that the bow and arrow was first used in that region as much as 200 years earlier than current evidence from the Bay-Delta Area. In the Sacramento Valley, the earliest arrows are small contracting-stem forms, commonly referred to as Gunther-barbed.

Түре	SITE (CA-)	FEATURE	¹⁴ C DATE	CAL BP	MATERIAL DATED
Desert Side-notched	BUT-84	Structure 18	240 ± 150	270	Charcoal
Stockton serrated	CCO-235	Burial 77	280 ± 40	370	Charcoal
Stockton serrated	ALA-555	Burial 25	370 ± 30	436	Charcoal
Stockton serrated	YOL-187	Burial 2	$1160 \pm 30, 1200 \pm 80$	540, 570	Olivella
Stockton serrated	ALA-329	Burial 23	1160 ± 30	540	Olivella
Corner-notched	ALA-329	Burial 127	1380 ± 40	675	Olivella
Stockton serrated	ALA-329	Burial 226	1380 ± 50	675	Olivella
Stockton serrated	CCO-696N	Burial 157	790 ± 40	715	Charcoal
Stockton serrated	ALA-329	Burial 239	1460 ± 40	745	Olivella
Gunther-barbed	BUT-496	Burial 23	1440 ± 40	750	Olivella
Gunther-barbed	BUT-496	Burial 33	1580 ± 50	910	Olivella
Gunther-barbed	BUT-84	Burial 117	1000 ± 150	925	Bone
Gunther-barbed	BUT-496	Burial 5	1620 ± 50	940	Olivella
Gunther-barbed	SAC-21	Burial 18	1050 ± 150	975	Bone

Table 27. Directly Dated Arrow Points from Central California.

Directly associated radiocarbon dates from burials at BUT-84, BUT-496, and SAC-21, indicate that the bow and arrow was in use as early as 975 to 750 cal BP (Table 27), spanning the entire Middle/Late Transition Period. If the bow and arrow was such a superior technology, what accounts for the variable and delayed introduction in the Bay-Delta Area?

Bettinger (2015:98) suggests two possible explanations. The first is organizational incompatibility, with a slower adoption of the bow and arrow due to political and economic systems that valued cooperation, including group hunting requiring shared quarry. Individual hunting efforts may not have been rewarded sufficiently to experiment with new technologies. That group hunting strategies were important economically throughout the Bay-Delta Area by the Middle Period may be reflected by the low number of dart points found in sites dating to the last 2,500 years (another consequence of the dearth in dart points is our inability to develop a meaningful projectile point chronology for this region). Ethnographically, central California groups used a variety of methods to capture deer, pronghorn, and elk. In addition to projectiles, surround hunts and drive fences, fire-drives, pit-traps, snares, nets, dogs, and decoys were all common hunting techniques. Most of these are group hunting strategies, and animals were often clubbed or speared at close range, resulting in few expended projectiles. Many or all of these techniques could have developed by the Middle Period, minimizing the need for the bow and arrow as a hunting weapon. Another explanation might be environmental. Bettinger (2015:98) argues that the dart and atlatl may have been a better hunting implement for waterfowl common in the marshes and estuary of the Bay-Delta Area. And the type of sinew strung and backed bow used throughout western California late in the pre-contact period does not hold-up well to moisture, particularly in the humid fog-prone Bay-Delta Area and in wetland environments common in this region. This too may have delayed adoption of the bow and arrow.

It is also possible that people living in the Bay-Delta Area may not have been regularly exposed to the new technology, particularly if social relations were hostile. Bennyhoff (1977; Bennyhoff and Fredrickson 1994:66–67) has previously argued that the early Gunther-barbed arrows in the lower Sacramento Valley are associated with the arrival of the Patwin—an ethnic migration that may not have been altogether peaceful. It is relevant, in this respect, that the Stockton serrated point is an entirely unique style that has no regional correlates. Virtually all other arrow point styles in western California can be traced over wide, contiguous, geographic areas that extend beyond political boundaries and likely point to a source of origin. For example, the contacting-stem arrow—Gunther-barbed—can be traced over much of the central and northern Sacramento Valley, southern Cascade-northern Sierra, across

northwestern California, and into Oregon. The corner-notched, Rose Spring-style arrow is found along the length of the central and southern, western Sierra Nevada and throughout the Great Basin. Both of these arrow point styles date earlier in regions to the north and east (e.g., Bettinger 2015; Kennett et al. 2013; Rosenthal 2011b), respectively, and were likely introduced to California from neighboring groups living in these adjacent regions. The Stockton serrated point, however, is an independently developed style that has a very discrete distribution in central California (King 1978), and was initially developed somewhere in the Bay-Delta Area or northern San Joaquin Valley (Rosenthal et al. 2007).

While the bow and arrow almost certainly arrived in central California by diffusion (or ethnic migration), the unique Stockton serrated point suggests that its adoption in the Bay-Delta Area was through a process of *guided variation* which contrasts with the alternate form of cultural transmission of *indirect bias* (e.g., Bettinger and Eerkens 1999; Boyd and Richerson 1985:94–95). In guided variation, new behaviors are acquired by copying others and modifying the actions by trial and error to suit an individual's own needs. Indirect bias, on the other hand, results in complex behaviors acquired in total, without modification of any of the variables. In this case, for example, groups in northern California who used the Gunther-barbed arrow point may have adopted the bow by way of indirect bias. They acquired not only the basic technology, but also the same style of arrow point, and possibly other characteristics (e.g., design elements, hunting rituals) from neighboring groups. The opportunity to acquire the entire complex suggests frequent cooperative interaction. In the Bay-Delta Area, however, the basic components of the technology were likely through significant trial and error (guided variation). This resulted in local changes to key variables of the technology, like the style of arrow point, and probably indicates only infrequent interaction with bow-using groups in the Sacramento Valley.

What this also suggests is that the introduction of the bow and arrow in the Bay-Delta Area was an *in situ* development and does not represent the in-migration of new people. Because of the wide geographic continuity of other arrow point styles in central California, ethnic-migration to account for the arrival of this technology cannot be ruled out. In fact, Bennyhoff (1994c:67) suggests that the simple bow, along with arrows tipped with Gunther-barbed style points, among other novel characteristics (e.g., collard pipes, simple harpoons, grave-pit burning, spindle whorls for net-making), are hallmarks of the so-called "Patwin Intrusion" into the lower Sacramento Valley during the Middle/Late Transition Period (see also Moratto 1984:214). That this new technology was adopted perhaps 200 years later in the Bay-Delta Area, and featured an independently invented point style, suggests cultural/ethnic continuity in this region from the Middle/Late Transition into the Late 1 Period. Once the technology was adopted, it appears to have diffused throughout the Bay-Delta Area by way of indirect bias among resident groups who interacted regularly, many almost certainly linguistically and ethnically related. As there is minimal evidence for an ethnic replacement after the *in situ* adoption of the bow and arrow, it seems most probable that Ohlone, Miwok, and Wappo groups who occupied this region at contact had land tenure extending back to at least the Middle/Late Transition and more likely into the Middle Period, if not earlier.

Recently, Bettinger (2013, 2015:149–152) has argued that adoption of the bow and arrow in California had profound effects on social and economic organization, facilitating increased kin group autonomy, private resource ownership, and a switch from patrilineal to bilateral descent and post-marital residence patterns. Economic and political authority was consolidated to the kin-group, as the need for cooperative hunting and requisite food-sharing was diminished. This resulted in a settlement shift from densely populated marsh-edge locations to less-populated interior woodlands and prairie, where hunting with the bow could be more successful, and abundant plant foods allowed increasingly more intensive collection and processing strategies. Thus, one of the effects of bow technology was the fissioning of social groups into smaller land-holding polities and a demographic shift, distributing people more evenly across the landscape. This is consistent with diminished occupation of the large shell mound sites during

the Late Period around San Francisco Bay (Lightfoot and Luby 2002:276–277), and smaller and more closely spaced settlements on the interior (e.g., Meyer and Rosenthal 1997). Increasing subsistence autonomy and smaller land-holdings also incentivized production (Bettinger 2015:184), which almost certainly included the development of surpluses and a monetized system of exchange. This, in turn, facilitated resource transfer between independent groups, and allowed food purchase as a way to overcome periodic short-falls in local productivity (Bettinger 2015:184; Chagnon 1970), and to benefit from comparative advantages in production and availability (Rosenthal 2011a).

Data Requirements

The timing of adoption is a fundamental issue for understanding the context and consequences of bow technology in different subregions of the Bay-Delta Area. This requires well-dated chronostratigraphic site components from the Middle/Late Transition and Late Periods which also contain projectile points. In the absence of entire site components, individual residential features or graves containing either dart or arrow points should be directly dated to better establish the timing of initial introduction. If the delayed adoption of the bow and arrow in the Bay-Delta Area is a consequence of preexisting political and economic organization, including post-marital residence patterns, isotope evidence related to individual life-histories may provide insight into these changes (e.g., Harold et al. 2016). Genetic, isotopic and stylistic information, as well as evidence for residential continuity from sites preand post-dating the bow, may also speak to whether adoption of this technology was associated with an ethnic migration or represents a local transformation in technology among resident groups. One of Bettinger's main predictions is that group size decreased, and previously under-used localities on the interior became the focus of residential activities during the Late Period, in part a consequence of the new technology. This could be evaluated with reference to site size and location and perhaps the size and familial composition of cemeteries dating before and after the Late Period adoption of the bow.

11. HUMAN DEMOGRAPHY AND POPULATION MOVEMENT

This research domain is comprised of three research topics: (1) reconstructing population movements at the regional and local scale; (2) pre-contact demographic transitions in the Bay-Delta Area; and (3) pre-contact violence and related activities.

RECONSTRUCTING POPULATION MOVEMENTS AT THE REGIONAL AND LOCAL SCALE

The movements of pre-contact Native American populations have long interested anthropologists working in California (e.g., Dixon and Kroeber 1919; Golla 2007; Kroeber 1925; Moratto 1984:529–574), primarily because Native California at European contact was a complex mosaic of more than 60 languages from a variety of language stocks and families (Shipley 1978). Not surprisingly, comparative linguistic analysis has led the way in constructing large, regional-scale migration models, tracking population paths, and ordering, as temporal milestones, the timing of specific expansions. The recent application of mDNA analysis of ancient human remains is providing a new and powerful line of inquiry to explore genetic relationships between groups in the past, and better understand population movement and mixing (Eshleman and Smith 2007; Johnson et al. 2012).

Despite the tremendous linguistic diversity and considerable time depth of its origins, it has been very difficult to assign a specific set of archaeological traits to a particular ethno-linguistic group and track its movement/migration across archaeological space and time (Hughes 1992). The use of mDNA from archaeological context has considerable potential to aid this pursuit; indeed, it is already forcing California prehistorians to reconsider the Penutian migration models constructed using primarily linguistic data (DeLancey and Golla 1997; Eshleman and Smith 2007). Overall, however, the reconstructions highlighted below have largely been hypotheses that need to be tested with archaeological data.

A recent study by Codding and Jones (2013) used ideal free distribution modeling to understand the processes that created the linguistic mosaic of Native California, and why linguistic diversity was so great (second only to western New Guinea). Their reconstruction notes that initial settlement was situated in the most productive areas, and subsequent occupation (including migrations) filled in less productive areas (cf., Baumhoff 1963; Gmoser 1988; Hale 2010). Ensuing migrations most likely displaced groups living in the less productive areas since their population densities were low; productive areas were assumed to have higher population densities and thus these groups were more difficult to replace except by new groups with stronger territoriality and a sedentary settlement strategy. In sum, they stress that high ecological diversity is a necessary condition for linguistic diversity to emerge, and areas with low ecological diversity should witness full population replacements. They do not, however, delve into the actual historical factors that led to the particulars of the linguistic diversity. For example, why was one of the two areas of very high productivity and high population density—the Santa Barbara area occupied by a single linguistic group (the Chumash) for a very long time, while the other-the San Francisco Bay/Sacramento Delta-occupied by a variety of linguistic groups that entered the area over the course of thousands of year. Understanding such questions will undoubtedly require more detailed consideration of a complex set of social factors as well.

The Bay-Delta Area has been of particular interest for reconstructions of regional population movements, inter-regional interaction, and the potential for conflict, since at Spanish contact it was occupied by varied speakers, including Coast Miwok, Wappo, Patwin, Bay Miwok, and Ohlone (Golla 2007; Milliken et al. 2007:100). The challenge for archaeologists is to muster data to test suggested reconstructions for the sequence of pre-contact events that ultimately resulted in this spatial configuration of different languages.

Three population migrations are typically hypothesized to explain the history of language groups in the Bay-Delta Area (Golla 2007; Milliken et al. 2007:112–114,118; Moratto 1984). The first consisted of either proto-Penutians—those populations that were ultimately speakers of Patwin, Miwok and Coastanoan (Breschini 1983; Gerow 1968)—or proto-Utians/Yok-Utians—those populations that were ultimately the speakers of Miwok and Coastanoan but not Patwin (Golla 2007:76–77). Moratto (1984:276, 281–283) suggested that this migration occurred around 4,500 years ago, and may have been associated with the appearance of the archaeological Windmiller pattern, considered intrusive to the Bay-Delta Area (see also Golla 2007). These populations would have displaced existing Bay-Delta Area inhabitants, presumed to be Hokan language speakers.

Subsequently, a population movement, generally referred to as the Meganos Intrusion, is particularly relevant to the south and east Bay-Delta Areas, but should also be considered elsewhere. With a possible origin area along the Delta near Stockton, the Meganos Aspect (Bennyhoff 1994a, 1994b; again mainly defined by mortuary patterns) is first seen in the East Bay around the end of the early Middle Period, and the eastern side of the South Bay during the Middle 2 Period (Hylkema 2002; Milliken et al. 2007). It is unclear, however, what language these people may have spoken. Increased violence and dismemberment/cultural modification of human bone, however, have been suggested as a byproduct of this intrusion, as represented in burial populations from this time.

Finally, the timing of the last migration—the Patwin's entry into the northeast edge of the Bay-Delta Area—is uncertain, although Bennyhoff (1994:66–67) has suggested it occurred in the Middle/Late Transition Period and was correlated with the Augustine Pattern. The latter point, however, is rejected by Milliken et al. (2007:118) since archaeological traits of the Augustine Pattern were shared by all other language groups in the Bay-Delta Area as well.

The precise timing and the mechanisms by which these population movements occurred remain uncertain and open to alternative interpretations. When precisely did these movements take place? What was the actual direction of these movements, and were they fast or slow? Did territorial expansions occur in a peaceful manner or not? It is also important to recognize that languages can spread without population movements. What are the archaeological signatures of these hypothesized population movements?

Recently, archaeologists have also begun to explore the movements of individuals during their lives, using their actual remains to reconstruct their life history, including where they were born, whether they relocated during their lifetime, and whether they were residents of the locality where they were buried (Brink et al. 2015; Eerkens et al. 2014a, 2014b, 2015; Greenwald and Burns 2016; Jorgenson et al. 2009; Martisius 2011; Monroe et al. 2013). Such studies, still in their early stages, reveal the power of combining a variety of lines of empirical data—stable strontium and sulfur isotopes to gain insight in the general geological setting where they were living; stable oxygen and nitrogen isotopes to ascertain what their diet consisted of (namely the degree of marine, brackish, freshwater, and terrestrial resources); and mDNA to ascertain who they were related to. Recent studies have even begun to follow life histories and inter-relatedness using dental calculus found on teeth. A particularly powerful aspect of this analysis is the ability to sample teeth and bone material, which form at different points in time during an individual's life.

Several initial studies have revealed the potential analytical power of this approach by concentrating on unique "mass graves," suggestive of violent conflict, to ascertain if these individuals were local or non-local, and explore the factors that led to their deaths (Eerkens and Bartelink 2013; Eerkens et al. 2014a, 2014b, 2015; Monroe et al. 2013). For example, Eerkens et al. (2015), in a study of a "mass grave" of seven males dating to circa 1100 cal BP (Middle 4) at ALA-554 in the Livermore Valley, demonstrated the individuals were non-locals, likely from the same riverine setting in the San Joaquin Valley, and were not closely related matrilineally. They also suggest that this may present a territorial dispute, the roots of which were a "byproduct of a village fissioning event" due to population growth in

the San Joaquin Valley, which in turn led to increased competition over resources (Eerkens et al. 2015:7). Similarly, isotopic analysis of a Late 2 Period "mass burial" of four males from SCL-38, near the south end of the Bay, revealed evidence of residence to the east or south, and a non-marine diet. These individuals also have mDNA, suggesting they were related matrilineally to the local village population (Monroe et al. 2013)—this may imply that despite their violent death, they also were ancestral Ohlone who at Spanish contact occupied an expansive area to the south and east.

Data Requirements

Reconstruction of large-scale population movements are probably best answered by interdisciplinary research that incorporates linguistics and a variety of archaeological evidence including human isotope and DNA analyses. Material cultural differences alone (Morgan and Dexter 2008:143; Pastron and Walsh 1988b:89) are insufficient to assign populations to different linguistic groups. Such investigations could interweave selective analysis of ethnohistoric data on linguistic divergence, rigorous dating of archaeological sites from different locations thought to have been inhabited by different precontact populations, and studies of mDNA. Strontium isotope analysis of human remains, as applied to the Windmiller migration hypothesis by Jorgenson et al. (2009) at CCO-548 (the Marsh Creek site), also has considerable potential to provide strong evidence into migration hypotheses.

For the Meganos problem, for example, it would be ideal to study contemporaneous burial populations thought to represent Meganos and non-Meganos groups. Burial populations could be contrasted with respect to mDNA, as well as cultural traits considered to be characteristic of the Meganos Intrusion (e.g., burial posture and key artifact types; Bennyhoff 1987, 1994), and as evidence for interpersonal violence. Methods of data collection for the latter avenue of research will follow those used by Lambert (1993) along the southern coast, and Nelson (1997) within the Sacramento Valley region. The results should provide insight into whether the Meganos Aspect was an actual population movement or just the dissemination of a shared set of cultural traits from one population area to another.

Similarly, the study of individual life histories, using isotopic analysis (e.g., Greenwald and Burns 2016) and mDNA, has tremendous potential to gain new insight into localized population movements, interaction, and conflict; this in turn allows us to explore issues tied to population growth, pressure, and territoriality. Of course, any such research on human remains requires that: (1) such remains are discovered; and (2) the appointed Native American MLD provides permission for such analyses to be carried out.

PRE-CONTACT DEMOGRAPHIC TRANSITIONS IN THE BAY-DELTA AREA

When Juan Rodriguez Cabrillo first made landfall in 1542, more Native people lived in California, per area of land, than anywhere in North America (Ubelacker 2006). In the San Francisco Bay-Delta area, Native population densities reached between six and 15 people per square mile in parts of Marin, Solano, Contra Costa, and Alameda Counties (Milliken 2006)—nearly as high, or higher, than the most densely populated horticultural and agrarian societies in the eastern United States and Pueblos of the southwest. Yet, California's Native people were foragers, subsisting entirely on wild foods (e.g., Anderson 1997; Lightfoot and Parish 2009; Moratto 1984). Why and how Native California's reached such high population densities is an enduring subject of archaeological and anthropological interest (Jones and Raab 2004).

Initially attributed to California's bountiful natural resources (e.g., Kroeber 1939; Jones and Raab 2004), anthropologists have come to view the unique demographic circumstances of Native California as the product of intensive foraging economies which developed over thousands of years. Quite the opposite of the "bountiful land" hypothesis of Kroeber and his contemporaries, modern researchers characterize Native subsistence economies in California as "encumbered" by high production costs, and argue that substantial declines in foraging efficiency occurred through the Holocene (e.g., Basgall 1987;

Beaton 1991; Bouey 1987; Broughton 1988, 1994a, 1994b, 1997, 1999; Broughton et al. 2015; Wohlgemuth 1994, 2004). At the same time, settlement permanence increased (e.g., Rosenthal et al. 2007); new technologies developed that were more complicated and costly to produce, but more efficient (Bettinger 2013, 2015; Eerkens 2001; Stevens 2012; Stevens and McElreath 2015); and novel political structures emerged to deal with seasonal and spatial resource asymmetry (e.g., Arnold 1991; Bean 1974; Bean and Blackburn 1976; Bettinger 2015; Cohen 1981; Gamble et al. 2001; King 1974; White et al. 2002). Most, or all, of these developments have been linked to changes in the ratio of people to available resources, i.e., population pressure (Baumhoff 1963, 1981; Keeley 1988). In the Bay-Delta Area, Milliken et al. (2007:118) suggest that "population pressure must have been incessant" and that "populations cyclically approached and overran carrying capacity, crashed...and quickly rebounded. Only technological or social innovations allowed the carrying capacity to be raised."

If Milliken et al. (2007) are correct, Native population expansion in the Bay-Delta Area must have progressed in a step-like manner. Each adaptive change would have been followed by a population expansion and plateau as a new techno-environmental carrying capacity was reached (e.g., Baumhoff 1981). Measures of economic efficiency in central California have provided reasonably convincing evidence that population pressure was comparatively high through the entire Late Holocene (e.g., Broughton 1994a, 1994b, 1994c, 1999; Wohlgemuth 1996, 2004). However, population pressure inhibits population growth. Conversely, population growth reflects a relaxation of demographic constraints (Bettinger 1991, 2015:41). Consequently, if population pressure truly inspired socio-economic changes in central California (Bettinger 2015:40), adaptive adjustments should have occurred in times of subsistence stress, not during periods of population expansion. To state it another way, population growth should have occurred during periods of low population pressure, either because natural resource productivity improved (increasing the ratio of food to people) or, as Milliken et al. (2007) suggest, adaptive changes were made to expand economic output from the same available resources. In either case, population growth should follow productive adaptive or environmental changes. The challenge then is to identify periods of population growth, and understand the socio-economic and environmental circumstances which allowed for these expansions.

As discussed in Chapter 5, radiocarbon data from the Bay-Delta Area, as a proxy of population, show continued growth through the Late 1 Period, with a slight decline into the Late 2 Period (Figure 57; note the Middle 2, 3, and 4 Periods are combined to correspond with burial data components). This is expressed in the number of dated site components assigned to each period (one or more dates from a site falling within a particular period was counted as one component; see Exploring Occupation Trends with Radiocarbon Dates, page 7-1). These results suggest that population growth was almost continuous through the late Holocene, although not always in the same pace. For example, the number of site components per year appears to have increased steadily from the pre-Late Holocene through Middle Periods. The highest rate of component increase occurred from the Middle/Late Transition to the Late 1 Period. There is then a slight downturn back to Middle/Late Transition Period levels in the Late 2 Period. This may suggest a decline in population, or could be a sample effect (i.e., fewer radiocarbon dates have been obtained for Late 2 Period sites because they can be dated through other means [e.g., clam shell disk beads]); an artifact of the calibration curve which loses resolution late in time; or a result of population consolidation, giving the appearance of population decline. Of course, these types of frequency-dependent analyses have inherent taphonomic pitfalls, making them potentially unreliable as a measure of population change (e.g., Hull 2012; Rosenthal 2011a; Rosenthal and Meyer 2004; Surovell and Brantingham 2007; Surovell et al. 2009).

Another way to evaluate population growth, and avoid taphonomic biases, is to measure changes in human fertility as reflected in cemetery populations (Bocquet-Appel 2011). Fertility can be evaluated using a simple Juvenility Index—the proportion of immature skeletons (aged 5–19 years) among all individuals \geq 5 years of age (abbreviated 15P5). The 15P5 index has a strong positive correlation with the



Figure 57. Radiocarbon-Dated Site Components by Temporal Division used for Demographic Analysis.

crude birth rate (r²=0.96) and the intrinsic growth rate (r²=0.875) in a sample of preindustrial populations (Bocquet-Appel 2002, 2011; Bocquet-Appel and Naji 2006). From this ratio, the rate of population growth can be inferred from the crude birth rate, assuming stable mortality (i.e., post-contact; Bocquet-Appel 2011; Bocquet-Appel and Naji 2006). In a growing population, the proportion of young people (living and dead) is high, while in a stable or declining population, the proportion is low. This corresponds to a population-age pyramid with either a wide or narrow base and reflects either a high or low birth rate, respectively. The birth rate in turn is a measure of fertility. Recently, Bocquet-Appel and others have used this Juvenility Index to demonstrate a world-wide demographic transition associated with the switch from foraging to farming (i.e., the so-called Neolithic Demographic Transition), recognizable in paleoanthropological records from across Europe, North Africa (Bocquet-Appel 2002, 2011), North America (Bocquet-Appel and Naji 2006; Kohler and Reese 2014; Kohler et al. 2008), and Mesoamerica (Lesure et al. 2014). These studies suggest that, if rapid, pre-contact, population growth occurred in the Bay-Delta Area, it should be detectable in the paleoanthropological record.

As an initial evaluation of population change in the Bay-Delta Area, we assembled demographic information from 52 burial assemblages, representing 62 temporal components and 4,294 individuals. Of these, 84% of the temporal components were within the study area, and the remainder in adjacent nearby settings. A total of 3,670 individuals was aged ≥5 years at death. Only those burial assemblages that fell within a single time period (as defined in Table 28), or could be reliably divided into two or more periods, were used. Time periods are based on Groza et al.'s (2011) Scheme D, although we grouped the Middle 2 through Middle 4 Periods into a single Middle 2–4 Period (1530–930 cal BP), and defined a Middle Holocene Period (7000-4200 cal BP). Where possible, age assignments were based on a combination of radiocarbon dates and corroborating evidence from temporally diagnostic shell beads (Groza et al. 2011). Unfortunately, the great majority of cemeteries evaluated for this study could not be reliably assigned to a single time period or reliably divided into two or more temporal components because contradictory chronological information existed within the burial assemblage, and most individuals were not directly dated. In all but two cases, the age associated with 15P5 values displayed in Figure 58 are based on mean calibrated radiocarbon dates from each site component. However, for the Middle Holocene component at SCL-12/H, the mean radiocarbon age for 12 directly dated N-series grooved rectangle beads from across California was used (Fitzgerald n.d.; Vellanoweth et al. 2014), since the undated burial assemblage included this distinctive Middle Holocene bead type (Arrigoni et al. 2008). Likewise, at the Dudley Ridge site near Dixon (Solano County), the mean age for the early Middle Period (Middle 1 Period) was used (i.e., 1840 cal BP; Groza et al. 2011), since no radiocarbon dates were obtained from the site (Chatten et al. 1997), but the recovered shell beads date locally to this time period (i.e., G Series Saucers and Rings; Rosenthal 1996).

Following Bocquet-Appel (2011; Bocquet-Appel and Naji 2006; see also Kohler and Reese 2014; Kohler et al. 2008) we use a Loess Curve (a weighted, linear, least squares regression, akin to a moving average) to examine the relationship between time and the associated ${}_{15}P_5$ values. The regression curve was calculated using a locally weighted polynomial regression (using the local polynomial regression function in R version 2.15.3). Taking into account the effect of outliers, a smoothing parameter (α) determines how much of the data is used to fit each polynomial, within a permissible range of 0.3–0.6 (Kohler et al. 2008:651). A smoothing function of 0.4 was used for this study. Following Kohler et al. (2008:651) and Lesure et al. (2014), the Loess Curve is weighted by sample size, ruling out the possibility that small samples unduly influence the results.

As can be seen in Figure 58, there is a significant rise in the curve beginning about 2000 cal BP during the Middle 1 Period, peaking in the Middle 2–4 Period about 1400 cal BP. After the peak, the curve declines through the Late 2 Period. These results show that the greatest period of population growth was during the second half of the Middle Period (Middle 2–4 Period). In a manner similar to that documented

	Denne		Age (count)		¹⁴ C MEAN	
SITE	PERIOD	5–19	20+	5+	15P5 INDEX	CAL BP
ALA-307	Early	17	34	51	0.33	3384
ALA-329	Late 2	8	70	78	0.10	378
ALA-329	Late 1	18	99	117	0.15	582
ALA-329	Middle 2	12	33	45	0.27	1157
ALA-342	Late 2	2	14	16	0.13	246
ALA-343	Middle 2	16	52	68	0.24	1242
ALA-413	Middle 2	4	49	53	0.08	1460
ALA-042	Middle/Late Transition	56	252	308	0.18	892
ALA-424	Middle/Late Transition	1	8	9	0.11	979
ALA-479	Middle 2	4	26	41	0.13	1330
ALA-483	Early	4	25	29	0.14	3242
ALA-483	Late 1	3	28	31	0.10	665
ALA-555	Late 2	15	94	109	0.14	406
ALA-555	Middle 1	13	58	71	0.18	1718
CCO-235	Late 1	4	35	39	0.10	544
CCO-030	Late 1	-	8	8	-	508
CCO-308	Middle/Late Transition	1	11	12	0.08	834
CCO-308	Middle 2	1	15	16	0.06	1141
CCO-308	Early	1	17	18	0.06	3809
CCO-309	Early	4	21	25	0.16	3943
CCO-431	Early	1	7	8	0.13	3064
CCO-548	Early	31	410	438	0.07	3615
CCO-600	Middle 2	5	14	19	0.26	1514
CCO-600	Middle 1	1	6	7	0.14	1726
CCO-637	Early/Middle Transition	1	12	13	0.08	2568
CCO-637	(Middle Holocene)	2	8	10	0.20	5083
CCO-696	Middle 2	1	11	12	0.08	1347
CCO-696	Middle 1	28	99	127	0.22	1744
CCO-696	Early/Middle Transition	2	20	22	0.09	2575
Dudley Ridge	Middle 1	3	22	25	0.12	1840
NAP-399	Early/Middle Transition	14	126	140	0.10	2320
SCL-006	Middle/Late Transition	21	112	133	0.16	680
SCL-038	Late 1	23	208	231	0.10	578
SCL-012	Early/Middle Transition	2	28	30	0.07	2593
SCL-012	(Middle Holocene)	1	6	7	0.14	4902
SCL-194	Early/Middle Transition	23	3	26	0.12	2228
SCL-287	Middle 1	3	20	23	0.13	1979
SCL-478	Early/Middle Transition	11	75	86	0.13	2285
SCL-689	Middle/Late Transition	7	70	77	0.09	806
SCL-689	Middle 1	4	43	47	0.09	1739
SCL-690	Middle/Late Transition	11	117	128	0.09	704
SCL-732	Middle 1	18	77	95	0.19	1956
SCL-755	Middle 2	9	7	16	0.56	1397
SCL-846	Late 1	5	52	65	0.09	556

Table 28. Burial Assemblages in or adjacent to the Study Area used in the Demographic Analysis.

6	Desse	А	.GE (COUNT)		D 1	¹⁴ C MEAN
SITE	PERIOD	5–19	20+	5+	₁₅ P ₅ INDEX	CAL BP
SCL-869	Middle 1	1	6	7	0.14	1627
SCL-919	Late 2	4	10	14	0.29	446
SFR-114	Middle 2	3	7	10	0.30	1393
SFR-004	Middle 2	3	10	13	0.23	1377
SFR-004	Early	4	10	14	0.29	3815
SFR-007	Late 1	1	19	20	0.05	562
SMA-125	Middle/Late Transition	3	15	18	0.17	798
SMA-160	Middle/Late Transition	2	32	34	0.06	720
SMA-077	Early	6	36	42	0.14	3047
SOL-315	Early	10	68	78	0.13	3819
SOL-355	Middle 2	4	26	30	0.13	1308
SOL-355	Early	2	23	25	0.08	3340
SOL-363	Middle 2	11	24	35	0.31	1371
SOL-364	Middle 2	10	14	24	0.42	1389
SOL-364	Middle 1	34	217	251	0.14	1946
SOL-425	Middle 1	7	10	17	0.41	1847
SOL-451	Middle 1	6	24	30	0.20	2170
YOL-069	Late 2	5	74	79	0.06	267
Total		527	3,127	3,670	-	-

Table 28. Burial Assemblages in or adjacent to the Study AreaUsed in the Demographic Analysis continued.

worldwide for the transition from foraging to farming, the initial rise in fertility and population growth was shortly followed by increasing mortality and an overall decline in the rate of population growth. This is consistent with the incremental demographic change proposed by Milliken et al. (2007:118), but is muted in the radiocarbon-based population estimates of Figure 57. If these latter estimates are correct, population growth during the Middle Period is likely responsible for the much higher population during the Late 1 Period, as suggested by Figure 57. That said, the rate of growth appears to have declined substantially in the latter portion of the Middle Period (Figure 58), reflecting greater population pressure. Declining fertility but higher population densities from the Middle/Late Transition Period through the Late 2 Period might also result from wholesale population movement, which could have increased population density and population pressure, at the same time reducing fertility.

What caused population pressure to be relaxed during the Middle Period, allowing populations to grow? If the relationship between demographic expansion and reduced population pressure is correct, either the local environment improved substantially over this time span (2150–930 cal BP), or a major adaptive shift took place shortly before the demographic change.

The paleoclimate record does not, at this point, suggest that some kind of substantial improvement occurred during the Middle Period. Based on a recent synthesis by Malamud-Roam et al. (2006), there was no appreciable increase in precipitation during the Middle Period which might have improved environmental productivity. In fact, eastern-most California tree ring evidence from the White Mountains and submerged shorelines at Mono Lake suggest reduced precipitation between about 1700 and 1325 cal BP in the west (Malamud-Roam et al. 2006; see also Broughton 1999). However, over this same span, sea level rise caused a continued expansion of the mud flats and salt marsh habitat along San Francisco Bay, and freshwater marsh habitat in the delta region (Figure 59). This habitat expansion could



Figure 58. Temporal Trends in Human Fertility using the Juvenility Index (15P5).



Figure 59. Projected San Francisco Bay Salt Marsh Size during the Holocene Based on Modern Bathymetry and Sea Level Curve of Meyer (2015).
bird, and mollusk populations. Of course, such a change in productivity may have had a limited geographic scope, affecting only those populations with direct access to estuary resources. Yet, if expanding marsh habitat had a positive effect on the size of local populations, one solution to renewed population pressure may have been to colonize new localities or redistribute population away from these centers (see *San Francisco Estuary Adaptations – A Test of Ideal Free Distribution*, page 8-1) This might be detectable in interior habitats, such as the smaller valleys of the east bay, by comparing the Juvenility Index from these sites to those from the bay shore and delta. The timing of initial colonization in outlying areas may also give support to this idea. If population pressure was perennially high in the core areas of the bay and delta, the most pronounced signature of demographic growth may be registered in outlying areas (e.g., Kohler and Reese 2014).

It is notable that the fertility rate declines sharply in the Middle/Late Transition Period (see Figure 58), during the well-documented regional drought associated with the Medieval Climatic Anomaly (e.g., Stine 1994). Of course, the Medieval Climatic Anomaly began prior to the Middle/Late Transition Period. In concert with growing populations, environmental degradation may have played a role in slowing the growth rate by increasing population pressure. However, in every study of the Neolithic demographic transition, an increase in fertility is always followed by a decline, as mortality increases due to parasites and other afflictions associated with dense, sedentary living situations (Bocquet-Appel 2011). In this respect, the role of the Medieval Climatic Anomaly in population change remains unknown, although the radiocarbon curves in Figure 57, suggest the drought had little effect.

In contrast to the environmental change hypothesis, adaptive evolution—expressed as the development of new technologies and processing procedures, or new forms of socio-political organization—may also be responsible for the decline in population pressure during the Middle Period. Based on the proportion of mortars and pestles in Middle Period sites, Basgall (1987) made the argument that intensive acorn use (balanophagy) began perhaps 4,000 years ago around the bay and 2,800 years ago in the Central Valley. Since that time, however, acorn nutshell has been found at several Early and Middle Holocene sites in central California (e.g., Meyer and Rosenthal 1997; Rosenthal and McGuire 2004; White et al. 2002; Wohlgemuth 2004). Likewise, there is now compelling stratigraphic evidence that the mortar and pestle was in use in parts of the East Bay as early as 6000 cal BP (Fredrickson 1966; Meyer and Rosenthal 1997; Milliken et al. 2007; Rosenthal and McGuire 2004). These more recent findings push evidence for acorn use much earlier than initially conceived (see *Milling Tools, Plant Foods, and Adaptive Strategies*, page 10-1), certainly much earlier than the demographic signature registered in the Juvenility Index.

Bocquet-Appel (2011; Bocquet-Appel and Naji 2006) argues that it is sedentism (not agriculture per se) that spurs the increase in fertility associated with the Neolithic Demographic Transition. A hastened end to lactational amenorrhea allowed women in sedentary communities to have more children (Bocquet-Appel 2011). The primary mechanism is the earlier return of the postpartum energy balance in mothers due to the energy gain provided by high calorie domestic plants and reduced energy expenditure from carrying infants, common among mobile foragers (Bocquet-Appel 2011; Valeggia and Ellison 2003). But, like the mortar and pestle, evidence for increased settlement permanence in the San Francisco Bay-Delta Area and elsewhere in central California first emerges in Early Period sites (ca. 4000 cal BP or earlier). This is also when the earliest known shell mounds begin to develop around the Bay, and large burial assemblages are first documented. Oxygen isotope information from East Bay shore skeletal samples indicates that early populations relied heavily on marine resources, with only a minor contribution of terrestrial plants and animals (Bartelink 2006:299–300). This suggests that these early groups did not switch habitats seasonally, but were residentially stable. Again, the decline in residential mobility may be too early in the occupation sequence to account for the increase in fertility noted during the late Middle Period.

Despite evidence for comparatively early acorn use in central California, the amount of acorn residue in archaeobotanical samples increases substantially in the Middle Period (Wohlgemuth 1996,

2004), suggesting that acorns could have played some role in the Middle Period demographic change. This may also be indicated by oxygen isotope information from bay shore sites which reflect increasing use of terrestrial foods from the Middle Period onward (Bartelink 2006:300–301; Beasley 2008:101). If this is true, why did it take so long for acorns to become important? One explanation may be the introduction of efficient leaching technology in the Middle Period (White 2003). Although, there are no archaeological traces of the type of sand-basin leaching employed ethnographically in central California, there is evidence for passive leaching in water-filled pits (Milliken et al. 2007; Wohlgemuth n.d.) and clay leaching (White 2003), dating to the Early Period and Early/Middle Transition. If active water-leaching replaced passive forms of processing, the time it took to process the tannic acid likely declined exponentially. Leaching could have been accomplished in a few hours, rather than days or weeks, using passive methods. Active leaching may have allowed the use of acorns to expand and become the staple crop recognized ethnographically. Unfortunately, it may be difficult to identify leaching features archaeologically.

Data Requirements

Since demographic change is an important avenue of future research in the San Francisco Bay-Delta Area, continued attention to the associated evidence will be required. In addition to the Juvenility Index, other studies which can directly address changes in fertility include oxygen isotope analysis focused on the age of weening (e.g., Eerkens et al. 2011), and dietary (trophic-level) differences through time. Evaluation of metabolic stress and other evidence for change in health status can also address the underlying causes of demographic change and variable population pressure over time. All of these studies, however, will require well-dated burial assemblage populations. In addition, more refined studies addressing changes in site size, number of sites/occupation components per unit of time, the size of burial assemblage populations, and continued collection of subsistence information, will also assist in evaluating causes and effects of pre-contact demographic change in the Bay-Delta Area.

Specific site assemblages will unlikely be able to be used to directly address this research topic, but aggregated information on site size, subsistence remains, and burial data will be important. Individual site eligibility under this topic may depend on the presence of human remains, particularly teeth (which can be studied to examine weaning patterns through nitrogen isotope analysis) and permission to analyze the remains. Information on the estimated age/sex of individuals will also comprise an important data point that, when aggregated, can help address issues of regional demographic change.

VIOLENCE-RELATED ACTIVITIES

Trends in violence and conflict have been explored in a variety of North American contexts, with cranial vault fractures, projectile injuries, and forearm parry fractures the main lines of evidence (Lambert 2002; Nelson 1997). Typically, the majority of pre-contact osteological data are from young males, and therefore it is generally inferred that these traumatic injuries were due to intergroup warfare rather than intra-community conflict. Dismemberment and the removal of skeletal elements, which occur in almost all societies worldwide, are also associated with conflict, possibly to avenge prior deaths, provide proof of successful conflict, or serve as symbols of supernatural protection and spiritual power (Chacon and Dye 2007a, 2007b; Lambert 2007; Walker 2000). There is also a considerable body of literature that aims to place cultural modification of human bone in a broader social-ideological context in indigenous North America and elsewhere (e.g., Hargrave et al. 2015; Johnston 2002). For example, Schermer et al. (2015:1–2) note that culturally modified bone are "laden with meaning" and their manufacture and use "is a complex process; modified bone objects can have more than one meaning, and those meanings can change during an object's use-life."

As most osteological evidence of violence has come from the Santa Barbara/Channel Islands and central California, especially the Bay-Delta Area, we briefly touch on perspectives from both areas. Walker (1989) and Lambert (1994, 1997) argue that ritualized, non-lethal inter-village violence (evidenced by healed, cranial vault fractures from club fights) predominated in the Chumash Santa Barbara/Channel Islands area during the Late Holocene. These activities served as effective social mechanisms to resolve and defuse inter-group conflict and tension (see also Lambert and Walker 1991). In contrast, lethal violence, primarily from projectile injuries, increased significantly between 1450 and 570 cal BP (after the introduction of the bow and arrow), subsequently decreasing. They assert that this reflects inter-village conflict within the core area of the Chumash, rather than between the Chumash and neighboring groups. The rise of lethal violence is considered to be tied to population stress, increased territoriality, and changes in political territory. Kennett (1998; Kennett and Kennett 2000) also note defensive positioning of settlements on the northern Channel Islands. The subsequent decline in violence is correlated with improved climatic conditions, increased trade, and greater social complexity, as larger scale polities—often termed chiefdoms—provided mechanisms to reduced violent dispute resolution.

In central California, a series of detailed, typically site-specific osteological and isotopic studies has explored violence in the Bay-Delta Area and Sacramento Valley (e.g., Andrushko et al. 2005; Eerkens et al. 2014a, 2014b; Hildebrandt and Darcangelo 2008; Jurmain 2001; Jurmain and Bellifemine 1997; Nelson 1997; Wiberg 2002). There has also been several recent overviews of violence, employing either the outdated Scheme B chronology (Bartelink et al. 2013), a combination of Schemes B and D (Andrushko et al. 2010:88); or an idiosyncratic chronology of uncertain origin (Schwitalla et al. 2014). Unfortunately, these results cannot be temporally correlated with other Bay-Delta Area archaeological data (structured using Scheme D) or paleoenvironmental data (since the Scheme B chronology is outdated) to accurately assess linkage and unravel causal factors, particularly during the last 1,200 years where the two chronologies greatly deviate. Nor can the data be reassembled and the temporal classification of sites and burials into time periods be assessed, since neither raw nor summary temporal data by site are presented in these overviews (see *Objective, Methods, and Outdated Approaches*, page 6-2). Therefore, only general temporal trends identified in these overview are useful.

Bartelink et al. (2013:300) summarize trends in violence and warfare at 30 sites in the Bay-Delta Area, and found that levels of violence were much lower than those documented in the Santa Barbara area (this holds true for all lines of evidence except dismemberment and cultural modification of human bone, which is very rare in the south). Their results also revealed temporal patterns, most notably an uptick in cranial vault trauma and dismemberment/cultural modification of human bone circa 2550/2450–2150 cal BP, followed by a generally steady decline, interrupted by a slight uptick of most indicators at the latter portion of the sequence, circa 1050/685 to 250/180 cal BP (of which only projectile injuries were higher than circa 2550/2450–2150 cal BP, but not statistically significant). Bartelink et al. (2013), following Andrushko et al. (2010:93), argue that the early upswing (circa 2550/2450–2150 cal BP) was probably tied to increased social stratification, individual-driven status acquisition, and possibly in-migration rather than population pressure. They also note regional trends, of which only more facial traumas in the southeast bay were statistically significant.

Andrushko et al. (2010) presents a synthesis of dismemberment and the cultural modification of human bone in Bay-Delta Area and Sacramento Valley. Although they argue that these data represent evidence of inter-group violence, other interpretations are possible (e.g., Eerkens et al. 2016). Andrushko et al. (2010) present evidence for perimortem (occurring around the time of death) dismemberment and element removal from 76 mostly young males that also often exhibit other evidence of trauma (such as multiple projectile point wounds); generally were buried in haphazard manners; and often were interred in burial pits with other similar individuals (Eerkens et al. 2015). The majority of these events entailed upper limb dismemberment (55%), with scalping and skull removal somewhat less common (30%),

followed by lower limb dismemberment (14%). Most of the sites with this dismemberment evidence are situated near the central or southern bay shore or in the Santa Clara Valley (n=19). The general temporal trend, spiking circa 2550/2450–2150 cal BP and declining thereafter, is consistent with Bartelink et al.'s (2013) results. This upswing is represented mainly by limb removals; scalping, decapitation and skull interments peak later on (circa 1250/930 to 1050/635 cal BP) and decline greatly thereafter.

Most recently, Schwitalla et al. (2014) examined trends in violence and dismemberment throughout central California (including the Bay-Delta Area, Sacramento Valley, and Sierra Nevada), with larger, but overlapping, data sets from the previous two overviews. The previously recognized early increase in dismemberment and element removal is observed (in this study falling within a time span circa 2550/2450 to 1530 cal BP) and the associated explanation is largely embraced. However, the concurrent uptick in cranial vault injuries noted by Bartelink et al. (2013) is not observed. In addition, the other notable trend is an increase in sharp force/projectile trauma and blunt force trauma at the very end of the sequence, between 230 and 51 cal BP:

Almost certainly this late surge in violence can be attributed to the presence of Europeans who had established themselves in Mexico and the American Southwest 200–300 years earlier. Problems experienced by people who were in direct conflict with Europeans probably had a rippling effect throughout indigenous western North America as people tried to migrate away from the zones of direct contact and conflict [Schwitalla et al. 2014:80].

They also suggest that the origins of this trend occurred much earlier, correlated either with the introduction of the bow and arrow some 950–750 years ago or Medieval Climatic Anomaly related droughts (see also Kennett et al. 2013 regarding the bow and arrow introduction).

These overviews have highlighted the need to carefully track Late Holocene trends in violence and dismemberment and skeletal element removal to gain insight into broader trends tied to warfare, territoriality, contested social boundaries, status and social complexity, and population pressure (see Allen 2012 and Allen and Jones 2014 for strident perspectives on the pervasive nature of warfare in California). Such research, however, must be conducted at a finer level of chronological resolution in order to unravel causality. Moreover, the divergent nature of trends in violence and warfare in the Santa Barbara versus the Bay-Delta Area (in terms of the rate of such events, their timing, and the main types of violence documented) highlight the likelihood that localized explanation are needed to unravel the social context of violence in the Bay-Delta Area.

Data Requirements

Reconstruction of geospatial and temporal trends in violence-related events requires detailed analysis of human remains from archaeological contexts by a bioarchaeologist with the requisite training and experience to discern and document perimortem injuries. Equally important is the necessity to accurately date the remains, ideally via direct dating or else by dating of material well-associated with the remains themselves (such as mortuary offerings). Finally, this evidence must be placed in a broader context and this requires comparing it to well-dated sites with radiocarbon or other data to place the site within Scheme D. Of course, any such research on human remains requires that: (1) such remains are discovered; and (2) the appointed Native American MLD provides permission for such analyses.

Sites eligible under this topic will certainly have large and well-dated mortuary assemblages that can be examined for evidence of violence. A lack of such evidence is, however, equally revealing.

12. TRACKING TRENDS IN PRE-CONTACT SOCIAL INTERACTION

This research domain covers societal structure and how groups interact. The four major topics are socio-political complexity, gender roles, animal interment and ceremonial activities, and social patterning and community organization.

ASSESSING ASSERTIONS OF SOCIO-POLITICAL COMPLEXITY

There is long-standing and widespread consensus that the Bay-Delta Area was occupied by complex hunter-gatherers during the Late Holocene, and many scholars have asserted that social organization entailed ascribed status and hierarchical inequality (Chartkoff and Chartkoff 1984; Milliken et al. 2007; Moratto 1984;). For example, Gamble (2012), in discussing the Patwin at Spanish contact, highlights the prevalence of social inequality and dominance of elites. In doing so, she stresses the importance of economic power, access to resources and goods, and how ideology was used to maintain social control.

The onset of status inequality has been variously estimated as starting in the Early/Middle Transition Period (Luby 2004:18), Middle 1 Period (King 1974:38), Middle/Late Transition Period (Fredrickson 1973), or Late 1 Period (Fredrickson 1974b; Hylkema 2002:258–261; Milliken et al. 2007). Taking a diachronic perspective, Milliken and Bennyhoff (1993) asserted that wealth and wealth differentiation increased from the Early Period to the Middle Period, increased markedly during the Middle/Late Transition Period, and steadily declined in the Late Period (see also Rosenthal 2011a). For the South Bay, Hylkema (2002:258–261) has argued that wealth disparity and evidence of conflict increased over time. The Early Period and the early half of the Middle Period had a fairly egalitarian social structure. The frequency of burials with increased quantities of items occurred in the latter half of the Middle Period and Middle/Late Transition Period, but Hylkema (2002) suggests that this is still reflective of an egalitarian society. Finally, the Late Period was characterized by greater wealth in fewer burials (both male and female), reflecting increased social complexity and ascribed status—consistent with historical accounts that suggest leaders held sway over multiple villages, and that some leaders were females (Hylkema 2002:258).

These reconstructions of pre-contact socio-political organization have been based largely on the analysis of cemetery populations. Studies have variously emphasized straight-forward temporal changes in the quantity of offerings interred in graves (Beardsley 1948; Milliken and Bennyhoff 1993); how the value of grave offerings—based on an estimate of their manufacturing cost—changed over time (Cartier et al. 1993); or statistical patterns in variance (both spatial and numerical) in the distribution of grave items in cemeteries (e.g., Atchley 1994; Bellifemine 1997; King 1970, 1974; Luby 2004).

Overall, these approaches to the modeling of social organization, using mortuary remains (such as those found in considerable numbers at various residential sites and cemeteries) to examine political complexity, have been structured to identify chiefs, elites, and the origins of ranked and stratified societies (e.g., Gardner 2013:404; King 1970, 1974). Based on the assumption that the treatment of an individual at death reflects his or her status and role in life, this logic is then expanded to an entire burial sample to infer the structure of the society as a whole (particularly focusing on whether status is achieved or ascribed). Notably, a child buried with numerous grave goods is considered strong evidence for ascribed status and hereditary elites, since it is assumed that a young person could not have accumulated such wealth on his or her own.

Expressing and Crafting Social Identity

Political complexity, however, is often imprecisely expressed in burial practices; political ranking may be exaggerated, disguised, or denied in death rituals. This is because mortuary practices, including

interment of the dead and other ceremonies, are public occasions during which shared social meaning and memory are constructed (Reddy 2015). These were opportunities to reinforce social order, promote group cohesion, and craft community-wide identities that cross-cut kin lines. As such, mortuary events were contexts in which ritual practices celebrated the dead, but they also facilitated an array of social objectives that only occasionally included denoting enduring political inequality through grave wealth. Such processes highlight the need to place more archaeological research attention on aspects of social identity and discerning changes in social interaction as defined by attributes such as age, sex, and group membership (see also Luby 2004). It is also worthwhile to consider how indigenous mortuary practices changed with Spanish colonization at post-contact village settings and within colonial settings (e.g., Panich 2015; Reddy 2015).

Recently, Byrd and Rosenthal (2016) applied this theoretical perspective to pre-contact Native American occupation of the Livermore Valley in the southeastern Bay-Delta Area where, based on other lines of evidence and general expectations (related to increased population density and population pressure, subsistence intensification, larger settlements, and heightened regional trade and interaction), political complexity increased over time and yet mortuary data suggest the opposite. For the Livermore Valley, few burials in the Early Period had grave goods, and when present, these items occurred in small quantities. Both the frequency and quantity of grave items increased in the Middle Period, and some exceedingly rich burials occurred. In the Middle/Late Transition Period, mortuary practices changed dramatically as many more people were buried with grave goods, concentrated among children and teenagers at the expense of older adults. Items of personal adornment dominated. Finally, in the Late Period, this practice declined and fewer individuals had grave goods; the average number of grave items also decreased.

Byrd and Rosenthal (2016) argue that Middle/Late Transition Period mortuary practices functioned primarily to mark social roles and memberships tied to age-grade patterns that cross-cut kin lines. These practices were not reflective of ascribed or achieved status, since only certain age grades had considerable quantities of grave goods—typically adolescents and young adults—while older adults rarely had any grave goods. These age-grade-related mortuary practices are considered tangible evidence of new social strategies that functioned as a stabilizing force to bind communities together within a set of increasingly multi-faceted social obligations. The new subsistence strategies, that entailed greater effort in procurement, processing, and preparation, were a major impetus for these developments. This study suggests that mortuary practices among trans-egalitarian groups can vary independently of political complexity, and can be powerful stabilizing forces that promote society-wide integration. Mortuary practices can also change dramatically over relatively short periods of time, and the search for broader regional trends in the archaeological record requires diachronic investigation.

Data Requirements

A profitable approach to the study of mortuary practices is to step away from an emphasis on political complexity—with its narrow focus on leaders and elites—and instead broaden the scope to examine social complexity by exploring mortuary activities and symbolism in relationship to a wider range of social categories defined by attributes such as age, sex, and group membership. Three patterns in grave good distribution can be highlighted to explore differences in status and social inequality by age and sex: (1) grave offerings by age class; (2) grave offering quantity by individual; and (3) selected grave offering categories by sex. As pointed out by Buonasera (2013), discerning the function and social role of individual grave-associated artifacts, particularly everyday items versus ritually charged objects, requires detailed study of how they were manufactured (including production costs), use-wear, and surface elaboration (e.g., whether or not applique, such as painting, was applied). As extensive burial complexes have been previously documented at a large number of sites in the Bay-Delta Area, application of this research approach to new data sets may provide fresh insights into the nature of local late-Holocene social organization, and into spatial variation between contemporaneous regional sites.

Eligible sites under this topic will have well-dated mortuary assemblages that contain grave goods and sufficient preservation to allow for age/sex of individuals to be determined.

UNRAVELING THE ROLE OF GENDER IN SOCIAL INTERACTION

Understanding the implications of social complexity, including whether status is ascribed or achieved, requires unraveling the nature of a community's social roles. This necessarily entails ascertaining what roles can discerned for individuals based on mortuary offerings, and whether such roles can be associated with subsistence practices, craft and manufacturing expertise, political leadership, or other socio-ideological tasks.

In delving into such issues, it is important to keep in mind that one of the general expectations of ascribed status is that if it was reflected in mortuary offerings, then it would be evident regardless of sex or age. Yet mortuary practices, as they pertain to males and females, are aspects of social interaction that can vary independently of political complexity. For example, the interment of objects that have a utilitarian function—as opposed to items of personal embellishment or symbols of affiliation—may provide insight into the division of labor within a society. Normative arguments of California huntergatherers, drawing on ethnographic discussions, depict strong gender roles—women gathered, prepared plant food for consumption, and wove; men hunted (e.g., Jackson 1991; Jones 1996:245; Wallace 1978; Willoughby 1963). If the presence of functional items in burials accurately reflects this pattern, then only men should be buried with items such as projectile points and bifaces, while women should have all the grinding and weaving equipment. It is also important to recognize that a complicating factor is that sex (based on biological markers) and gender (culturally constructed roles) are not always synonymous (Hollimon 2009; Hollimon and Murley 2012).

Several studies of mortuary remains have delved into this topic. For example, Byrd and Rosenthal (2016), in a synthesis of Amador-Livermore Valley trends, note that the presence of some individuals, mostly males, with large quantities of grave goods leaves open the question of hereditary status (Byrd and Rosenthal 2016; Rosenthal and Byrd 2006). Instead, these data may indicate that males were able to achieve higher status than females during the course of their lives. If males were able to rise to higher positions of leadership, or acquire more prestige and status during their lives, then this may indicate that gender roles within the society were relatively rigid. This would have limited the opportunities for women to rise to positions of power or authority.

Rosenthal and Byrd's (2006:41-43) study of such trends in the mortuary data from Amador-Livermore Valley reveals some interesting patterns when the entire assemblage is examined. Overall, the distribution of four functional artifact categories (points, awls, pestles, mortars) were examined, by sex, for all time periods. First, these categories are not binary between sexes – instead some males and females have each of these items. If mortuary behavior was accurately reflecting gender-based labor roles, then these patterns suggest that divisions of labor by sex were not strongly developed. Males and females were equally interred with mortars and bone awls. In contrast, females represent 62% of the burials with pestles, while males comprise 76% of individuals with projectile points. The high frequency of males with mortars (47%) is particularly striking, and suggests that perhaps men and women both played important roles in plant processing. One possible interpretation is that males had a greater role in the control of production (as witnessed by their interment with mortars), while women had a greater role in the actual plant processing (as signaled by their interment with pestles). Overall, these burial patterns do not readily support the proposition that a strong division of labor by sex was present, or that women's work roles limited their opportunities to garner high status and prestige. Instead they appear to be more similar to trends noted elsewhere by McGuire and Hildebrandt (1994) for the Middle Holocene where gender-based work roles were not well-established.

In an important recent study, Buonasera (2013) examines social roles and status differences by gender through an analysis of ground stone from burial contexts at four sites in the South Bay. Exploring trends in the manufacture, function, and social role of ground stone, she argues that very large elaborate mortars (termed flower-pot mortars) and pestles—which flourished late in the sequence—were used primarily during ceremonial feasting events. Patterns in the distribution of these tools in burials revealed that females were typically associated with pestles, while both males and females had flower-pot mortars, often adorned with painted applique or shell inlay, while bowls mortars, primarily recovered from the earliest site contexts, were associated with males. These trends largely mirrored those noted by Rosenthal and Byrd (2006) for the Livermore Valley. Buonasera (2013) also notes a strong association with these elaborate ground stone tools and higher frequencies of grave goods (such as shell beads); this is interpreted as revealing how women's social roles may have changed over time, as some were able to use ceremonial and feasting events to enhance their status and authority.

Data Requirements

Data requirements are generally the same as the prior research topic discussion. Additionally, it is important to carry out bioarchaeological studies of burials to document work-related skeletal stress (such as osteoarthritis) that can give insight into the types of tasks that were repeatedly carried out (e.g., Meyer et al. 2011; Weiss 2007).

ANIMAL INTERMENTS - A WINDOW INTO CEREMONIAL ACTIVITIES

Animal interment is another line of evidence that has the potential to provide unique insight into pre-contact ceremonial events and ritual activities (such as bear shamanism and the Kuksu and Pota ceremonies), and in turn gain greater insight into socio-political complexity (e.g., Gifford 1926; Holliman 2004; Kroeber 1932; Loeb 1932, 1933). Throughout western North America, animal interments are rare prior to the Late Holocene, and most frequent during the last 1,000 years (see overview in Byrd et al. 2013). Most are canids (typically inferred to be dogs), although other animals are interred, including birds (raptors, macaws/parrots, and turkeys) and occasionally bears in the Southwest (Hill 2000), and foxes and birds in coastal southern California (Hale and Salls 2000; Vellanoweth et al. 2008). In the Bay-Delta region of central California, canids dominate, along with birds (including a condor), bears, badgers, deer/elk, and antelope (Byrd et al. 2013; Cambra et al. 1996; Heizer and Hewes 1940:589-590; Jones 2010; Simons 2004; Simons et al. 2014). The canid interments typically include offerings (such as abalone pendants, clam shell disk beads, stone rods, or spear points, charmstones, or bone awls), and many lack hindquarters. Based on recent aDNA analysis, most of the canid interments are likely to be dogs, rather than coyotes or wolves (Byrd et al. 2013). It also appears likely that most were sacrificed and ceremonially interred, possibly as part of larger ritual activities such as annual mourning ceremonies, rather than representing symbolic totem markings for moieties or lineages or the simple disposal of personal property (Hale and Salls 2000; Heizer and Hewes 1940; Langenwalter 1996, 2005).

In North America, dogs figured prominently in ceremonial and feasting events in a variety of contexts (e.g., Cail 2011; Simoons 1994; Snyder 1991). Interment of dogs in central California may possibly be considered food offerings to the dead during ceremonial events, such as annual mourning rituals, and ritual consumption may have occurred based on the removal of the hind quarters from some interments. This possibility is given anecdotal support by several central California ethnographers who note the role of dogs in varied ceremonies events, including Kuksu initiation and the Pota ceremony (Gayton 1948:154, 290; Gifford 1926:397, 1955:195–196; Kroeber 1932:328).

Data Requirements

A useful perspective used to address this topic in the future is that of Hill (2000:363–364), who distinguishes three categories of animal interments to gain insight into the nature of associated ritual activities in the Southwest. These categories include: (1) animal sacrifice and disposal as "ceremonial trash," typically after portions of the body (such as wing feathers, or hides) were retained for use in ritual activities (see also Walker 1995); (2) dedicatory interment as an offering during a commemorative function (such as the founding or abandonment of a ceremonial structure); and (3) simple interments/expedient disposal lacking perimortem trauma or contextual association. This interpretive approach stresses the importance of distinguishing archaeological context, the cause of death, and what portions of the body were interred to understand the roles animals played in ritual practices. It also stresses the importance of dating the interments and discerning if other items are associated with the remains. Finally, where canids are involved, aDNA analysis can definitively ascertain which species is represented.

Sites with any sort of animal interment are likely to be eligible as contributing to this topic. Care must be taken, however, to distinguish intentional interment under any of the three methods described in the preceding paragraph from generalized consumption and deposition in refuse-related middens.

INFERRING SOCIAL PATTERNING FROM INTRA-SITE SPATIAL TRENDS

In general, the onset of sedentism is considered to have resulted in associated changes in social organization (cf. Bender 1978, 1990; Flannery 1972; Hayden 1990; Hodder 1990). New social and economic mechanisms were no doubt needed to integrate and maintain larger populations in sedentary villages, and detailed examination of the community organization has the potential to provide insight into the development and consolidation of successful village economies.

With sedentism, local resources, particularly subsistence-related, became restricted in nature and heavily utilized. This had the potential to lead to more limited sharing networks, more resource competition, and differential access within local communities (Netting 1990; Wilk and Netting 1984:11; Wilson 1988). Restricting the social network involved in sharing resources to a smaller group reduced productivity risks, since it was easier to observe and deal with individuals who were not fully contributing (Plog 1990; Winterhalder 1990). Over time, the rights to certain resources and the land itself became more explicit and less loosely defined and shared. Typically, the household emerged as the basic unit in the community that maintained and transmitted such rights and access to resources (Byrd 1994, 2005; Flannery 1972:48; Netting 1990:60; Wilson 1988).

A need for more regulatory mechanisms that integrated the entire community is also anticipated to have occurred with the development of sedentism and increased size of population aggregations (Byrd 1994, 2005; Flannery 1972; Hitchcock 1987:418; Whalen 1983). Community-scale mechanisms were necessary to deal with issues related to subsistence and economic activities and scheduling. More competition, more formal rights to resources, inheritance rules and competition, and the growing autonomy of smaller social groups, such as households, increased jealousy and stress. More formal mechanisms were also needed to deal with conflict resolution and to promote group cohesiveness (Adler 1989; Adler and Wilshusen 1990; Flannery 1972:47–48; Wilson 1988). The development of formal suprahousehold organization functioned to integrate the community, either on extended kin lines (such as lineages), on the community level, or possibly both. These corporate bodies played a role in resolving disputes, suprahousehold decision making, and related ceremonial and ritual activity. Their membership may have been based on the criteria of age, gender, or kinship. These corporate groups also may have controlled the use of community land (as separate from household-owned land), as well as knowledge relating to the practical, sacred, and supernatural.

Archaeological investigations of these issues require consideration of the factors that influence the material correlates of social relationships. Whether or not community organization changed with the onset of sedentism in central California is a viable research problem. Potential developments include increased village population, new forms of community organization and layout, formalization of public space, and shifts in household size and structure. Potential archaeological correlates of these changes in social organization might include: more expansive settlements; changes in intra-settlement spatial configuration, increased distinction between public and private space; appearance of specialized non-domestic structures and spaces (such as sweat houses or dance floors); changes in the nature and size of domestic buildings; presence of a few large residences for wealthy and powerful families and individuals, such as chiefs; and greater discreteness and redundancy in the spatial location of built features, activities (both within buildings and in outdoor areas), ritual spaces (for meetings and ceremonies), and burial areas.

Data Requirements

This is not a topic that has received substantive attention in central California, in part because structures were made with perishable material; only occasionally, when structures have burnt or house pit depressions were preserved, can architectural evidence be examined. Archaeological data from the Bay-Delta Area that can be applied to this research topic should be focused on discerning intra-site spatial patterns tied to the function and organization of space. This may include the nature of any structures that may be preserved (especially whether they appear to be residential or non-residential in nature), the distribution and spatial location of features and activity areas, the spatial distribution of burials, and analysis of the distribution of subsistence remains and artifactual material to discern spatial patterning in residential or ceremonial activities. Any such analysis is invariably closely related to research geared to unravel the function of mounded space (e.g., Lightfoot and Luby 2012), as discussed on page 8-16.

Eligible sites under this topic are expected to contain structural features or identifiable activity areas within a single site and sufficient preservation to investigate the differences in tool use, processing, and dietary evidence within each area. The presence of house features with well-defined assemblages originating from inside and outside the feature is sufficient for eligibility under this topic.

13. RECONSTRUCTING REGIONAL INTERACTION SPHERES

Hunter-gatherers participated in regional spheres of social interaction larger than the territory of a single group's annual round. The nature, scale, and spatial orientation of these supra-territorial interactions were not static, were typically unstable, and may have varied greatly over time. Important manifestations of these phenomena include trade and exchange networks, travel corridors, and socioideological interaction.

Ethnographic and ethnohistorical accounts reveal that a wide range of goods was traded throughout California, with Native Americans from the California coast to the Hohokam of central Arizona participating (e.g., Davis 1961; Heizer 1978; Heizer and Treganza 1944; Sample 1950). Trade ran both east-west and north-south along a series of established routes. For example, the Ohlone were reported to have traded with adjacent groups, most notably the Yokuts and the Miwok (e.g., Barrett and Gifford 1933:251–252; Pilling 1950:438). Some items were local, while others were extra-local and procured via down-the-line trading. The Ohlone, at a minimum, traded dried abalone and mussel and salt to the Yokuts and received young dogs, obsidian, and pine nuts in return.

Tangible archaeological evidence that similar activities took place in the past rests largely on the recovery of extra-local, non-perishable goods. Archaeological evidence suggests that long-distance trade in California had great antiquity, extending back into the early Holocene (e.g., Fitzgerald et al. 2005; Howard and Raab 1993; Smith and Fauville 2015). Evidence for the full range of traded goods, however, may be preserved only at the termination point, due to the nature of down-the-line trading, or if direct acquisition took place. Archaeological evidence suggests that wide-ranging obsidian trade networks characterized interactions in central California (Jackson 1988; Jackson and Ericson 1994), often structured by the nature of social boundaries (Bettinger 1982; Ericson 1982; Hughes and Milliken 2007).

Intra-regional trade, such as between Ohlone tribelets, was also undoubtedly important, playing a role in distributing resources that have limited source localities and in cementing regional social networks (Heizer and Treganza 1944). For example, populations in the South Bay-Delta Area may have acquired raw materials from well-known sources elsewhere in the Bay-Delta Area: Franciscan chert from a variety of localities in the Santa Clara Valley (Elsasser 1986:46), Monterey chert from the west Santa Cruz Mountains or the East Bay (Elsasser 1986:51; Heizer and Treganza 1944:314; Parsons 1990), quartz crystals from eastern Alameda County (Bowen 1962:13), asphaltum from Duxbury Point in Marin County (Moratto 1984:221), and hematite from the East Bay hills (Heizer 1951).

The central California region appears to have included a series of potentially overlapping regional interaction networks. Travel corridors represent the conduits by which Native Americans interacted within the region and beyond, facilitating regional interaction, trade, ritual activity, and warfare. Thus, the reconstruction of travel corridors provides an important opportunity to gain insights into a series of overlapping aspects of Native American social interaction. Trail systems were the focal point of regional pre-contact travel, and key trails ran up and down the major valleys and through major mountain passes. Travel along river corridors and across the San Francisco Bay was also an important facet of this system.

For archaeologists in California, most discussions of pre-contact trade and exchange are centered on the two most widely traded, durable materials—obsidian and shell (e.g., Hughes and Milliken 2007). Moreover, there is widespread recognition that the nature of regional interaction networks differed markedly at various points of time, and that the volume and areal extent of trade were not static (e.g., Gilreath and Hildebrandt 1997, 2011; Hildebrandt and McGuire 2002). Although myriad trade items might be investigated, we focus on three topics that have previously received attention and for which additional data have potential to provide valuable information about pre-contact trade and exchange—obsidian movement into the Bay-Delta Area, trade of clamshell disc beads, and trade of abalone ornaments.

OBSIDIAN EXCHANGE

Obsidian is common in Bay-Delta Area sites, though the relative source profile make-up and abundance relative to other raw materials varies through time. Napa Glass Mountain obsidian makes up the vast majority (80.3%) of all obsidian identified, while other North Coast Range sources in Napa and Lake Counties (Annadel, Franz Valley, Borax Lake, and Mt. Konocti) account for another 14.2% (total sample size 5,674 pieces with either visual or X-ray fluorescence spectroscopy sourcing from 160 study area sites). It is not surprising that Napa Glass Mountain is the predominant obsidian since it is of relatively high quality and the quarry is in close to Bay-Delta Area sites (particularly in the Northwest and North Delta regions). Although of lower overall quality, Annadel obsidian (hereafter, Annadel includes the small sample of obsidian sourced as "Franz Valley" or "Trinity") is also near the Bay-Delta Area and therefore its presence in Bay-Delta Area sites is not surprising. It is intriguing that the two Lake County sources—Borax Lake and Konocti—represent only 0.6% of the total Bay-Delta Area assemblage despite their location much closer to the San Francisco Bay-Delta Area than sources east of the Sierra Nevada (Figure 60). The remainder of obsidian assemblages comes from the east side of the Sierra Nevada (5.5%), predominantly Bodie Hills (2.8%) and Casa Diablo (2.4%), though Coso, Mono Craters, Mt. Hicks, and Queen are also represented, each by fewer than 10 identified flakes.

When examined by region, patterning of obsidian becomes much more distinct (Table 29; Figure 61). The study area north of the San Francisco Bay/Carquinez Strait has only Napa and other North Coast Ranges obsidians, while the percentage of eastern sources increases in the Southwest Bay, South Delta, and East Bay to between 4.1 and 6.4%, with a much higher percentage of eastern Sierra sources in the South Bay (14.3%).

Region	NUMBER OF SITES	Number of Obsidian	NAPA (%)	Other North Coast (%)	Eastern Sierra (%)
Northwest Bay	34	1,202	69.0	31.0	-
North Delta	6	150	94.7	5.3	-
South Delta	23	1,740	87.1	6.7	6.2
East Bay	30	902	87.9	5.7	6.4
South Bay	33	604	79.2	6.6	14.3
Southwest Bay	25	1,065	86.4	9.4	4.1
Total	151	5,663	80.3	14.2	5.5

Table 29. Summary of Obsidian Source Data by Region in the Study Area.

A further indication of trade is found in the relative percentage of obsidian to other raw material types through time. A sample of sites from the South Delta and East Bay regions identifies an interesting pattern through time in the relative ratio of chert to obsidian debitage, as well as the relative percentage of eastern Sierra debitage (Figure 62). In all samples, obsidian is relatively rare compared to chert in Early and Middle Period assemblages, whereas it increases dramatically to make up over half (and in the case of Kellogg Creek Valley 90%) of the debitage assemblage at sites by the end of the sequence (Late 2). At the same time, the relative proportion of the eastern Sierra Nevada obsidians drops to its lowest levels during the combined Middle/Late Transition and Late Periods. Fredrickson (1974b) noticed this pattern with a smaller sample size and correlated it with differences in burial assemblages between flexed and extended burials during the same time period. He argued that the pattern reflected the Meganos Intrusion during the Middle/Late Transition and into the Late Period.



Figure 60. Obsidian Sources Identified in Study Area Sites.



Figure 61. Density Distribution of Eastern Sierra and Non-Napa North Coast Obsidian Sources in the Study Area.



Figure 62. Summary of Raw Material Use and Contribution of Eastern Sierra Nevada Obsidian Sources through Time for South Delta and East Bay Valleys.

More recently, several studies have identified social boundaries based on a combination of obsidian source profiles and obsidian-to-chert ratios (e.g., King et al. 2011; Rosenthal 2011b, 2012; Whitaker et al. 2008). These studies follow a long line of regional syntheses that identifies breaks in the distribution patterns of raw materials that indicate directionality of trade rather than a strict distance-decay relationship between sources (e.g., Ericson 1981; Jackson 1986). Finally, a recent study by Panich (2016) of Santa Clara Mission archaeological data revealed a persistence of obsidian use that for the most part is similar to pre-contact South Bay data (see Table 25). This entailed a continued dominance of the Napa Glass Mountain source (69.2%) and a moderate use of eastern Sierra sources (10.2%). It also, however, included a higher frequency of Annadel obsidian (19.5%) than noted in pre-contact settings in the South Bay and adjacent areas.

Trade Networks and Social Boundaries in the San Francisco Bay-Delta Area

The broad-stroke distribution of obsidian sources in the study area demonstrates at least two notable trends. First, obsidian from the Eastern Sierra does not penetrate the North Delta and Northwest Bay regions. Second, eastern Sierra obsidian is increasingly more common along a north-south gradient, with a significant proportion of obsidian in the South Bay region (nearly 15%) coming from eastern sources. As a corollary to both of these patterns, Konocti and Borax Lake obsidian do not penetrate the Bay-Delta Area in great abundance, despite the relatively short distances between these sources and the Northwest Bay and North Delta regions. A similar pattern was noted by Ericson (1981) and more recently by Whitaker et al. (2008), demonstrating a more northern network of exchange for these sources centered around Clearlake and the immediately surrounding North Coast Ranges and southern Sacramento Valley. It appears that Napa Valley obsidian was traded to the south and east almost exclusively, whereas Borax Lake and Konocti were traded to the north, east, and, to a lesser degree, west. These patterns match the ethnographic territories of the Pomo around Clear Lake, and the Coast Miwok/Penutian groups to the east.

The southern portion of the Bay may have been more integrated with trade patterns to the east, where down-the-line trade with the Yokuts, and in turn the Sierra Miwok, provided ready access to eastern Sierra Nevada obsidian. Future research could focus on the South Bay patterns of obsidian use and source profiles. Increased sample sizes and regional coverage of debitage assemblage make-up in well-dated assemblages at sites in the Southwest Bay, South Bay, and Northwest Bay regions could provide analogous datasets to those presented above, and may explicate shifts in trade networks and potentially identify shifting social boundaries through time in the study area.

History of Quarry Use and Distribution at Napa Glass Mountain

As noted, Napa Glass Mountain obsidian is the most-common source identified in the region. It is found at nearly every site in the Bay-Delta Area that has obsidian, and accounts for 80% of all studied site assemblages. Obsidian hydration readings are available for 5,309 samples from 160 sites in the study area. When all hydration readings are compiled, the overall profile of Napa obsidian shows a peak of use between 2.4 and 2.6 microns. If we use Rosenthal's (2005) conversion rate to years cal BP, which does not require a correction for EHT, this corresponds to a peak of Napa obsidian distribution within the study area sample during the Middle 4 and Middle/Late Transition (approximately 1000–850 cal BP; Figure 63). A disruption in obsidian use is suggested by a strong drop in the frequency of 1.6 micron samples (circa 380 cal BP), perhaps coinciding with initial European contact. This source-use profile appears similar to those identified at eastern Sierra sources (e.g., Gilreath and Hildebrandt 1997; Rosenthal 2011b). Given the large sample size, it is unlikely that further samples of Napa Valley obsidian will provide additional information, but correlating shifts in its overall source-use profile, with trends in the relative use of obsidian versus other raw materials and Napa versus eastern Sierra sources, might provide insight into how trade relationships changed through time.



Figure 63. Histogram of All Napa Valley Obsidian Hydration Rims for a Sample of Sites from the Study Area.

Data Requirements

Addressing obsidian exchange requires assemblages from well-dated contexts, and both source and hydration analyses. Source profiles from such sites can be combined with regional samples to identify changes through time in obsidian source distributions and use. In addition, mapping the distribution of various sources through time can provide baseline predictions regarding shifting social boundaries or trade and exchange networks that might be further tested using subsequent datasets.

The presence of substantial assemblages (>25% of sourced obsidian) from rare sources (i.e., sources other than Napa Valley or Annadel) would make a site eligible under this topic. In addition, the presence of large assemblages of Napa Valley or Annadel obsidian from well-dated contexts could contribute when combined with a broader sample of regional sites.

OLIVELLA AND CLAMSHELL BEAD MANUFACTURE AND TRADE

Numerous studies have stressed the importance of trade in shell, centered on a single species – *Olivella biplicata* (the purple olive snail)—indigenous to the sandy beaches of the eastern Pacific Ocean between Baja and British Columbia. This is due to several factors, including its ubiquity in the archaeological record, the antiquity of its use, its widespread distribution, and diversity in formal characteristics of the resulting ornaments made from this small shell. *Olivella* was traded at least as far as the central Mojave Desert during the Early Holocene (Fitzgerald et al. 2005), and by the Middle Holocene at least one bead type (N-series grooved rectangle beads) was traded within regional interaction networks from the Channel Islands to Oregon (Howard and Raab 1993; Vellanoweth 2001). By the Late Holocene, long distance trade of *Olivella* was so extensive that Bennyhoff and Hughes (1987) prepared an entire monograph, introducing a new shell ornament typology and its temporal implications, using only trade beads from sites in the Great Basin.

In western California, extensive research has focused on formal variation in *Olivella* shell bead types, stressing the implications for defining chronological stages; the social importance of these beads, and their manufacture in the rise and perpetuation of political complexity and elites; their importance in the maintenance of regional interaction networks; the ideological and social implications of their presence in mortuary contexts; and their role in sophisticated economic dealings, including the possibility they functioned as a form of money (e.g., Arnold and Graesch 2001; Chagnon 1970; King 1974, 1981; Milliken and Bennyhoff 1993). Research has also examined stable isotopes in an attempt to identify probable source localities along the Pacific coast for different ornament types (Eerkens et al. 2005).

Rosenthal (2011) has recently summarized shell bead exchange in central California with an emphasis on the trade of clamshell (*Saxidomus* spp.) disc and *Olivella* beads in the Bay-Delta Area. Beginning with Chagnon (1970), it has been argued that shell beads were not just a trade item, but a currency in its true modern sense—a length of beads had a real and agreed upon value that corresponded to, for example, a basket of acorns, a side of venison, or a salmon fillet. Chagnon (1970) argues that shell bead money acted as a buffer against seasonal shortfalls in a group's territory—when one territory experienced seasonal surplus, its residents could trade this surplus to neighbors for shell beads which could then be used to acquire surplus from elsewhere the next time there was a seasonal shortfall in one's own territory:

Thus the spring run of salmon in the larger rivers coincided with the 'starvation period' of the 'hill' peoples. These latter having nothing in the form of edibles to exchange for salmon, used shell beads and other valuables until they could reciprocate with acorns when the fall crop ripened [Chagnon 1970:10].

Taking this a step further, King (1990) argues that in southern California, the expansion of shell bead exchange allowed for a trade with non-local trade partners and across linguistic and socio-political

boundaries. Bettinger (2015) has echoed this sentiment, arguing that as population grows, it is more difficult to monitor the individual reputations that most hunter-gatherer trade is based on. The use of money circumvents this problem as transactions using a common currency negate the need to trust someone as a trade partner:

In a system made up of many small but fiercely independent property-holding social units who were covetous of territory and resentful and deeply suspicious of their neighbors, money facilitated the transfer of a broad range of goods across social boundaries without social entailments or obligations; in short, without significant sociopolitical overhead [Bettinger 2015:230].

An important aspect of research is the limited distribution of both clam and *Olivella* along the California coast. It was potentially possible for groups to control access to the resource and its supply. Based on the ethnographic record, some have argued that people living in the Bay-Delta Area could directly access the coast to obtain shells for bead manufacture (Gifford and Kroeber 1939;359; Kniffen 1939; Stewart 1943). Rosenthal (2012), however, points out that the ethnographic record is based on post-contact lifeways under which trade and exchange networks and other social structures had likely collapsed, and that "coastal forays by interior people during the historic period may simply have been a response to the disintegration of more traditional forms of remote access (e.g., trade), and do not necessarily describe prehistoric conditions" (Rosenthal 2011:84). Since shell beads require manufacturing, there should be a durable archaeological record that demonstrates where and at what points in time they were made. For instance, *Olivella* bead manufacturing has been well-documented along the Santa Barbara bight and adjacent Santa Barbara Channel Islands (Arnold 2004; Arnold and Graesch 2001; Arnold and Munns 1994; Kennett 2005).

Rosenthal (2011) posits that the production and conveyance of shell beads should expand as the result of: increasing residential stability and/or territorial circumscription and declining foraging efficiency that results in more frequent resource shortfalls as the result of natural decline or increased population. Production should be obvious in the form of shell bead manufacturing debris and drills in archaeological assemblages, while the conveyance should be recorded by the presence of beads in archaeological assemblages. These two datasets represent the beginning and end point of the production and conveyance trajectory.

Distribution of Beads as a Conveyance Endpoint

Rosenthal (2011) summarizes the distribution of beads through time, marking a baseline for the endpoint of trade. He finds that *Olivella* beads, found in contexts from throughout the Holocene, appear to be treated as a commodity beginning in the Middle Period when the diversity of beads increase to their peak. Middle Period beads are virtually all wall beads that are oval to round in shape and could have been strung together (Bennyhoff and Hughes 1987:134). These beads are replaced in the Late Period, after about 450 cal BP, by clamshell disc beads throughout most of the northern Bay-Delta Area, though they are rarely found at South Bay sites.

Although it appears that shell beads first represent a commodity beginning in the Middle Period, their peak abundance may have been during the Middle/Late Transition, though it is difficult to ascertain how they were used (Rosenthal 2011:97). The distribution of beads is easier to track. Clamshell disc beads, for instance, are found exclusively in the Northwest Bay, North Delta, and South Delta Regions and into the interior Sacramento Valley (Figure 64).



Figure 64. Distribution of Sites with Clamshell Disc Beads and/or Manufacturing Debris (after Rosenthal 2012).

Distribution of Bead Manufacturing Sites

In contrast to the Santa Barbara channel, where there is abundant evidence of *Olivella* shell bead manufacturing, (Arnold 2004; Arnold and Graesch 2001; Arnold and Munns 1994; Kennett 2005), there is almost no evidence for their manufacture in northern California, either in the interior of the San Francisco Bay-Delta Area or along the Central Coast. However, there are some types of *Olivella* beads found in central California that are not found in southern California, so they had to be manufactured somewhere else (Bennyhoff and Hughes 1987). These include saddle beads (type F; Milliken 2012), the dominant type during the intermediate and late portions of the Middle Period, and rectangular sequin beads (type M1a) found during the Late Period in central California. As such, Rosenthal (2011) posits the existence of a limited number of production centers in central California that have yet to be discovered. With as yet no evidence for production, there is likely only a few locations where it occurred, and regular production of beads by people travelling to the coast and returning with raw materials did not exist.

In stark contrast to *Olivella* beads, there is abundant evidence of clam disc bead production after 450 cal BP. In fact, Rosenthal (2011) identifies bead blanks, bead-making debris, or drills at 26 sites north of the Bay-Delta Area in Marin, Sonoma, Napa, Lake, Yolo, Solano, and Sacramento Counties. These include three sites (MRN-357, MRN-374, and NAP-15) in the Northwest region of the study area. The vast increase in production sites points to a shift between an economy in which shell bead production was tightly controlled, to an open system of production where anyone with the inclination and access to raw materials could produce shell beads.

The Origins of Central California Shell Bead Manufacture

Several outstanding research topics are apparent from the preceding discussion. In particular, several questions regarding the origins of shell beads recovered in sites throughout the Bay-Delta Area remain unknown. Sites that contain drills, bead blanks, and shell manufacturing debris may provide evidence of bead manufacturing. Shifts throughout the Early and Middle Periods in the importance of certain bead types might be better understood if manufacturing of these beads can be tied to other socio-economic trends, either in sedentism or population growth or to in-migrations of new linguistic groups (whether they were distinct culturally or not). Important considerations include whether people had access to coastal frontages from which the raw materials for *Olivella* bead manufacture originated, or whether people living on the coast controlled access through the manufacture of beads, akin to the pattern observed in southern California.

The Clam Disc Bead Revolution

The extremely late pre-contact (post-450 cal BP) advent of clam disc bead manufacturing appears to have swept across the Northwest Bay and North Delta regions into the North Coast Ranges and Sacramento Valley. The shift in focus from *Olivella* shell beads to clamshell disc beads was sudden and spatially limited. An important research question that may be answered by future research is: why are pre-contact clam disc beads limited to the northern portion of the Bay-Delta Area and are rarely, if ever, identified in South Bay or Southwest Bay archaeological sites? Clam discs are, however, present in Native American mission contexts in the South Bay (Panich 2014, 2015). In light of this, if shell bead money was the norm throughout California in this period, why was the open system of production that marks clam disc bead manufacture in the North Bay not mimicked in the *Olivella* bead distribution in the South Bay during the same period. Again, identification of bead manufacturing sites in the South Bay has potential to address this question.

Data Requirements

Examining shell bead exchange is possible with most sites that contain abundant shell beads, shell bead manufacturing debris, and/or drills. Sites with shell beads but lacking evidence of manufacture can still address regional research questions if the beads recovered are out of the ordinary (e.g., clam disc beads in the South Bay), or if special studies can identify the bead origins. Eerkens et al. (2005) have attempted this by sourcing a small sample of *Olivella* shells using stable isotope analysis. While they were able to identify some source areas, broadly defined as southern or central California, future studies might be able to track the origins of shells to a particular place on the coast.

ABALONE PENDANT EXCHANGE

Abalone (*Haliotis*) pendants and ornaments, while important burial assemblage constituents and ethnohistoric trade items, have received less attention than the ubiquitous *Olivella* shell. Heizer (1978:691) does, however, succinctly highlight the importance of abalone in pre-contact and historical trade:

Numerous species of marine shells (*Haliotis, Olivella*, and pectin were favorites) traveled from the Pacific shore across the Colorado Desert and River into the Southwest in prehistoric times (Brand 1938; Gifford 1949; R. Ives 1961; Fewkes 1896; Henderson 1930). Shells (*Olivella, Haliotis*) and finished beads and ornaments from the coast of Central California were traded during the last 4,000 years across the Sierras into western Nevada (Bennyhoff and Heizer 1958; Grosscup 1960:37–40; Tuohy 1970). Not be to be confused with prehistoric trade is the importation of abalone (*Haliotis*) shell from Monterey to the Northwest Coast by European sea otter fur traders in the late eighteenth century (Heizer 1940; Taylor 1860).

Bennyhoff and Hughes (1987) and Taite (in Bouey 1995) have provided typologies for *Haliotis* ornaments, and Milliken (in Hylkema 2007) has summarized bead assemblages, including *Haliotis* ornaments at several sites in the Bay-Delta Area during the Middle/Late Transition and Late Periods. We briefly summarize salient information regarding ethnohistoric shell ornaments, focusing on abalone. Meacham (1979:12–32), in her review of reported ethnohistoric uses of abalone, distinguishes four functions: decoration, social organization, religious, and subsistence. As Kroeber (1925:826) notes *"Haliotis* was much used in necklaces, ear ornaments, and the like, and among tribes remote from the seas commanded a considerable price...." The use of abalone pendants and ornaments figures prominently in dance and ritual regalia, including headdresses, and baskets.

The Ohlone are reported to have traded abalone shell and dried abalone to the Yokuts (Davis 1961:19; Levy 1978:488; Wallace 1978:465); the Yokuts in turn traded shell beads and pendants eastward to groups living in the Owens Valley region (Arkush 1993). Latta (1977:321) notes that the most highly prized shell artifacts were made from abalone, used in ceremonial events and placed over the eyes, ears, and mouth of the dead. Other shells were also traded: the Ohlone are also reported to have traded *Olivella* to the Sierra Miwok (Davis 1961:19; Levy 1978:488), and the word used by the East Bay Chocenyo Oholone for clam disc beads appears to be a Miwok loan word (Levy 1978:488–489). Barrett and Gifford (1933:251–256), in their monograph on the Miwok of the east Delta and Sierra, provide an extensive discussion of shell ornaments. They note that abalone was the only shell regularly used by the Miwok to manufacture ornaments. Red abalone was acquired directly from the coast, and in 1923, an elderly man at Knights Ferry was observed making rectangular abalone ornaments for use as pectorals. Interestingly, Barrett and Gifford (1933) report that the Ohlone allowed the Miwok to directly acquire *Olivella* from Monterey Bay, while *Saxidomus* clam shell beads were acquired as finished products from groups living to the north (possibly the Patwin or Pomo).

Johnson (1978:352) states that pre-contact, the Patwin acquired shell from the coast as finished beads, but in historical times, they traded for whole shells and made their own shell ornaments. The Pomo of Clear Lake obtained abalone in trade from the west (Kroeber 1925:257), while clams were reported to have been directly acquired by the Pomo in Coast Miwok territory on Bodega Bay (Kroeber 1925:249, 825). Perry et al. (1985:130–132) describe clamshell disk bead making among the Makahmo Pomo, with Washington clams acquired "during their summer trade expedition to Bodega Bay in Coast (Bodega) Miwok territory."

Perry et al. (1985:208) state that abalone was also available from Bodega Bay, and figured prominently in ceremonial regalia, and the Pomo were also reported to have supplied the Yuki with dried abalone (Davis 1961:35). Farther to the north in the Central Valley, Goldschmidt (1951:334–335) reported that the Nomlaki traded for abalone, possibly whole, and put the shells on shirts and hides. Recently, Colligan et al. (2015) have synthesized the record of abalone in coastal sites north of the Golden Gate, including Marin, Sonoma, Mendocino, Humboldt and Del Norte Counties. They find that abalone, while present, never make up a large percentage of shell assemblages, and argue that this indicates a locus south of the Golden Gate as the center of abalone trade to the interior.

Overall, this review of ethnohistoric observations on abalone shell trade, exchange, and manufacture in central California reveals several interesting trends. First, the spatial orientation of trade and exchange patterns appears to have differed significantly between clams and abalone. Clam shell acquisition and manufacture appear to have been concentrated north of San Francisco Bay-Delta, with Bodega Bay representing a major source locality (Bennyhoff and Hughes 1987:155). In contrast, a major node of abalone trade and exchange appears to have centered on the Monterey Bay area. It also appears that Olivella acquisition may well have been more tightly tied to abalone trade and exchange than to clam shell acquisition and manufacture. It should also be kept in mind that historic-era direct acquisition of coastal goods may have been largely due to the collapse of elaborate down-the-line trade and exchange networks during pre-contact times when population densities were high. It is quite possible, however, that the spatial orientation of these historical interaction networks reflects exchange networks just prior to contact. These patterns indicate that the Monterey Bay Ohlone may well have been an important supplier of abalone (both as food and as shell ornaments) to the Bay-Delta Area Ohlone, Yokuts, and Central Miwok, though abalone has also been identified farther north on the San Mateo County coast, and raw material for pendants may also be found there. It should be noted, however, that this reconstruction differs from King's (1978:60) earlier assessment of post-contact and Historic Period shell bead exchange networks. He defined a central interaction area, running from just north of Monterey Bay to the upper Sacramento Valley (including the Pomo and the Wintu).

Based on this review of the status of archaeological and ethnohistoric observations on abalone shell ornament trade and exchange patterns, we can generate a number of research questions that can be explored in future studies. Clearly we currently lack firm insight into the three most fundamental questions: where were the source locations for abalone?; where were abalone ornaments manufactured?; and what was the nature of abalone trade and exchange networks? Several related questions also need to be considered—where were the source locations where abalone was the focus of exploitation?; did different species have related source locations?; and was there a shift in the choice of species over time? Turning to manufacturing patterns, future research also needs to consider whether abalone was manufactured near the coastal sources or traded as whole pieces, and subsequently as ornaments made at various local inland settings. Similar to Rosenthal's (2012) reconstruction of *Olivella* ornament manufacture, did tight control over the venue of abalone ornament manufacturing in the Early and Middle Periods give way to a plethora of local manufacturing centers in the Late Period? We would also anticipate that the nature of trade and exchange networks fluctuated over time, particularly during

periods of population disruption, movement, and conflict such as the purported Middle Period Meganos Intrusion into the East Bay-Delta Area.

Data Requirements

A number of strategies could be used to gather data to address this set of research questions. The first entails identifying the source locality and species of abalone. To address this question, a pilot study of stable isotope fingerprinting could be undertaken using an approach similar to that of Eerkens et al. (2005) for *Olivella*. This study could examine whether stable carbon or oxygen isotopes of modern abalone shells correlate with differences in ambient sea surface temperature, as well as local upwelling. Ideally, such a study should test samples from likely source locations such as Monterey Bay, Bodega Bay, and southern California. It should also include samples of both red and black abalone. If successful, then the technique could be applied to archaeological samples from different localities and time periods to ascertain the orientation of trade and exchange networks.

The second strategy would be to explore diachronic trends in pre-contact use of abalone ornaments in locations which would have logically acquired Monterey Bay abalone through trade and exchange. A logical setting for such a study would be the South San Francisco Bay-Delta Area which lacks locally available abalone. The South Bay is also closer to Monterey Bay than Bodega Bay, the other likely source locality. In addition, both the South Bay and Monterey Bay were inhabited by the Ohlone at contact, and it is likely that intra-tribal trade and exchange were more prevalent than inter-tribal exchange. The South Bay is also an area that had high population densities during the Late Holocene, and archaeological investigations have documented diverse and abundant samples of abalone ornaments from mortuary contexts dating from the Early Period onward (Hylkema 2002; Milliken et al. 2007). This would be an ideal context in which to explore whether changes in abalone ornaments in the Late Period were correlated with a contemporaneous surplus of abalone raw material in Monterey Bay (Mikkelsen and Jones 2010; Whitaker and Byrd 2012).

Eligible sites will have abalone pendants that can be tested isotopically, or abalone shell with evidence of modification indicative of abalone pendant manufacture. The presence of a single abalone pendant may not be sufficient to meet eligibility requirements under this topic, but a pilot study may require sampling of numerous pendants to identify the source location of manufacture. Pendants need not be found in complete form to address this research issue. In fact, sampling of pendant fragments may be preferable since complete pendants are often found in burial contexts.

14. INDIGENOUS ASSIMILATION AND PERSISTENCE (with Randall Milliken)

Between the 1770s and 1830s, the majority of tribal people of the San Francisco Bay-Delta Area left their lands and moved to Missions San Francisco Asis (Dolores), San Rafael, San Francisco Solano, San Jose, and Santa Clara. Populations of between 200 and 400 individuals, living within small tribal territories, variously dealt with Spanish colonial settlement, mission outreach, mission life, escape and capture, disease, and depopulation. The only systematic archival sources available to reconstruct Native life just prior to and during the Mission Period are the Franciscan mission records of baptism, marriage, and death. The missionaries were obliged to document basic information about each individual they baptized, so the registers provide a systematic and nearly comprehensive tally of Bay-Delta Area groups. The mission records also contain the only information regarding the original home groups of the vast majority of Native people in the study area. These data make it possible to track the declining village populations of the Bay-Delta Area, as individuals and groups were assimilated into the missions.

As summarized in Chapter 3, Milliken (1983, 1995, 2006, 2010) has developed and expanded a systematic record of Native baptisms, marriages, and deaths based on mission record data. This research has now been incorporated into a potent ethnogeographic research tool—the CDM—which combines mission register and all available ethnographic data to reconstruct the local-level tribal landscape just prior to the Mission Period (Milliken 2006, 2010). The CDM identifies mapping "regions," which represent the lands of territorial communities or tribelets, which were present throughout the Bay-Delta Area. A key element of the CDM is the Mission Register database which tracks the vital statistics of individuals who moved to Franciscan missions from their native regions. Details on the CDM are presented in Appendix B, including discussions of how to access and use it.

USING THE COMMUNITY DISTRIBUTION MODEL'S DIGITAL DATA TO TRACK INDIGENOUS ASSIMILATION

CDM regional attributes can be used to generate numerous maps and databases that can aid in the task of close local study and analysis of broad regional patterns. Pertinent to regional pattern analysis of study area-wide indigenous assimilation are population densities and baptism rates, by region, identified in the CDM database. The database also provides a basis for examining the marriage networks and social outreach areas of contact-period landholding groups. Irrespective of community size, be it 20 people or 300 people, its marriage networks with neighbors always involved pools of at least 500 people (Milliken 2006). The CDM provides a reasonable starting point for studying differences in pre-mission human population density in various parts of the San Francisco Bay-Delta Area (Table 30). It suggests that the highest Bay-Delta Area populations, more than 12 persons per square mile, were in the Novato Creek and San Antonio Creek regions on the northwest edge of San Pablo Bay (see Figures 13 and 14). It provides information valuable for tracking each landholding groups' history of migration to the missions and survivorship in them.

To extend the use of the CDM data, we can track the cumulative baptism rate of each identified region to understand patterns of assimilation, by mission. Bennyhoff (1977:20) identified a general principle in his early mission register-based studies—rancherias close to missions generally sent their people for baptism earlier than villages at greater distances, resulting in a "domino" effect outward from each mission. A shown in Figure 65, the study area is a classic example of this. The five missions within or in close proximity to the study area were founded within a 47-year period—between 1776 (San Francisco Asis) and 1823 (San Francisco Solano). Mission Santa Clara was built one year after San Francisco Asis (1777), Mission San Jose 20 years later (1797), and Mission San Rafael 20 years after that

_	Predominant	BAPTIZED	Average Adult	TRIBAL	ADJUSTED	AREA IN	POPULATION BAPTISMAL
LANGUAGE	RANCHERIA IN	ADULTS	BAPTISM YEAR	MORTALITY	TOTAL POPULATION	SQUARE MILES	PER SQUARE MILE MISSION
BAY MIMOV	REGION			PACIOK	TOPULATION	WIILES	IVIILE
DATIVIIVOK	Tatcan	106	1804	0.72	294	68	4 DO IO
	Omnin	74	1811	0.72	294	84	4 DO, JO 3 IO
	Chuncan	7 4 06	1810	0.57	200	80	
	Chupcun	90 107	1706	0.56	240	00 71	4 DO, JO 4 DO
	Sacian	107	1/96	0.86	249	/1	4 DO
	Volvon	//	1805	0.69	223	93	2 DO, JO
(Julpun	110	1814	0.54	407	111	4 JO
COAST MIWO	ĸ	(0)	1000	0.70	1	-	
	Guaulen	69	1802	0.78	177	56	3 DO
	Omiomi	220	1812	0.56	786	50	16 DO, RA
	Olema, Echatamal	222	1808	0.61	728	87	8 DO, RA
	Huimen	101	1798	0.84	240	47	5 DO
	Olompali	243	1817	0.51	953	78	12 DO, JO, RA
	Tamal Aguasto	175	1804	0.72	486	59	8 DO
	Alaguali	102	1816	0.52	392	59	7 JO, DO
	Napa	172	1815	0.53	649	91	7 JO, DO
MIWOK: PLAII	NS						
	Musupum	41	1825	0.43	191	52	4 JO
	Anizume	171	1813	0.55	622	103	6 JO
Ohlone: Kar	RKIN						
	Carquin	100	1808	0.6	333	65	5 DO
Ohlone: San	FRANCISCO BAY						
	Solano	179	1791	0.91	393	74	5 CL, JO
	Huchiun-Southern	162	1792	0.9	360	78	5 DO
	Seunen,Patlan	110	1802	0.78	282	54	5 JO
	Santa Ysabel	128	1797	0.85	301	81	4 CL
	Tuibun	238	1798	0.84	567	99	6 CL, JO
	Chiguan	23	1787	0.95	48	43	1 DO
	Aramai (Pruristac)	25	1784	0.97	52	23	2 DO
	Puichon	183	1793	0.89	411	74	6 CL, DO
	Pelnan/Cavuran	90	1804	0.75	240	61	4 JO, CL
	Olpen	116	1794	0.88	264	69	4 DO, CL
	Cotegen	25	1790	0.92	54	36	2 DO
	Lamchin	105	1791	0.91	231	62	4 DO
	Urebure	19	1782	0.98	39	12	3 DO
	Yelamu	68	1781	0.99	137	57	2 DO
	Olion	69	1791	0.91	152	61	2 DO
	Ssalson	93	1788	0.94	198	71	3 DO
	Huchiun-Aouasto	164	1804	0.72	456	81	6 DO
	Tamien	159	1789	0.93	342	74	5 CL
	(Partacsi)	80	1795	0.87	184	72	3 CL
	San Carlos	296	1793	0.07	665	128	5 CI
	Causen	173	1801	0.09	304	120	
	Sourcen	82	1804	0.01		т0 61	4 IO
	55иусн Таниан	100	1802	0.72	220	100	
	1 4411411	100	1002	0.78	250	100	Continued on name 14 5
							Commueu on puge 14-5

Table 30. Mission Record Attributes for Study Area Tribal Regions (after Milliken 2010).

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4



Figure 65. San Francisco Bay-Delta Study Area showing Cumulative Baptism Trends by Tribal Community.

Language	Predominant Rancheria in Region	Baptized Adults	AVERAGE ADULT BAPTISM YEAR	Tribal Mortality Factor	Adjusted Total Population	Area in Square Miles	POPULATION PER SQUARE MILE
Ohlone: San Francisco Bay/Miwok: Bay							
	Jalquin/Irgin	150	1802	0.78	385	95	4 JO, DO
PATWIN							
	Suisun/Malaca	277	1815	0.53	1,045	175	6 DO, FS
Yokuts, Delta							
	Jalalon	24	1817	0.51	94	47	2 JO

Table 30. Mission Record Attributes for Study Area Tribal Regions (after Milliken 2010) continued.

Notes: DO – Dolores; JO – San Jose; FS – San Francisco Solano; RA – San Rafael; CL – Santa Clara; CR – Santa Cruz.

(1817); the last group of adults from the Bay-Delta Area regions were baptized in 1832. Overall, this represents a 56-year period when populations of between 200 and 400 individuals, living within small tribal territories ("regions"), dealt with mission outreach.

The impact of the first mission, San Francisco Asis, on the Bay-Delta Area Ohlone is clear within the first four years of its founding, when up to 80% of the local region's inhabitants were baptized; 100% of the inhabitants of the three regions closest to the mission were baptized by 1790. Thereafter, the regions extending south along the San Francisco peninsula show steadily increasing baptism rates, with the whole peninsula and southern part of the study area showing 80–100% baptism rates at Missions San Francisco Asis, Santa Clara, and San Jose by 1800. Mission San Jose started having an immediate impact on the surrounding area, with 100% of the population of the east-central study area baptized by 1810.

The northern part of the study area shows a similar but later trend. The four Coast Miwok regions surrounding Mission San Rafael had 100% baptism rates by 1820, three years after its founding. With the addition of San Francisco Solano, almost all individuals in the northern study area regions (Coast Miwok, Patwin, Plains and Bay Miwok) were baptized by 1830. The significant exceptions are the regions of Fairfield (Patwin) and Andrus Island (Plains Miwok), which maintained a small percentage of their population into the 1830s (see Figure 65; Table 31); it is in these regions that some of the latest surviving rancherias are likely to be found archaeologically.

It can also be considered that after 1810, the other 10 northern regions, shown on Figure 65, would have varying levels of sensitivity for persistence in indigenous occupation in the archaeological record, with baptism rates of 0–40% having a high potential; 41–80% with a moderate potential; and more than 80% with a low or no potential.

Lawouter	DECADES						Terre		
LANGUAGE	1770–1780	1780–1790	1790–1800	1800–1810	1810-820	1820–1830	1830–1840	1840–1850	TOTAL
Bay Miwok	0.1	0.1	19.5	36.4	42.2	1.6	-	-	100
Coast Miwok	-	0.9	3.6	38.8	55.2	1.4	-	-	100
Miwok: Plains	-	-	-	-	83.4	16.3	0.3	-	100
Ohlone: Karkin	-	0.7	2.0	75.8	21.6	-	-	-	100
Ohlone: San Francisco Bay	4.8	27.9	45.2	22.0	0.2	-	-	-	100
Ohlone: San Francisco Bay/ Miwok: Bay	0.4	0.4	4.3	94.9	-	-	-	-	100
Patwin	-	-	-	-	89.2	7.9	2.9	-	100
Yokuts, Delta	-	-	-	-	86.2	13.8	-	-	100

Table 31. Percentage of Baptisms by Decade and Language Group (after Milliken 2010).

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ARCHAEOLOGICAL ASSESSMENTS OF INDIGENOUS PERSISTENCE

As can be seen, mission record studies can, among other things, track the sequential events of Spanish colonialism in the Bay-Delta Area and subsequent emptying of tribal territories. Ethnographic studies also detail village abandonment due to disease, attacks from neighboring groups located farther from the missions, and population decline (e.g., Milliken 1995). However, it is known that Native groups did not fully abandon their ancestral landscape or their culture. Studies on resistance, refuge, and indigenous autonomy offer clues on this persistence, particularly in relation to archaeological models of post-mission settlement. Notably, these include investigations of Native American lifeways in prominent colonial settings, such as the missions themselves, the San Francisco Presidio, Fort Ross (farther north along the coast), and Rancho Petaluma, as well as in other more autonomous settings (e.g., Lightfoot 2005, 1995; Lightfoot et al. 2006; Panich and Schneider 2015; Schneider 2010, 2015a, 2015b; Silliman 2004, 2010; Voss 2003, 2005, 2008).

Schneider (2010) focuses on Native resistance and refuge from the missions, and archaeological findings from three Marin County shell mounds (MRN-114, -115, -328), all located in the CDM San Rafael region of the Coast Miwok, also the location of Mission San Rafael. Schneider (2010:182) argues for "persistent returns to old village sites," not only by escape but also with approved leave (*paseos*), and also to hunt and fish in the surrounding territories to maintain mission food supplies. While such hunting and gathering practices were likely maintained during the Mission Period, it is likely that remaining villages were to be found farther and farther north, as village populations closest to the mission dropped below a critical level for sustainability. Regional cohesion was also destroyed (i.e., trade, gatherings) with the loss of major villages within a region (Milliken 1995:222), further disrupting any cohesive settlement system. Native communities were not as easily dismantled during the Mission Period as previously assumed and, while efforts are still underway to develop techniques for detecting and studying sites of refuge in the San Francisco Bay-Delta area (Schneider 2015a, 2015b), discoveries in other regions of California (e.g., Bernard et al. 2014) show great promise for identifying and showcasing such critical places of cultural resiliency and change.

While Schneider (2010:183) notes that the three shell mound sites were occupied "30 years after the founding of the first Spanish mission in the San Francisco Bay Area," this is also prior to the founding of nearby Mission San Rafael (1817), which very quickly and completely incorporated individuals from the surrounding areas (see Figure 65). While a return to home villages is suggested, it is likely that those closest to the missions were completely deserted. Archaeological evidence also shows a near-absence of Spanish-related artifacts at the sites (e.g., glass beads, ceramics), indicating that mission outreach did not fully impact this area until San Rafael Mission was established in 1817. It is also known that some villages were repopulated following the Mission Period (post-1834), for example the Coast Miwok at *Rancho Nicasio*, and the Ohlone at *Alisal* (Schneider 2010:186).

Panich and Schneider (2015) have also examined Native autonomy in the Spanish Mission Period, particularly focusing on freedom of movement and action and the colonial hinterlands in the northern San Francisco Bay-Delta Area (see Von der Porten and DeGeorgey 2015 for another example). They note that many individuals left the missions, with or without permission, to hunt, fish, gather, give birth, die, or disappear (Panich and Schneider 2015:52). They further state that some Natives were able to totally avoided missionization, information which mission records would not be able to capture. Evidence from on-going archaeological excavations at Mission Santa Clara indicates the persistence of trade networks, given the abundant obsidian and shell beads found at the mission, and evidence of continued hunting and gathering (Allen et al. 2010; Panich 2015, 2016). Mission Santa Clara records do indicate that some neophyte deaths occurred outside the mission, with burial taking place in their homelands, others were, of course, buried at the missions (Panich 2015). Panich and Schneider (2015:55) also characterize another Marin peninsula site, MRN-402, as an "enduring village settlement," clearly

used in the post-Mission Period. Individuals from another Coast Miwok village, MRN-193/H (*Olompali*), occur on baptismal registers for Missions Dolores, San Jose, and San Rafael (Milliken 2009), but the site shows evidence of continued occupation, from pre-contact times into the mid-1800s (Panich and Schneider 2015; Slaymaker 1972).

As individuals went to the missions over an extended period, it is likely that some villages and autonomy were maintained, though ultimately not in any sustainable way. Reddy (2015), for example, examines the role of food in the persistence of Native subsistence practices and ceremonies (both mortuary and feasting related) during the Mission Period in the Los Angeles Basin in southern California. She highlights how traditional food practices served as a mechanism for reinforcing community identity, while selective use of introduced Euro-American domesticates revealed changes in social practices and networks. Reddy's (2015) research highlights how subsistence practices and the role of traditional foods persisted and changed among Native populations in Native villages (despite considerable environmental and cultural changes), and sheds further light on the types of social mechanisms at play as Native groups strove to retain their cultural foods and practices within the Mission walls (see also Cuthrell et al. 2016 for mission context study of tobacco).

Data Requirements

Gaining insight into trends in Native adaptations to the Spanish colonization and missionization of the region requires fine-grained chronological data owing to the short time span involved. This is particularly the case in the northern portion of the study area where Native settlements persisted for several decades after the first local missions were founded. Drawing on the CDM, Figure 65 provides an initial sensitivity assessment that shows the likelihood of encountering persistence in indigenous occupation in the archaeological record (High Sensitivity 0-40% baptized; Moderate Sensitivity 40-80%, and Low Sensitivity 80-100%). Extra effort must be taken in areas of high sensitivity to ascertain if Native occupation falls in the Late 2 Period or in the Mission era, particularly since few if any European goods may be present. Archaeological investigations into Native settlement and subsistence practices should be focused on identifying rapid changes in orientation, the introduction of non-native plants and animals, and the adoption of new technologies or material culture. Gathering other lines of data will also be needed to identify post-Mission re-occupation or short-term visits during the Mission Period. In addition, use of the CDM provides an important archival line of evidence to supplement this avenue of research. The database is currently available in the Bancroft Library reading room; plans are to make it downloadable in DASH⁸, through the Bancroft's digital library, where information can be expanded, modified, and annotated. It should be kept in mind that some areas, particularly remote places that have not yet been fully surveyed and studied, might have seen reuse during and after the missions, and future archaeological projects should certainly be sensitive to this possibility.

Sites are eligible that contain evidence of post-mission Native American occupation. This may include the presence of domesticated plants (e.g., wheat or barley) or animals (cows, sheep, or goats). Objects of Euro-American manufacture may also be present. As noted, however, sites dating to this period are unlikely to contain such items since the occupants were avoiding missionization and attempting to maintain their traditional lifeways. Sites with radiocarbon dates near the threshold of the curve may also be candidates for post-Mission occupation.

⁸ https://dash.berkeley.edu/xtf/search

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

SECTION 3 – OPERATIONALIZING EVALUATION AND MITIGATION

Procedures for field methods, artifact and ecofact analysis, and documentation in a technical report and with public outreach, are outlined for operationalizing the study area research design in a professionally acceptable and cost-effective manner.

TOPICS

- Field Methods
- Analytical Methods
- Technical and Public Documentation



15. RECOVERING, EVALUATING, AND REALIZING THE POTENTIAL OF ARCHAEOLOGICAL DATA

The preceding sections have identified regional contexts and eight research themes relevant to the pre-contact archaeological record of the San Francisco Bay-Delta Area. In our *User's Guide to Building Research Designs* (page 5-3), we identify various classes of archaeological data (e.g., flaked stone, ground stone, plant remains) relevant to numerous Bay-Delta Area archaeological research issues (see Tables 14 and 15, pages 5-5 and 5-7). Basics of field planning and logistics (e.g., basic excavation techniques, Native American consultation, permitting) are not detailed here as they are specific to individual sites and the potential effects of individual projects. Research issues and methods need to be adapted to each site within each project context.

Caltrans procedures for archaeological studies are described in several documents. The SER, Volume 2 provides format and content requirements for Extended Phase I (Exhibit 5.2), Phase II (Exhibit 5.4), and Phase III (Exhibit 5.7) proposals. In addition, Attachment 6 of the 2014 *First Amended Programmatic Agreement* provides guidance on justification for data recovery excavation as a mitigation measure, and preparation of data recovery or treatment plans (Exhibit 5.6) attached to a Memorandum of Agreement or project-specific Programmatic Agreement.

In this section, we again emphasize the importance of identifying temporal components as a first step to significance evaluation and analysis. Then, the following sections are organized by data type, reiterating the potential research themes they can contribute to (with links to research issues and data requirement by page and electronically). We then cover best-practices for field sampling techniques, laboratory methods, and minimum reporting standards for each data class. These sections are not meant to be exhaustive, how-to guides for analysis, but rather basic outlines on how to identify, recover, and report each data type in relation to research issues, site significance, and data recovery.

For any CRM report to be useful for addressing current and future research issues, three basic questions must be answered about each item recovered: (1) what is it? (2) where did it come from? and (3) how old is it? While in many cases, simple presence absence information is sufficient to address research issues, for other topics it is necessary to know something about material type, technology, and function—all require some level of descriptive, comparative, and/or metrical information about artifacts and ecofacts, along with context, and stratigraphy. Each question requires thorough documentation of general and specific characteristics. Finally, it is important to note that regional database building to address research questions is a cumulative process, and meeting minimum reporting standards is crucial to future research syntheses.

WHAT IS IT?

In addition to basic description of size, weight, and other metrical information, this question requires a consideration of general material and form, as well as specific taxonomic identifications (where possible), and appellation of appropriate regional typologies.

	Examples		
	MATERIAL ARTIFACT TYPE		
GENERAL	Stone, bone, shell, plant	Flaked stone, ground stone, modified bone, mammal bone, bead	
Specific	Obsidian, Monterey chert, faunal bone, estuary shell	Biface, tule elk right metapodial, <i>Mytilus edulis</i> , Stockton Serrated projectile point, pestle, gorge hook, <i>Olivella (Callianax)</i> sp., M1a, Normal Sequin	

WHERE DID IT COME FROM?

This question prompts a broad range of contextual observations, including general environmental and geomorphic context and stratigraphic position, in addition to simple provenience information (e.g., unit, level, depth).

	Examples		
	ENVIRONMENTAL CONTEXT	Landform	STRATIGRAPHIC CONTEXT
GENERAL	Valley, upland, bayshore	Floodplain, alluvial fan, spur ridge	Surface soil, buried soil, residual upland soil, cumulic soil
SPECIFICOak woodland, riparian forest, grassland savannaPleistocene-age fan, Late Holocene floodplain, pre-Quaternary bedrock ^a A horizon, Btk horizon, 2Ab horizon, Feature 1, Stratum 3			
Note: ^a Bay-Delta Area Quaternary geology map (https://geomaps.wr.usgs.gov/sfgeo/quaternary/details.html).			

HOW OLD IS IT?

While this is sometimes the most difficult of the three questions to answer, it is also the most critical for significance assessment and addressing most or all research issues. Importantly, one should never leave the field without knowing which of the collected sample(s) will allow you to answer this question for all important contexts.

		Examples
	INDIRECTLY DATE THE ARTIFACT-BEARING STRATUM	DIRECTLY DATE THE ARTIFACT-BEARING DEPOSIT
General	Use the Quaternary geology map to determine the age of the associated landform (provides a maximum limiting age)	Radiocarbon date charred plant remains, bone, shell, or soil organic matter from flotation samples, unit levels, or picked from sidewalls; obtain obsidian hydration measurements for contexts that appear to have chronological integrity
Specific	Provide a maximum age for the artifact-bearing stratum by radiocarbon-dating the underlying stratum	Date individual features, artifacts, tools, beads by radiocarbon or hydration analysis

SITE EVALUATION VERSUS DATA RECOVERY

Site significance testing (Phase II) has very different goals and methods than data recovery (Phase III). When testing a site, we are identifying spatial and stratigraphic boundaries, contents, features, and concentrations. We adjust excavation methods based on findings in the field to discover intact, discrete temporal components using spatial patterns in temporally diagnostic artifacts and stratigraphic observations. Excavation should proceed until these contexts have been identified, or until it can be reasonably concluded they are not present. It is often the case that more excavation is necessary to demonstrate a site does not have potential to contribute important information, than to demonstrate it does have that potential. Likewise, sufficient work should be completed in a project area to fully characterize spatial and temporal variability in site deposits, allowing subsequent data recovery excavations (if necessary) to be directed at the most important contexts, without the need for additional exploration. Subsequent laboratory analyses and reporting should focus on materials recovered from discrete temporal components, and provide well-supported rationale for component identification. The evaluation report, in turn, should present important research issues that might be addressed with information from the site, justifying recommendations for significance.

For data recovery, project-related impacts are mitigated by focusing excavation on those areas with well-defined temporal components that cannot be avoided. This work should be designed to obtain enough information to fully characterize site activities for any given temporal period. Excavations
should closely follow the approved data recovery plan and proposal, but sampling can be modified based on field conditions and results. While it is often appropriate to sample more than initially anticipated, if time and budgets allow, field decisions that substantially deviate from, or diminish, efforts described in the approved plan, should be discussed with the Caltrans Principal Investigator, and justification for the decision documented.

All tabulated data in any technical document relating to artifact types and attributes should be presented by temporal component. A full catalogue and analytical data on **all** artifacts and features, and details on dating and technical studies (e.g., radiocarbon, obsidian hydration, X-ray fluorescence spectroscopy reports) should be presented in appendices for all excavations.

Identifying Temporal Components

Given the importance of temporal components for addressing research issues, basic methods for identifying these spatially and chronologically discrete deposits are summarized here (see Chapter 6 for details). If a site lacks chronologically sensitive information, it cannot contribute to a wide range of research issues.

Component chronological assignments are most reliable when based on several independent lines of evidence—site stratigraphy, radiocarbon dating of organic remains, bead or ornament seriation, projectile point types, obsidian hydration readings, and regional artifact comparisons ("cross-dating"). Component identification follows from careful spatial and stratigraphic analyses of these chronological indicators, resulting in the identification of contiguous site areas and associated assemblages representative of a single period of occupation. Successful dating efforts invariably entail assessing initial results of technical studies (e.g., radiocarbon dates, obsidian hydration readings) and then submitting additional samples to resolve outstanding issues. Radiocarbon dating provides the most consistent and reliable means of dating, and is the most useful for identifying and refining chronologically discrete areas. Obsidian hydration is a less accurate dating technique, but does provide information useful in understanding the chronological relationships of individual artifacts, components, and sites, along with the certainty that analyzed samples relate to cultural activities. Correction factors for the two most common obsidian sources, Napa Glass and Annadel, provide a convenient way to convert hydration measurements to calendar-year estimates, with the understanding that resulting age estimates are very general. Age ranges for different shell bead types have been reasonably well established, with a resolution of a few to several hundred years, depending on the type (or mix of types), but additional refinements are possible. Groza et al.'s (2011) Scheme D chronology should be applied to the dating of shell bead types and in assessing the chronological integrity of site components (see Table 3).

Assessments of site-formation processes and post-depositional disturbances are crucial to defining components. All available chronological information should be combined from the same contexts (e.g., depositional strata, unit, level, or contiguous units) to assess and identify distinct chrono-stratigraphic components (see Figure 7). When horizontally and vertically contiguous deposits can be shown to be chronologically related, the case for discrete chronological components is strongest. However, it is rare for each type of chronological information to match precisely and the accuracy of a given method of dating should be considered when determining which piece of conflicting data is most reliable.

Finally, for documentation, a detailed rationale, supported by charts or figures, should identify how conflicting temporal data were resolved, and which areas have discrete or mixed temporal contexts. It is the chronologically discrete component areas that should be the focus of subsequent analyses.

FLAKED STONE TOOLS AND DEBITAGE

Flaked stones and manufacturing waste are present in almost every Bay-Delta Area site and have various levels of potential to contribute to seven of the eight research themes (Table 32). The most relevant topics include temporal control and exchange through obsidian hydration and source analysis, and the important social and economic changes associated with the shift from dart to arrow; these topics clearly require either obsidian or projectile points. Information on lithic reduction strategies (e.g., biface versus core reduction, debitage types) and raw material distributions (e.g., obsidian versus non-obsidian) can be relevant to settlement pattern issues, including site function, the identification of residential versus logistical mobility, the definition of socio-political boundaries, and changes in the organization of toolstone production.

	ABILITY OF THE	Sei	e Page
RESEARCH ISSUES	ADDRESS RESEARCH ISSUES	Research Issue	Data Requirements
TEMPORAL TRENDS IN OCCUPATION			
Obsidian Hydration as a Chronological Tool	+++	<u>7-9</u>	<u>7-13</u>
Refining Accuracy of Scheme D	+	7-13	<u>7-18</u>
SETTLEMENTS IN SPATIAL CONTEXTS			
San Francisco Estuary Adaptations	+	<u>8-1</u>	<u>8-13</u>
Discerning and Modeling Settlement Organization	++	8-13	<u>8-15</u>
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	+	<u>8-16</u>	<u>8-19</u>
Bay-Delta Area Sedentism – Causal Factors and Trajectory	++	<u>8-21</u>	<u>8-23</u>
EXPLORING CHANGES IN DIET AND HEALTH			
Resource Intensification	++	<u>9-1</u>	<u>9-7</u>
IMPORTANCE OF TECHNOLOGICAL CHANGE			
Social/Economic Implications of the Bow and Arrow	+++	<u>10-10</u>	<u>10-14</u>
HUMAN DEMOGRAPHY AND POPULATION MOVEMENT			
Reconstructing Population Movements	++	<u>11-1</u>	<u>11-3</u>
TRACKING TRENDS IN PREHISTORIC SOCIAL INTERACTION			
Role of Gender in Social Interaction	+	<u>12-3</u>	<u>12-4</u>
Inferring Social Patterning from Intra-Site Spatial Trends	++	12-5	<u>12-6</u>
RECONSTRUCTING REGIONAL INTERACTION SPHERES			
Obsidian Exchange	+++	<u>13-2</u>	<u>13-8</u>
Olivella and Clamshell Bead Manufacture and Trade	++	<u>13-8</u>	<u>13-12</u>
INDIGENOUS ASSIMILATION AND PERSISTENCE			
Assessing Indigenous Persistence	+	<u>14-6</u>	<u>14-7</u>

Table 32. Research Issues Addressed by Flaked Stone and Debitage Analysis.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; ++ = Certain. <u>Page numbers</u> are hyperlinks.

Field Recovery Methods

Standard practice is to collect all flaked stone tools and debitage from screens (including an 1/8-inch sample) during both evaluation and data recovery excavation. For the evaluation effort, intra-site variability in flaked stone material types (e.g., obsidian versus other toolstone) and temporally or functionally diagnostic artifacts (arrows versus larger darts) can provide information on spatial and stratigraphic differences in site components, and should be tracked in the field. If substantial intra-site differences are

identified, contrasting assemblage areas should be targeted for further sampling and subsequent chronological analyses. In addition, two sampling techniques related to flaked stone assemblages merit specific discussion—surface collection and rapid recovery units.

Surface Collection

Surface tools often lack sufficient stratigraphic association to provide meaningful information, but may be important for identifying spatially segregated temporal components or intra-site functional variability during a single period of site use. When collected, tools should be piece-plotted on site maps, and their location recorded using a sub-meter-accurate GPS unit. Each artifact should be assigned a unique identifier that links it to its mapped location. Tracking spatial patterns in the distribution of these tools may lead to the identification of functionally or temporally separate site loci and/or site components.

Rapid Recovery Units

Although flaked stone material is ubiquitous, temporally diagnostic tools, such as projectile points, bifaces, or drills, are often rare (per volume of excavation) in Bay-Delta Area middens. As these tool types are necessary to address several research issues, it may be desirable to implement rapid recovery units to increase the sample sizes of stone tool (as well as other) assemblages. These units are typically processed with 1/2- or 1/4-inch screens, and are designed to selectively recover certain classes of highly informative artifacts (i.e., projectile points, bifaces, shell beads, ground stone), by forgoing the time consuming effort of collecting micro-constituents and other common artifact classes (e.g., debitage, shell, dietary bone). These units are generally excavated during the data recovery phase once fine-grained, controlled sampling is complete, but prior to disturbance or destruction by construction activities.

Laboratory Analysis

Flaked stone artifacts should be well defined based on discrete metric and non-metric attributes, **using descriptive terms** (e.g., flake tool, biface, cobble tool) **rather than functional** (e.g., scraper, knife, chopper). Appendix I provides some guidelines to flaked stone analysis, including artifact types and attribute analyses. A host of attributes inform flaked stone analyses, from material type to technological characteristics. These should be used to identify intra- and inter-site patterns in different artifact types which can then be used to evaluate differences or similarities though time and space, necessary to address all important research issues.

In particular, projectile points should be measured and characterized following an accepted methodology (e.g., Thomas 1981) which allows uniformity in morphological description and comparability between researchers. Such uniformity is necessary to understand culture-historical and temporal variability in projectile point styles and shifts in technology (e.g., dart to arrow). In other regions of California, neck width, thickness, and notch-angles have proven particularly useful in metrically discriminating different projectile point types (Basgall and Hildebrandt 1989; Rosenthal 2011b). However, no metrically based projectile point typelogy exists for the San Francisco Bay-Delta Area, in part due to the dearth of this tool type. Bifaces are generally categorized by stage or mode of reduction, which allows inferences about site function and on-site activities (e.g., tool manufacture versus finishing or retooling) and evaluation of technological characteristics of stone tool-making debris (e.g., early biface thinning, pressure) can assist in defining the pattern(s) of stone tool acquisition, reduction/production practices, use, and discard at a particular site and through time.

Obsidian Sourcing and Hydration Analysis

Obsidian samples should be submitted for sourcing and hydration analysis; visual sourcing of some types can be used to bolster the sample. Selection and reporting of samples has been described in Chapter 6 and is not repeated here.

Minimum Reporting Standards

- Table with counts of artifacts and debitage by material type and component
- Tables summarizing obsidian hydration rim measurements by context, with mean, standard deviation, and coefficient of variation
- Scans, drawings, or photographs of projectile points
- Appendices with descriptions of analytical criteria and results of analysis, including basic measurements on all tools
- Appendices or tables with results of any sourcing and hydration studies

GROUND STONE TOOLS AND BEDROCK MILLING FEATURES

Given their similar functions, we are discussing portable ground stone tools and bedrock milling features in one section. Ground stone tools alone have limited potential to contribute to site eligibility, but may be valuable in addressing six research topics from three research domains (Table 33). The most direct application is for research on adaptive strategies and plant foods; also relevant are discerning and modeling settlement organization, and inferring social patterning from intra-site spatial trends. These tool forms are generally rare in Bay-Delta Area archaeological sites, so a sufficiently large assemblage is necessary to meet data requirements for ground stone related topics beyond simply presence/absence by type.

	Ability of the Data to Address Research Issues		SEE PAGE	
RESEARCH ISSUES	GROUND STONE TOOLS	Bedrock Milling Features	Research Issue	Data Requirements
SETTLEMENTS IN SPATIAL CONTEXTS				
San Francisco Estuary Adaptations	+	-	<u>8-1</u>	<u>8-13</u>
Discerning and Modeling Settlement Organization	++	++	<u>8-13</u>	<u>8-15</u>
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	+	-	<u>8-16</u>	<u>8-19</u>
Bay-Delta Area Sedentism – Causal Factors and Trajectory	++	-	<u>8-21</u>	<u>8-23</u>
EXPLORING CHANGES IN DIET AND HEALTH				
Resource Intensification	++	+++	<u>9-1</u>	<u>9-7</u>
Plant Resource Exploitation	++	+++	<u>9-24</u>	<u>9-29</u>
Construction of Anthropogenic Landscapes	-	+++	<u>9-30</u>	<u>9-32</u>
IMPORTANCE OF TECHNOLOGICAL CHANGE				
Milling Tools, Plant Foods, and Adaptive Strategies	+++	+++	<u>10-1</u>	<u>10-10</u>
TRACKING TRENDS IN PREHISTORIC SOCIAL INTERACTION				
Role of Gender in Social Interaction	+	-	<u>12-3</u>	<u>12-4</u>
Inferring Social Patterning from Intra-Site Spatial Trends	++	-	<u>12-5</u>	<u>12-6</u>
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Table 33. Research Issues Addressed by Ground Stone Tool Analysis.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; +++ = Certain. <u>Page numbers</u> are hyperlinks.

Field Recovery Methods

The first consideration is whether to collect and curate all specimens, or analyze some or all in the field. Considerations include limits on curation space, and whether artifacts will be destroyed or displaced by a project. Many basic metrics and observations can be quickly recorded in the field (see Appendix I for detailed analytical procedures).

Field recording of bedrock milling features should include a drawing, with scale and key; measurements of the outcrop and individual milling areas (length, width, and depth); and photographs with scale⁹. New technologies allow for more detailed mapping of features using total stations and/or camera-mounted drones.

Laboratory Analysis

Simply the presence/absence of the various ground stone implements along with basic morphological attributes offer important information on technological investment (expedient versus. curated, shaped versus unshaped), residential mobility (portable versus stationary), and economic intensification (number and density of tools). Although resource-specific claims have long been made about ground stone tools (e.g., handstone and millingslab = small seed processing), archaeobotanical remains have rarely supported such inferences. More direct evaluation through residue analysis on individual tools has the potential to better clarify the tool-resource relationship. As a result, ground stone artifacts can be rinsed, but areas of potential use-wear could have starch grains or other residues so should not be scrubbed.

Basic attributes on all artifacts should include material type, length, width, and thickness, and descriptive tool type. For functional interpretation, artifacts should be examined for degree of polish; presence of striations—indicative of use direction; battering; shaping; and burning (Appendix I). It is important to include attribute definitions/measurements when ranges are used (e.g., flat, shallow, concave basins). Furthermore, unmodified water-rounded cobbles are often mistaken for ground stone tools, so the proper documentation of use-related wear is critical for demonstrating cultural modification.

Starch Grain Analysis

Starch grains are preserved on ground surfaces where plant materials have been processed. These may include portable ground stone tools and bedrock milling features. Starch grain extraction and preparation vary. We follow methods recently developed by Wisely (2015). Samples are extracted using 15 milligrams of distilled water and a sonic toothbrush. Artifacts or bedrock mortar features should be sonicated for a minimum of 10 minutes before the resulting aqueous sediment can be pipetted into a centrifuge tube for transport. New powder-free gloves, a new sonic toothbrush head, and a new, sterile pipette should be used to extract each sample.

Fine-grained identifications are made based on a combination of measurements and morphology. Some grains may not be identifiable due to a lack of comparative

STARCH GRAIN LAB PROCESSING

- Centrifugal sample distillation
 Sodium polytungstate for heavy liquid flotation
- Mount distilled sample on semi-permanent slide
- Transect slide at 100X magnification under crosspolarized light
- Identify starch grains based on presence of the extinction-cross
- Photograph under 400X magnification using brightfield light and cross-polarized lighting
- Measure morphology and compare to modern comparative collection
- Vibrate slide to rotate starch grain to potentially examine 3D morphology

samples, damage, or being obscured by other grains or materials within the sample. It should be noted that some grains are too small to be visible at 100X magnification.

⁹ See http://ohp.parks.ca.gov/?page_id=28351 for DPR 523F Milling Station Record.

Minimum Reporting Standards

- Methods and criteria for differentiation of tool types and attributes
- Illustrations and/or photographs of a sample of artifacts
- Name of starch grain analyst, methods, and comparative collection used
- Table of raw counts and densities of starch grains
- Appendix with metric and use-wear attributes for each artifact

BONE AND SHELL TOOLS/SHELL BEADS

Bone and shell artifacts are fairly common constituents of Bay-Delta Area sites, and shell beads provide one of the best avenues for identifying the timing of site occupation. Shell beads, as both a chronological marker and coveted trade item, have potential to contribute information germane to nine research issues within four research themes (Table 34). Most notably, they are the key sources of information for refining the accuracy of Scheme D and examining the manufacture and trade of *Olivella* sp. and clamshell beads. Bone and shell tools have more limited relevance to research but may be germane to six topics from four research themes, including most notably the role of gender in social interaction, and reconstructing population movement (Table 34). Generally, sites with robust assemblages of bone and shell tools or shell beads will be eligible for listing on the National Register if found in single component contexts.

	Ability of the Data to Address Research Issues		SEE PAGE	
RESEARCH ISSUES	BONE AND SHELL TOOLS	Shell Beads	Research Issue	Data Requirements
TEMPORAL TRENDS IN OCCUPATION				
Radiocarbon Dates (things you can date)	+++	+++	<u>7-1</u>	<u>7-7, 7-9</u>
Refining Accuracy of Scheme D	-	+++	<u>7-13</u>	<u>7-18</u>
SETTLEMENTS IN SPATIAL CONTEXTS				
Discerning and Modeling Settlement Organization	+	+	<u>8-13</u>	<u>8-15</u>
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	+	+	<u>8-16</u>	<u>8-19</u>
Bay-Delta Area Sedentism – Causal Factors and Trajectory	++	+	<u>8-21</u>	<u>8-23</u>
EXPLORING CHANGES IN DIET AND HEALTH				
Resource Intensification	++	-	<u>9-1</u>	<u>9-7, 9-32</u>
Fishing Trajectories	+	-	<u>9-7</u>	<u>9-10, 9-32</u>
HUMAN DEMOGRAPHY AND POPULATION MOVEMENT				
Reconstructing Population Movements	++	-	<u>11-1</u>	<u>11-3</u>
TRACKING TRENDS IN PREHISTORIC SOCIAL INTERACTION				
Assessing Assertions of Socio-Political Complexity	-	+	<u>12-1</u>	<u>12-2</u>
Role of Gender in Social Interaction	++	+	<u>12-3</u>	<u>12-4</u>
RECONSTRUCTING REGIONAL INTERACTION SPHERES				
Olivella and Clamshell Bead Manufacture and Trade	-	+++	<u>13-8</u>	<u>13-12</u>
Abalone Pendant Exchange	-	++	<u>13-12</u>	<u>13-14</u>
INDIGENOUS ASSIMILATION AND PERSISTENCE				
Assessing Indigenous Persistence	-	+	<u>14-6</u>	<u>14-7</u>

Table 34. Research Issues Addressed by Bone and Shell Tools and Shell Beads.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable;

+++ = Certain. <u>Page numbers</u> are hyperlinks.

Field Recovery Methods

Standard recovery techniques are generally sufficient to recover shell and bone artifacts. Smaller mesh size is preferable for the recovery of shell beads, and heavy fractions from soil samples should be screened through 1/16-inch mesh to recover smaller shell bead types. Soils from human interments and other features are more likely to contain shell beads and bone tools, and should be treated carefully in the field to avoid breaking these fragile artifacts.

Laboratory Analysis

The usefulness of these tool forms is primarily in their identification, but standard methods should be followed in shell and bone tool analysis.

Shell Tools and Beads

Olivella spp. shell bead measurements and classification should follow Bennyhoff and Hughes (1987), with additional metrical criteria, as revised by Milliken in the *California and Great Basin Olivella Shell Bead Guide* (Milliken and Schwitalla 2012). Use of the associated comparative shell bead cast collection is highly recommended, with attention to the primary discriminating characteristics of each type. Shell portion and edge finish, along with diameter, thickness, and perforation diameter, are the best ways to narrow the field of possible types in any bead collection. See Figure 37 (page 7-16) for seriation of Central California radiocarbon dates associated with shell beads.

Bone Tools

There has been no attempt to update the bone tool classification offered by Gifford's (1940) *Californian Bone Artifacts* or Bennyhoff's *Californian Fish Spears and Harpoons* (1950). Until a future synthesis of these tools is carried out, laboratory analysis is limited to basic metrics and descriptions. The fragmentary nature of many assemblages precludes classification by morphological type; rather, only general characterizations can be made. For example, a given fragment might be cylindrical in form or lenticular in cross-section, scored or highly polished. Because some of these features might signal morphological types, or production practices with chronological, functional, or technological implications, the classification of attributes can be related to three kinds of modifications—degree of finish, degree of shaping, and degree of heat-treatment. Other attributes to consider include burin scars and post-depositional observations. Of course, each worked piece should be identified to the most specific taxonomic level possible, resulting in nested classifications ranging from the class level (Pisces, Aves, Mammalia) to the ordinal and more specific levels (i.e., Artiodactyl order, Cervidae family, *Odicoileus* genus, and *Canis latrans* species). Further divisions of Aves and Mammalia can be based on size differences (i.e., small, medium, and large). Each specimen should be identified (where possible) to anatomical element, condition, size, side, age/fusion, and percentage of completeness.

Minimum Reporting Standards

- Metrics on shell beads—type of shell, diameter, thickness, perforation type and diameter
- Methods used to type beads based on Scheme D
- Species/element for bone tools
- Measurements and any modification of bone tools
- Illustrations or scans (including close-ups of modifications) for bone and shell tools

CEREMONIAL FEATURES AND OBJECTS/ORNAMENTS (SHELL, BONE, STONE)

Sites with shell, stone, and bone ornaments, including most notably abalone pendants, found in chronologically discrete contexts, are often eligible for listing on the National Register since they can provide valuable data to interpret a number of research issues—regional interaction spheres, trends in prehistoric social interaction, and population movements (Table 35). Ceremonial features are also a sign that a site was used extensively, or that it held special meaning for its Native occupants.

	Ability of the Data to Address Research Issues		SEE PAGE	
RESEARCH ISSUES	Ornaments (shell, bone, stone)	Ceremonial Features and Objects	Research Issue	Data Requirements
TEMPORAL TRENDS IN OCCUPATION				
Radiocarbon Dates (things you can date)	+++	+	<u>7-1</u>	7-7, 7-9
Refining Accuracy of Scheme D	+	++	7-13	<u>7-18</u>
SETTLEMENTS IN SPATIAL CONTEXTS				
Discerning and Modeling Settlement Organization	+	+++	<u>8-13</u>	<u>8-15</u>
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	-	+++	<u>8-16</u>	<u>8-19</u>
Bay-Delta Area Sedentism – Causal Factors and Trajectory	-	++	8-21	<u>8-23</u>
EXPLORING CHANGES IN DIET AND HEALTH				
Dogs in the Diet	-	++	<u>9-15</u>	<u>9-16, 9-32</u>
HUMAN DEMOGRAPHY AND POPULATION MOVEMENT				
Reconstructing Population Movements	+++	++	<u>11-1</u>	<u>11-3</u>
TRACKING TRENDS IN PREHISTORIC SOCIAL INTERACTION	N			
Assessing Assertions of Socio-Political Complexity	+++	+++	<u>12-1</u>	<u>12-2</u>
Role of Gender in Social Interaction	+++	++	<u>12-3</u>	<u>12-4</u>
Animal Interments - Window into Ceremonial Activities	-	+++	<u>12-4</u>	<u>12-5</u>
Inferring Social Patterning from Intra-Site Spatial Trends	-	++	<u>12-5</u>	<u>12-6</u>
RECONSTRUCTING REGIONAL INTERACTION SPHERES				
Olivella and Clamshell Bead Manufacture and Trade	+++	-	<u>13-8</u>	<u>13-12</u>
Abalone Pendant Exchange	+++	-	<u>13-12</u>	<u>13-14</u>
INDIGENOUS ASSIMILATION AND PERSISTENCE				
Assessing Indigenous Persistence	++	+	<u>14-6</u>	<u>14-7</u>

Table 35. Research Issues Addressed by Ceremonial Features and Bone, Shell, and Stone Ornaments.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable;

+++ = Certain. <u>Page numbers</u> are hyperlinks.

Data recovery techniques are unlikely to change based on the presence of either of these data classes, though the excavation of rapid recovery units and systematic stripping of deposits within a project's Area of Direct Impact (ADI) are advisable when ceremonial features are known or suspected at a site.

Field Recovery Methods

Field recovery methods for ornaments do not deviate from standard techniques. Many ornaments will be associated with human remains; similar protocols described below for the recovery and treatment of burials also apply to burial-associated objects.

Ceremonial features should be carefully excavated similar to any other feature on a site. Many ceremonial features in the San Francisco Bay-Delta Area are interments of animals. These should be excavated in a fashion similar to human burials, with matrix removed to pedestal all bone and associated artifacts. Once this pedestalling is complete, a plan view map should be drawn and a photograph taken. Soil associated with ceremonial features should be screened separately or taken as a bulk sample for micro-constituent processing. Non-interment ceremonial features can be fully exposed, then cross-sectioned to delineate the profile and plan outlines of the feature. Artifacts and ecofacts collected from these features should be bagged and recorded separately.

Laboratory Analysis

All ornaments should be analyzed in the manner described in the preceding discussion of bone and shell tools. Shell artifacts may be examined in light of Gifford's (1947) *California Shell Artifacts,* though descriptive labels of artifacts, such as the typology provided in Table 10 of Bennyhoff and Hughes (1987:144), are preferred to the unsupported functional categories provided by Gifford (see also Bouey 1995:Appendix G).

Feature artifacts should be kept separate from non-feature contexts in site catalogues and analytical tables, but otherwise treated as proscribed under individual artifact headers in this section.

Possible Special Analyses

Ceremonial features include animal interments, in particular dog burials. The remains from dogs and other animals can be submitted for isotopic and DNA analysis to reconstruct human and canine diets (isotopes) and population histories of domesticated and non-domesticated canids. Specific methods for these special analysis and examples of studies in the Bay-Delta Area are provided in the *Dietary Bone* section below (see ahead to page 15-22).

Minimum Reporting Standards

- Plan views and profiles of features, possibly with photographic overlays
- Tables of artifacts and ecofacts recovered from feature contexts, by temporal component
- Photographs, scans, or illustrations of ornaments
- Tables or appendices with all basic measurements of stone, shell, and bone ornaments

MIDDEN (ANTHROPOGENICALLY ENRICHED SEDIMENT)/ ANTHROPOGENIC STRATIGRAPHY

Anthropogenic stratigraphy and midden are called out as distinct data types, and the presence of midden is called out as important to 16 research topics from five research themes (Table 36). The presence of midden is not, per se, a sufficient condition for site eligibility. Instead, artifact and ecofact constituents of midden offer the potential to address research issues. Similarly, data recovery techniques should be designed around recovering specific artifact types rather than targeting midden deposits, as midden development is often the product of repeated, long-term use of the same location, frequently resulting in chronologically mixed deposits.

Field Recovery Methods

Identification of stratigraphic and spatial variability within midden deposits is essential. It is often easy to differentiate midden and non-midden soils; however, identifying distinct stratigraphic units and horizons within midden deposits is more difficult. The production of master site profiles by a

	ABILITY OF THE Reseat	Ability of the Data to Address Research Issues		SEE PAGE	
RESEARCH ISSUES	Anthropogenic Stratigraphy	Midden (anthropogenic enriched sediment)	Research Issue	Data Requirements	
TEMPORAL TRENDS IN OCCUPATION					
Radiocarbon Dates (things you can date)	+++	+++	<u>7-1</u>	7-7, 7-9	
Obsidian Hydration as a Chronological Tool	+	-	<u>7-9</u>	<u>7-13</u>	
Refining Accuracy of Scheme D	-	+	<u>7-13</u>	<u>7-18</u>	
SETTLEMENTS IN SPATIAL CONTEXTS					
San Francisco Estuary Adaptations	++	++	<u>8-1</u>	<u>8-13</u>	
Discerning and Modeling Settlement Organization	++	++	<u>8-13</u>	<u>8-15</u>	
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	+++	+++	<u>8-16</u>	<u>8-19</u>	
Bay-Delta Area Sedentism – Causal Factors and Trajectory	+++	+++	<u>8-21</u>	<u>8-23</u>	
Seasonality of Occupation	++	++	8-23	<u>8-25</u>	
EXPLORING CHANGES IN DIET AND HEALTH					
Resource Intensification	++	++	<u>9-1</u>	<u>9-7, 9-32</u>	
Fishing Trajectories	++	++	<u>9-7</u>	<u>9-10, 9-32</u>	
Species-Specific Exploitation Histories	++	++	<u>9-10</u>	<u>9-15, 9-32</u>	
Dogs in the Diet	++	++	<u>9-15</u>	<u>9-16, 9-32</u>	
Shellfish gathering	++	++	<u>9-18</u>	<u>9-24, 9-32</u>	
Plant Resource Exploitation	++	++	<u>9-24</u>	<u>9-29, 9-32</u>	
Construction of Anthropogenic Landscapes	++	++	<u>9-30</u>	<u>9-32, 9-32</u>	
IMPORTANCE OF TECHNOLOGICAL CHANGE					
Milling Tools, Plant Foods, and Adaptive Strategies	-	++	<u>10-1</u>	<u>10-10</u>	
TRACKING TRENDS IN PREHISTORIC SOCIAL INTERACTION					
Inferring Social Patterning from Intra-Site Spatial Trends	++	++	<u>12-5</u>	<u>12-6</u>	

Table 36. Research Issues Addressed by Midden and Anthropogenic Stratigraphy.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; +++ = Certain. <u>Page numbers</u> are hyperlinks.

qualified geoarchaeologist/geologist is essential for documenting micro- and macro-stratigraphic patterns in occupation. Without detailed stratigraphic analysis, discrete chrono-stratigraphic site components may be missed and data potential lost.

Data recovery excavations within, stratified midden deposits can proceed using stratigraphic rather than arbitrary excavation techniques. Finely laminated midden deposits may include strata that are less than 10 centimeters in depth, or that do not parallel the ground surface, and might be missed or cross-cut using standard, arbitrary, 10-centimeter levels.

Fire-Affected and Fire-cracked Rock

Fire-affected and fire-cracked rocks are common constituents of anthropogenic midden deposits, and make up a large proportion of shell mound and other residential assemblages. Conventional field methods (if documented at all) have typically included weighing (to the nearest kilogram) and counting fire-affected rock from a given provenience/unit-level, and then discarding it on-site. To this point, fire-affected rock (i.e., cooking stones—not always fire-affected) has been an often neglected constituent of many sites and may hold much more potential than traditionally recognized, either by informing us

about cooking practices (Black and Thoms 2014; Thoms 2008, 2009), or yielding residues related to the types of resources processed (e.g., Thoms et al. 2015; see *Starch Grain Analysis*, page 15-7).

Minimum Reporting Criteria

- Detailed soil/stratigraphic profiles of unit and trench sidewalls prepared by a geoarchaeologist/geologist
- Soil descriptions tied to chronological data from midden constituents to form discrete chronological components
- Temporal components identified by stratigraphic unit

STRUCTURAL FEATURES

Structural features generally include house floors and storage pits, but are rarely preserved (or simply not identified when present) in Bay-Delta Area archaeological sites. Those that contain intact features can contribute to nine discrete research topics within five research themes—sedentism, intra-site social trends, and regional settlement patterns (Table 37). Due to the rarity of such features, when they are present, the site is almost certainly eligible for the National Register.

Data recovery should focus on large block excavations to expose structural features and fully delineate composition and internal organization. Soil and other samples should be obtained from within and outside of the feature.

	ABILITY OF THE	SEE PAGE	
RESEARCH ISSUES	Data to Address Research Issues	Research Issue	Data Requirements
TEMPORAL TRENDS IN OCCUPATION			
Radiocarbon Dates (things you can date)	+++	<u>7-1</u>	<u>7-7, 7-9</u>
Refining Accuracy of Scheme D	++	<u>7-13</u>	7-18
SETTLEMENTS IN SPATIAL CONTEXTS			
Discerning and Modeling Settlement Organization	+++	<u>8-13</u>	<u>8-15</u>
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	++	<u>8-16</u>	<u>8-19</u>
Bay-Delta Area Sedentism – Causal Factors and Trajectory	+++	8-21	<u>8-23</u>
Seasonality of Occupation	++	<u>8-23</u>	<u>8-25</u>
EXPLORING CHANGES IN DIET AND HEALTH			
Plant Resource Exploitation	++	<u>9-24</u>	<u>9-29, 9-32</u>
IMPORTANCE OF TECHNOLOGICAL CHANGE			
Milling Tools, Plant Foods, and Adaptive Strategies	++	<u>10-1</u>	<u>10-10</u>
Social/Economic Implications of the Bow and Arrow	++	<u>10-10</u>	<u>10-14</u>
TRACKING TRENDS IN PREHISTORIC SOCIAL INTERACTION			
Inferring Social Patterning from Intra-Site Spatial Trends	+++	<u>12-5</u>	<u>12-6</u>
Notes: Define the shility of the data to address the research issue Limited likelihood, - Dessible.			

Table 37. Research Issues Addressed by Structural Features.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; +++ = Certain. <u>Page numbers</u> are hyperlinks.

Field Recovery Methods

The full horizontal extent of structural features should be delineated stratigraphically by expanding excavation away from the control unit in which the feature was identified, usually using 1-x-1- or 1-x-2-meter blocks. Full recordation of the feature, both in plan and profile, should be undertaken using standard mapping techniques or with laser or camera-based mapping software programs. Matrix removed from within the structural feature should be screened separately, and a number of soil samples should be taken from atop and within the feature itself. Once it has been recorded, excavation may continue into the feature to expose a full profile. The profile should be drawn and photographed.

An important issue relating to the archaeology of structures is formation processes, including spatial patterning, sub-features, abandonment, refuse, burning, and post-habitation fill. Heizer and Graham (1967:73), in their field guide to archaeology, state:

[architectural] remains will frequently present an infinitely confusing array of fragmentary structural features...It will be the excavator's task to sort out precisely the various steps in the sequence of events...Cultural deposits in architectural remains are often confused and complicated by the construction, use, and subsequent alteration of structures.

Features, identified as "fixed construction elements or furniture" within a structure, are important indicators of function (e.g., food processing, storage, artifact maintenance; Byrd 2005:103). These include hearths, pits, post holes, and entrances. They are often the sole evidence of function left within a structure following either rapid or slow abandonment.

In relation to horizontal and vertical distributions of artifacts within depression features, more often than not, they reflect mixed deposits. Attempts to distinguish any possible stratigraphic patterning would ideally focus on findings from a minimum of three distinct vertical stratigraphic contexts: (1) fill slough; (2) roof collapse; and (3) floor. Of particular importance is distinguishing floor zone material from fill material; association of varied artifacts above the floor is often ambiguous at best. Besides obtaining samples of the floor for in-depth analysis (e.g., dietary remains), excavation of the floor can reveal caches and pits, clearly associated items.

Minimum Reporting Criteria and Curation

- Detailed mapping of structural features in plan view and profile
- Photographs
- Results of artifact collection organized by location in relation to the feature (e.g., within, on, outside)

HUMAN REMAINS/BURIALS

Sites with intact human burials are almost always considered eligible for listing on the National Register. From a research perspective, there is tremendous data potential from basic recording and more advanced and minimally destructive special studies (Table 38). Fragmentary and redeposited human remains have relatively less research potential, but can still be used for special studies outlined below. In addition, there is tremendous cultural and spiritual relevance of human remains to modern Native Americans.

Prior to initiating data recovery at a site with known or suspected human interments, an agreement should be made between the MLD and the lead agency that outlines the procedures for removing and analyzing any human remains identified during either data recovery excavations or project implementation¹⁰. Generally, data recovery excavation occurs within the ADI; therefore, prior to the start of

¹⁰ http://nahc.ca.gov/resources/discovery-of-native-american-human-remains-what-to-do/

	ABILITY OF THE	SEE PAGE		
RESEARCH ISSUES	ADDRESS RESEARCH ISSUES	Research Issue	Data Requirements	
TEMPORAL TRENDS IN OCCUPATION				
Radiocarbon Dates (things you can date)	+++	<u>7-1</u>	<u>7-7, 7-9</u>	
Refining Accuracy of Scheme D	+++	7-13	<u>7-18</u>	
SETTLEMENTS IN SPATIAL CONTEXTS				
San Francisco Estuary Adaptations	++	<u>8-1</u>	<u>8-13</u>	
Discerning and Modeling Settlement Organization	++	<u>8-13</u>	<u>8-15</u>	
Bay-Delta Area Sedentism – Causal Factors and Trajectory	++	<u>8-21</u>	<u>8-23</u>	
EXPLORING CHANGES IN DIET AND HEALTH				
Resource Intensification	+++	<u>9-1</u>	<u>9-7</u>	
Fishing Trajectories	+	<u>9-7</u>	<u>9-10</u>	
Diet and Health from Human Remains	+++	<u>9-29</u>	<u>9-30</u>	
HUMAN DEMOGRAPHY AND POPULATION MOVEMENT				
Reconstructing Population Movements	+++	<u>11-1</u>	<u>11-3</u>	
Prehistoric Demographic Transitions	+++	<u>11-3</u>	<u>11-12</u>	
Violence-Related Activities	+++	<u>11-12</u>	<u>11-14</u>	
TRACKING TRENDS IN PREHISTORIC SOCIAL INTERACTION				
Assessing Assertions of Socio-Political Complexity	+++	<u>12-1</u>	<u>12-2</u>	
Role of Gender in Social Interaction	+++	<u>12-3</u>	<u>12-4</u>	
Inferring Social Patterning from Intra-Site Spatial Trends	++	12-5	<u>12-6</u>	

Table 38. Research Issues Addressed by Human Remains and Burials.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; +++ = Certain. <u>Page numbers</u> are hyperlinks.

construction, a final removal of all affected site deposits should be undertaken to insure all human burials are properly identified and respectfully removed.

Field Recovery Methods

Most pre-contact sites in the Bay-Delta Area were used for hundreds of years, if not millennia, and most cemetery sites in this region include human graves emplaced over a similarly long time span. As a consequence, one of the more challenging tasks is to determine which period(s) of site use a particular grave is associated with. While some graves may have temporally diagnostic beads or other artifacts that allow for dating, most will not. As a consequence, the first step in determining the age of an individual burial begins in the field, with careful stratigraphic observations, including the depth of each individual grave below ground-surface, as opposed to (or, in addition to) an arbitrary datum. Knowing the depth below surface is critical for reconstructing the vertical relationship between graves and, ultimately, their chronological relationship.

Once removed from the project's ADI, the site's MLD should be consulted prior to any analysis. These discussions should include the types of analyses that could be performed, the effects of those analyses on the physical remains (i.e., whether they are destructive, the amount of bone/tooth required), and what information might be gained. If invasive sampling is permitted, further discussion should include the disposition of unprocessed material from analyses (i.e., should unprocessed bone be returned for reburial?) and how the data will be disseminated to the public, appear in reports, or appear in scholarly articles.

Osteological analyses constitute the basic recording of burial features. *In situ* analysis should minimally include the position and aspect of the remains, any associated artifacts, and any other contextual information which will be lost when the remains are removed (e.g., stratigraphic observations). Recordation should include detailed feature mapping and, if permitted, photographs. Individual bones should be labelled on the sketch, as necessary for clarity.

Laboratory Analysis

Once removed, basic osteological information can be obtained, including measurements on long bones and crania that allow for estimates of stature. Examination of non-metric traits can reveal sex of the individual, and observation of all elements can

OSTEOLOGICAL ANALYSIS

- Inventory of skeletal elements present
- Age, sex, stature
- Dental wear and disease
- Non-metric genetic traits
- Pathologies, injuries, cultural modifications
- Archeometric Analysis
- Very small samples required
- AMS dating of death
- DNA for ancestry and genetic affinities
- Stable isotopes
- \circ $% \left({{\rm{where}}\;{\rm{an}}\;{\rm{individual}}} \right)$ where an individual was born, grew up, and died in the same location
- o trace diet from childhood (including weaning) onward
- Tooth calculus for bacteria DNA, phytoliths, and inhalants (e.g., tobacco)

provide evidence of trauma or paleopathologies. These analyses do not require a laboratory setting. Ideally, an osteologist will be allowed to take possession of the remains and have sufficient time to complete analysis, but field analysis is also possible. Results should follow the *Standards for Data Collection from Human Skeletal Remains* by Buikstra and Ubelaker (1994). New archaeometric applications are constantly being applied to the archaeological record in California, and future work should consider taking advantage of cutting-edge techniques to analyze archaeological specimens.

Remote Sensing for Human Remains

It is important to identify all potential human remains prior to the beginning of construction activities. Remote sensing techniques may be useful in this process by identifying locations within a large project area where remains may be present. Techniques in the San Francisco Bay-Delta Area include the use of forensic dogs and ground penetrating radar. The former uses the scent of decomposing human remains to locate graves. Ground penetrating radar can recognize disturbances in the ground surface that might be human interments or other cultural features. Finally, systematic mechanical excavation of a project's ADI allows for the identification and recovery of features and human interments prior to construction, and may be used to "ground truth" remote sensing techniques. Typically, this is accomplished in shallow scrapes using a backhoe or excavator equipped with a smooth-cutting blade.

Stable Isotope Analysis

Archaeometric analysis of bone and tooth is a rapidly expanding field, and new discoveries and methods are being made regularly. Current archaeometric analyses of small samples of **collagen and apatite** can provide insight into the age of weaning and changes in diet, health, and residence over an individual's life time through analysis of stable isotope ratios of nitrogen, carbon, strontium, and sulfur (e.g., Bartelink 2006, 2009; Beasley et al. 2013; Eerkens et al. 2014; Gardner 2013; Graham 2006; Greenwald and Burns 2016; Leventhal et al. 2010, 2011; Morgan and Dexter 2008; Van Bueren and Love 2008). Bone can be sent to the laboratory for processing. Very small samples are obtained from a bone fragment or tooth, and the apatite and collagen are extracted. The remainder of the material can be returned for reburial.

Paleogenomics and Mitochondrial DNA

DNA analyses have become increasingly powerful and cost-effective in recent years with the advent of genome sequencing machinery and data. A very small sample can provide a detailed genetic make-up of an individual. DNA is extracted from a bone or tooth fragment and a genomic library, generating around 200 million sequence reads, is created.

Dental Calculus

Other recent advances include the use of **dental calculus** to gain insight into past bacterial diseases through identification of DNA, as well as pre-contact use of tobacco by identifying the chemical compounds of nicotine (Eerkens et al. 2014, 2016) preserved in the calculus.

Minimum Reporting Criteria and Curation

- Specific age or time period of individual burials using temporally diagnostic associations (e.g., shell beads), radiocarbon dates, and stratigraphic context
- Burial associations
- Appendices—burial forms

PLANT REMAINS

Plant remains are certain to contribute to at least five identified research topics under the temporal trends in occupation, exploring changes in diet and health, importance of technological change, and indigenous assimilation and persistence research domains. Recovery of plant remains offers the most secure and abundant source of non-shell carbon to date sites. Direct dietary data are available from plant remains, and therefore high densities can contribute to myriad issues related to diets, health, and associations between technological change, diet, and settlement (Table 39).

For sites determined eligible under research domains that include plant remains as data, methods should target well-dated contexts, and a large number of soils samples should be obtained for flotation processing to recover archaeobotanical remains for analysis.

Field Recovery Methods

All archaeological excavations should retrieve bulk sediment through column samples (for vertical and horizontal control) or selective stratigraphic sampling (features, single component areas) to recover small materials routinely missed during field screening, as well as for radiocarbon dating (see Chapter 6). In addition to carbonized plant remains recovered using the flotation technique, soil samples are an excellent way to recover small fish bones through wet-screening (1.5- and 0.75-millimeter mesh). The bulk sediment samples should be dispersed and large enough to characterize the full range of fish and plant species and to discern spatial and temporal variation in these remains.

	Ability of the Data to	SEE PAGE			
RESEARCH ISSUES	ADDRESS	RESEARCH	DATA		
	RESEARCH ISSUES	ISSUE	REQUIREMENTS		
TEMPORAL TRENDS IN OCCUPATION					
Radiocarbon Dates (things you can date)	+++	<u>7-1</u>	<u>7-7, 7-9</u>		
Obsidian Hydration as a Chronological Tool	+	<u>7-9</u>	7-13		
Refining Accuracy of Scheme D	+	7-13	7-18		
SETTLEMENTS IN SPATIAL CONTEXTS					
San Francisco Estuary Adaptations	++	<u>8-1</u>	8-13		
Discerning and Modeling Settlement Organization	++	<u>8-13</u>	<u>8-15</u>		
Construction, Structure, and Function of Bay-Delta Area	++	<u>8-16</u>	<u>8-19</u>		
Mounds and Middens					
Bay-Delta Area Sedentism – Causal Factors and Trajectory	+	8-21	<u>8-23</u>		
Seasonality of Occupation	++	8-23	<u>8-25</u>		
EXPLORING CHANGES IN DIET AND HEALTH					
Resource Intensification	+++	<u>9-1</u>	<u>9-7, 9-32</u>		
Plant Resource Exploitation	+++	<u>9-24</u>	<u>9-29, 9-32</u>		
Construction of Anthropogenic Landscapes	+++	<u>9-30</u>	<u>9-32, 9-32</u>		
IMPORTANCE OF TECHNOLOGICAL CHANGE					
Milling Tools, Plant Foods, and Adaptive Strategies	+++	10-1	<u>10-10</u>		
Social/Economic Implications of the Bow and Arrow	++	10-10	<u>10-14</u>		
INDIGENOUS ASSIMILATION AND PERSISTENCE					
Assessing Indigenous Persistence	++	<u>14-6</u>	<u>14-7</u>		

Table 39. Research Issues Addressed by Plant Remains.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; +++ = Certain. <u>Page numbers</u> are hyperlinks.

Column Sampling

Column samples are taken primarily to recover controlled, vertical and horizontal samples from select excavation units in different site contexts. They should be collected systematically by stratigraphic deposit or arbitrary 10-centimeter level, and include samples from all temporal components and loci. The size of these samples is largely dependent on the nature and age of the archaeological sediments encountered; older deposits typically require larger samples.

Samples can be taken from selected unit sidewalls showing the least disturbance and clearest stratigraphic profile. If the cultural deposit is deep and requires shoring, a unit corner can be designated for sediment sampling. Soil from each level can be placed in a bucket to a marked 10liter line, bagged, and tagged prior to excavating the rest of the level. While this method can also be done in lieu of a sidewall column sample, its location cannot be based on observed sidewall profiles unless adjacent to a previously excavated unit.

COLUMN SAMPLING

- Recover controlled vertical and horizontal samples
 Select units by comparent or contact.
- Select units by component or context
 - Dependent on site size, deposit thickness, spatial variability
- Collect stratigraphically or by 10-centimeter levels
 Sample size:
 - 10x10x10 centimeters in rich dense middens
 - 20x20x10 centimeters in sparse middens or diffuse or thin deposits
- Sample from unit sidewall
 - Select least disturbed
 - Excavate after profile completed
- Record on unit plan and section drawings
- Take corner sample of level

0

- Quicker method, but lacks strategic choice of sample
 - Use if shoring makes sidewall inaccessible
- Fill bucket to 10-liter line prior to excavating rest of unit; bag and tag sample

Feature and Unique Context Sampling for Flotation

Sediment samples from features, strata, or unique contexts (small ash lens or other thin or spatially limited archaeological deposit) should be collected for fine mesh wet screening and flotation. **Samples should be taken from within and adjacent to features and other unique contexts to ensure adequate comparisons**. For example, samples from within hearths rarely contain abundant carbonized plant remains but samples adjacent to hearths often yield well-preserved context-associated material. All samples should be plotted on plan or profile drawings of the unit.

Sediment sampling should not be limited to feature contexts. While many features can produce abundant plant remains, they are, by definition, atypical deposits that can give a skewed picture of fish and plant use (Lennstrom and Hastorf 1995). Midden samples provide robust plant remains.

In the past, study of carbonized plant remains at

FINE MESH WET SCREEN & FLOTATION SEDIMENT SAMPLING

- Collect sufficient sediment from the full range of midden contexts
- Sample size
 - o At least 10 liters
 - 15-25 liters at older or seasonally occupied sites
- Collect data from single component areas and a representative sample of site variability
- Frequent errors in sample collection:
- Focusing solely on feature contexts and ignoring adjacent sediments or midden deposits
- Collecting sediment samples that are too small
- o Collecting too few samples

some sites with good preservation has been compromised by collecting samples that were too small. Most archaeobotanists suggest collecting at least 10 liters of sediment per sample (D'Alpoim Guedes and Spengler 2014; Pearsall 2015). For older component sites or small, seasonally occupied deposits, particularly along the ocean or bayshore where plant remains are usually less common, 15–25-liter samples are more appropriate. More extensive excavations, including all data-recovery projects, warrant more extensive sampling and analysis (10 or more samples per temporal component), while one or two test units require fewer samples to obtain the full range of undisturbed, productive contexts. Samples may be discarded in the laboratory if appropriate, and in consultation with Caltrans.

Laboratory Analysis

Macrobotanical remains are identified from light-fraction samples derived from the flotation technique used to recover systematic samples of charred plant remains (Table 40). Samples must be dried out prior to flotation; damp charred plant material does not float as readily as when it is dry. Sediment sample volume **must be** measured to the nearest 0.1 liter to allow for density studies to account for variability in plant frequency and intensity of use between samples, components, and sites.

Since dense charred nutshell (and to a lesser extent berry pits) is common in regional archaeological sites, flotation techniques must target materials less likely to be recovered by simple water separation. Such remains often are suspended in flotation below the surface, and must be collected by decanting the water from the non-buoyant sediment, bone, shell, and stone. There is no substitute for experienced personnel in conducting flotation.

Small seeds are also an important part of charred plant dietary assemblages. Using a mesh opening no larger than 0.4-millimeter (40 mesh/inch) for the light fraction (materials that float or are in suspension, mostly plant materials) ensures recovery of the full range of small seeds. Heavy fraction (materials that do not float) should be washed through 1-millimeter (1/16-inch) or 0.7-millimeter (1/24-inch) mesh to recover small-scale remains, notably fish bone but sometimes small beads and bead fragments.

Table 40. Plant Macrofossils Collection, Processing, Documentation, and Curation Procedures.

SEDIMENT SAMPLE COLLECTION	FLOTATION PROCESSING	LIGHT FRACTION SORTING	DOCUMENTATION AND CURATION
SEDIMENT SAMPLE COLLECTION Context: collect sediment samples for flotation from features, middens, discrete strata, distinct site areas Size: 10-liters or more per sample; larger if old component or sparse deposit Number: more is always better Test Excavations: full range of site contexts Data Recovery: full range of site contexts; at least 10 total samples Column Samples provide greatest flexibility in site sampling, but can consume storage space until processed Procedures: Keep Sample Log Assign sample number List full provenience Use Stout Garbage Bags Double bag if necessary Label Using Two Pieces of Flagging Tape List site, provenience, sample number Put one inside Tie second label to close bag DO NOT tie knot using bag itself	FLOTATION PROCESSING Prior to Flotation: Fully dry out samples first Measure volume in liters (to 0.1 liter) Weigh sample in kilograms Update sample log with volume and weight Keep small sediment samples if instructed by principal investigator Flotation: By trained personnel only Use 0.4-mm or smaller mesh to collect light fraction Use 1/16- or 1/24-inch mesh for heavy fraction Use technique that recovers denser materials (decant water) Collect light fraction in fine-mesh nylon chiffon Hang to drain and dry (may take several days)	 LIGHT FRACTION SORTING Dry out completely prior to handling Size-sort light fraction by size grade: 2-millimeter (10/inch) 1-millimeter (24/inch) 0.7-millimeter (35/inch) Sorted or checked by experienced California archaeobotanist using a comparative collection of California reference materials Sort constituent kinds by size grade: nutshell/berry pits to 0.7-mm (to 0.5-mm if absent in larger grades) small seeds to 0.5-mm wood charcoal samples to 1-mm roots/corms and non-grain amorphous pieces to 2-mm Sort all or at least 25% of each size grade (smaller % OK for wood charcoal) bag sorted vs. unsorted materials separately, and label each accordingly Weigh charcoal, nutshell, and berry pits to 0.1 mg Tag for each sorted constituent Store constituents by taxon/type in separate vials by taxon and size grade; code tags for provenience, size grade, and taxon Identify wood charcoal or send for 	DOCUMENTATION AND CURATION Report: Describe Flotation Methods Provide by-sample table of results Give results as density of finds per liter of sediment List for each site component area: Number of samples sorted Total liters of sediment sorted Number of Identified Specimens (NISP) Curation: Use plastic centrifuge tubes for constituents Use 4-mil plastic bags for light fractions Curate all sorted and unsorted light fractions Curate all identified constituents Bag all specimens of each constituent by taxon Acid-free paper label for each constituent bag Include explanation of curation and list of taxa codes Give one catalogue number to the entire bag of all sorted constituents

Light Fraction Sorting

Light fractions must be completely dry before size- and constituent sorting. **Only carbonized plant remains should be recorded when studying pre-contact sites**—uncarbonized material is undoubtedly intrusive. A 0.7-millimeter screen is recommended, in addition to more standard 2.0-millimeter, 1.0-millimeter, and 0.5-millimeter mesh. The 0.7-millimeter size grade is a useful cut-off for sorting nutshell and berry pits, while the 0.5-millimeter grade is used to recover a broader range of small seeds. Sorting nutshell to the 0.7-millimeter grade is recommended to fully assess nut use and to compare with regional sites. As California, like everywhere else, has its particular mix of plants that requires regional, and sometimes local, expertise to identify, an archaeobotanist with California experience should sort or quality-control light fractions sorted by technicians.

Sometimes carbonized plant remains can be very dense, and subsampling is appropriate to stay within project budgets. When possible, we recommend sorting no fewer than 25% of a size grade, although there are contexts with thousands of nutshell and/or seed remains that can appropriately be subsampled substantially less. Ideally, sampling strategies should be as consistent as possible across size grades and contexts. Samples of wood charcoal (from the 2.0-millimeter and 1.0-millimeter grades, often much less than 25%) must be sorted to calculate their frequency, a useful standard against which the frequency of dietary debris can be measured (Pearsall 2015). Wood charcoal samples can also be used to identify the range of woody plants present in light fractions.

Wood charcoal samples, plant dietary debris, and other constituents of light fractions should be sorted from bulk light fraction material and stored in bulk by constituent type (e.g., all pieces of a taxon sorted) and size grade in curation-ready hard plastic translucent centrifuge tubes. Acid-free paper tags, labeled with site number, flotation sample number keyed to unique provenience, size grade, and a constituent code number, should be inserted in each centrifuge tube.

Phytolith and Diatom Analysis

The phytolith extraction method from soils varies slightly between workers. In each case, a heavy liquid, such as a 2.3 gram/mol sodium polytungstate solution is used to separate biogenic silica from soil. Phytolith removal from artifacts and teeth typically requires sonication. Phytolith isolates are mounted on slides in immersion oil to allow for three-dimensional rotation, cells are counted under a standard petrographic microscope along non-overlapping transects until at least 200 short-cell phytoliths are counted in concordance with statistical methods (Piperno 2006).

Diatoms can also be extracted and counted using the same method. Diatoms, or microscopic algae, abundant in certain soils and lacustrine sediments, hold information about water salinity and depth, and substrate and cover (Smol and Stoermer 2010), important information for reconstructing the paleoenvironments of the Bay-Delta Area.

Other Techniques

Several other techniques are available and have been use in the San Francisco Bay-Delta Area. These include pollen studies and other microfloral studies that provide paleoenvironmental information, and charcoal identification studies. These are new and changing fields, and identifying specific methods here for each one is impractical since these descriptions would quickly be out of date. Instead, several things should be kept in mind when considering these advanced technical studies. First, sampling techniques may be required that are different from standard recovery in archaeological settings. As a result, archaeological Principal Investigators who plan to use any non-standard archaeometric technique should consult with specialists **prior to fieldwork** to obtain a sampling protocol that targets these specific datasets. Second, many of these special analyses are carried out in academic settings where the timeframe

of CRM archaeology cannot always be met. This time delay should not preclude these studies, but cultural resources managers should bear these scheduling issues in mind when authorizing and carrying out special studies. Third, although many assume that these special studies are expensive and therefore resist using them, most are quite cost-effective and provide more information than many other analyses that cost the same amount (i.e., faunal or lithic analyses of non-component portions of an assemblage).

Minimum Reporting Criteria and Curation

• Table of results by sample, including the density (parts per liter) and raw numbers of counts either in the text or as an appendix.

DIETARY BONE

Dietary bone offers direct evidence of diet, and can be used to address research topics from five different research domains (Table 41). To provide sufficient data potential to make a site eligible for listing on the National Register under Criterion D, however, a site must have a relatively large sample of bone identifiable to species, genus, or (minimally) family level in intact contexts. Large assemblages of highly fragmented, unidentifiable bone, or the inability to place faunal assemblages within discrete temporal components, preclude addressing regional research issues.

	ABILITY OF THE	SEE PAGE	
RESEARCH ISSUES	ADDRESS	RESEARCH	DATA
	RESEARCH 1550E5	155UE	REQUIREMENTS
TEMPORAL TRENDS IN OCCUPATION			
Radiocarbon Dates (things you can date)	+++	<u>7-1</u>	<u>7-7, 7-9</u>
Refining Accuracy of Scheme D	+	<u>7-13</u>	7-18
SETTLEMENTS IN SPATIAL CONTEXTS			
San Francisco Estuary Adaptations	++	<u>8-1</u>	<u>8-13</u>
Discerning and Modeling Settlement Organization	+	<u>8-13</u>	<u>8-15</u>
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	++	<u>8-16</u>	<u>8-19</u>
Bay-Delta Area Sedentism – Causal Factors and Trajectory	+	8-21	<u>8-23</u>
Seasonality of Occupation	++	8-23	8-25
EXPLORING CHANGES IN DIET AND HEALTH			
Resource Intensification	+++	<u>9-1</u>	<u>9-7, 9-32</u>
Fishing Trajectories	+++	<u>9-7</u>	<u>9-10, 9-32</u>
Species-Specific Exploitation Histories	+++	<u>9-10</u>	<u>9-15, 9-32</u>
Dogs in the Diet	+++	<u>9-15</u>	<u>9-16, 9-32</u>
Construction of Anthropogenic Landscapes	+	<u>9-30</u>	<u>9-32</u>
IMPORTANCE OF TECHNOLOGICAL CHANGE			
Social/Economic Implications of the Bow and Arrow	+++	<u>10-10</u>	<u>10-14</u>
INDIGENOUS ASSIMILATION AND PERSISTENCE			
Assessing Indigenous Persistence	++	<u>14-6</u>	<u>14-7</u>

Table 41. Research Issues Addressed by Dietary Bone.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; +++ = Certain. <u>Page numbers</u> are hyperlinks. Data recovery methods for sites determined eligible under these research topics should focus on obtaining large samples of bone from temporal components. The type of bone (e.g., large versus small mammal, fish, bird) will determine recovery methods.

Field Recovery Methods

Dietary bone includes mammal, fish, reptile, and bird. Analytical results are heavily dependent on field sampling techniques, most notably on the mesh size used and whether wet- or dry-screening is employed. It is general practice to collect all bone from screens.

Six-millimeter (1/4-inch) screen should be used rarely when smaller animal taxa are suspected, or should constitute only a subsample of all screened deposits (e.g., when

SCREENING TECHNIQUES FOR DIETARY BONE

- Dry screening dry, loose sediments
- Wet screening clays, wet soils
- Indicate mesh size in field forms and catalogue
- Detail and summarize in report
- Tabulate total volume (liters or cubic meters) excavated by sampling/screen size technique

determining site boundaries). Three-millimeter (1/8-inch) screen is the default standard for Bay Area and Delta sites. This mesh will catch most mammalian and avian remains. However, some soil samples should be collected to process for smaller fish bone in the lab.

Laboratory Analysis

Vertebrate faunal remains are some of the most commonly recovered archaeological constituents. In general, all remains recovered from 1/4- and 1/8-inch mesh should be analyzed. Subsampling from these contexts, however, is recommended if samples are large and complex. To recover a representative sample of fish bone, which includes many tiny, identifiable specimens, collected soil samples should be passed through 1.5-millimeter (1/16-inch) and possibly 0.75millimeter (1/32-inch) mesh as **the majority of fish species of interest in the Bay-Delta Area are recovered only from sediments screened through these smaller screens.** Flotation-processed soil samples for plant remains (see *Plant Remains, Field Recovery Methods*, page 15-18) can also be processed for fish bone. Similar to plant remains, it is

VERTEBRATE FAUNAL ANALYSIS

- Subsample large quantities from dated components
- Identification
- Record:
 - o Element
 - Portion of element
 - Weight
 - Demographic information (sex, age)
 - Cultural and natural modification
 - o Burning, cut marks, polish weathering
- Burned or unburned; degree (Lyman 1994)
- o Tabulated by temporal component
- Indicate sediment volume of sample

important to collect feature and non-feature soil samples for a representative fish sample. There is usually a high number of unidentifiable fish remains (generally classified as "ray-finned fish" by Bay-Delta Area faunal analysts), often requiring analysis of all available fishbone to obtain a representative sample.

Identifying meaningful patterns through time in archaeological assemblages requires robust samples of elements identified to family and, generally, genus or species level (i.e., the lowest taxonomic level possible). The statistical power of any tests of trends grows with greater sample size. Number of elements identified to species in the hundreds are preferred for such analyses.

A faunal comparative collection is required to adequately make identifications. Low-cost or free use of comparative collections is available at a number of regional museums, including the Museum of Vertebrate Zoology at UC Berkeley, the California Academy of Sciences (marine mammals in particular), the Zooarchaeology laboratory at UC Davis, and the Zooarchaeology laboratory at Chico State University.

Where elements can only be identified to Class or Order (i.e., mammal or duck), size estimates should be used to further subdivide elements. These classifications allow for the inclusion of the large

number of unidentified elements in broader analyses of diets, since research questions may involve the relative ratio of large- to small-bodied taxa through time. Table 42 provides a recommendation for mammalian size classes based on logarithmic body mass categories. Note that the intermediate classes (e.g., Small-Medium Mammal) do not signify that an element is either one or the other (i.e., small OR medium), but instead represent classes (e.g., Small-Medium) in and of themselves. Size classifications lose their analytical value if they are further combined (e.g., a Medium to Medium-Large Mammal). If an element cannot be placed within one of the size classes, then it should be categorized as "indeterminate mammal." One exception is the "Medium+ Mammal category," which includes all elements that are thought to be from a medium, medium-large, or large mammal. In essence, the analyst is signaling that while they cannot place the element in a size class, they know it belongs to a mammal larger than a rabbit. Thomas (1969) proposes the use of a similar system in the Great Basin, but assigns size class numbers to obviate such confusion.

SIZE CATEGORY	Example	WEIGHT
Very Small Mammal	Mice, Voles	<50 grams
Small Mammal	Woodrats, Gophers	100–500 grams
Small/Medium Mammal	Hares, Rabbits, Cottontails	700 grams-20 kilograms
Medium Mammal	Coyotes, Raccoons, Dogs	5–25 kilograms
Medium+ Mammals ^a	Mammals larger than medium	-
Medium/Large Mammal	Sea otter, Deer	20–100 kilograms
Large Mammal	Elk, Sea lions, Harbor seal	>100 kilograms

Table 42. Mammalian Size Classes based on Body Mass; Size Categories used to Classify Unidentified Mammal Bone.

Notes: ^a The medium+ category captures anything that is larger than a hare/rabbit but that cannot be placed in either. Medium, Medium/Large, or Large categories.

Ancient DNA

Ancient DNA analysis has successfully been applied to faunal remains from the San Francisco Bay-Delta Area (Beck 2009; Broughton et al. 2013; Byrd et al. 2013; Witt et al. 2015). These studies have examined population histories and the relationship between modern and ancient animal populations. Generally, these studies require no additional field sampling or laboratory protocols, but must be carried out by a qualified laboratory for ancient DNA. Samples from archaeological sites are of interest to paleogeneticists who are often willing to work with archaeologists.

Stable Isotope Analyses

The methods and preparation of samples for stable isotope analyses are outlined in the *Human Remains/Burials* section (page 15-14) and are similar for other animal remains. Animal stable isotope samples have been used as a proxy for human diet (nitrogen and carbon; Byrd et al. 2013) and to examine the origin of prey species and therefore patterns of distant-patch hunting (strontium; Grimstead 2005; Grimstead et al. 2016). Several stable isotope laboratories are operating in Northern California, including the University of California, Davis, and Chico State University.

Minimum Reporting Criteria and Curation

- All bone should be tabulated (number/weight) according to unit, depth, and mesh size
- The volume of sediment from which the sample derived should be included at the top of each column in the provenience table—volume reporting is crucial for comparing the results of various mesh sizes, as 1/16-inch or smaller samples are generally derived from small flotation/soil samples, whereas all other bone comes from generalized site midden

- Summarize data by component or horizontal and vertical distribution across the site
- The use of common names in the text is generally preferred; a concordance of the Latin name should appear in tables or an appendix so that data can be synthesized regionally
- Appendix should include tabulated analytical information for each element identified, or lot of unidentified elements

DIETARY SHELL

As with other organic remains, dietary shell has potential to address numerous topics related to temporal trends in occupation, settlements in spatial contexts and exploring changes in diet and health research domains (Table 43). Robust shell assemblages from discrete temporal components are necessary to address many of the research topics. In addition, some resource issues, such as seasonality of site occupation, species-specific exploitation histories, shellfish gathering, and resource intensification, may require large samples of whole shells.

Data recovery excavations can target bulk samples from discrete component assemblages but some forethought is also useful in designing sampling methods that allow for the collection of large assemblages of whole shells. This might include collecting all whole shells from all contexts and systematic collection of shell from only bulk samples. Strategies such as these are described in more detail below.

	Ability of the Data to	SEE PAGE		
RESEARCH ISSUES	ADDRESS RESEARCH ISSUES	Research Issue	Data Requirements	
TEMPORAL TRENDS IN OCCUPATION				
Radiocarbon Dates (things you can date)	+++	<u>7-1</u>	<u>7-7, 7-9</u>	
Obsidian Hydration as a Chronological Tool	+	<u>7-9</u>	7-13	
Refining Accuracy of Scheme D	+	7-13	7-18	
SETTLEMENTS IN SPATIAL CONTEXTS				
San Francisco Estuary Adaptations	++	<u>8-1</u>	<u>8-13</u>	
Discerning and Modeling Settlement Organization	+	8-13	<u>8-15</u>	
Construction, Structure, and Function of Bay-Delta Area Mounds and Middens	++	<u>8-16</u>	<u>8-19</u>	
Bay-Delta Area Sedentism – Causal Factors and Trajectory	+	<u>8-21</u>	<u>8-23</u>	
Seasonality of Occupation	+++	8-23	<u>8-25</u>	
EXPLORING CHANGES IN DIET AND HEALTH				
Resource Intensification	+++	<u>9-1</u>	<u>9-7, 9-32</u>	
Fishing Trajectories	+	<u>9-7</u>	<u>9-10, 9-32</u>	
Species-Specific Exploitation Histories	+++	<u>9-10</u>	9-15, 9-32	
Shellfish Gathering	+++	<u>9-18</u>	<u>9-24, 9-32</u>	
INDIGENOUS ASSIMILATION AND PERSISTENCE				
Assessing Indigenous Persistence	+	<u>14-6</u>	<u>14-7</u>	

Table 43. Research Issues Addressed by Dietary Shell.

Notes: Rating the ability of the data to address the research issue: - = Limited likelihood; + = Possible; ++ = Probable; +++ = Certain. <u>Page numbers</u> are hyperlinks.

Field Recovery Methods

Sampling Shell

Shell is one of the rare material types that can be field-sampled depending on the abundance and density of remains at the site. Where shell is sparse, it is recommended that all shell be collected from screens. Where shell is dense, however, a column sample and/or bulk midden samples can be used to control for volume and recover a sufficient sample. Shell can be sampled from the same column samples as fish bone and archaeobotanical remains, but often a larger sample is necessary to examine shellfish harvesting patterns through time.

Whole Shell Collection

Recovering large samples of whole shells to supplement controlled volume samples is an excellent way to address many issues related to seasonal harvest in the intertidal and human effects on shellfish population. Bulk samples are often insufficient to provide statistically significant numbers of whole shells. As such, it is recommended that even if not all shell will be collected from screens that all whole shells of species of interest be collected from some or all control units.

Laboratory Analysis

If large quantities of shellfish remains are recovered, then sampling strategies should be devised. Marine and/or freshwater shellfish remains should be identified by species or genus (where possible), weighed, and tabulated according to species, unit, depth, and site component. If appropriate (to reduce sample sizes), shell can be passed through 1/4-inch mesh before analysis as few identifiable shellfish elements are lost in this process.

The same principles of taxonomic identification used for vertebrate taxa should be employed for shellfish, though size class designations are meaningless and should not be employed. Identification to lower taxonomic levels is also possible with shellfish since there are fewer potential species available. This somewhat lower taxonomic diversity can prove problematic, however, if it leads to overconfidence in identifications. This can particularly be true in contexts where shell may derive from any number of open coast, estuary, or freshwater contexts. It is acceptable to have a large "unidentifiable" category of shell. Distinguishing between bay mussel (*Mytilus edulis*) and California mussel (*Mytilus californianus*) is important in pursuing any of the research issues outlined in this research design.

The convention in the San Francisco Bay-Delta Area, and many other coastal contexts, has been to report shell abundances using weight. Issues of fragmentation, however, sometimes make this a problematic approach. Therefore, if feasible, calculating MNI statistics is also a useful exercise. This statistic is calculated by counting the number of shells with a non-repetitive identifiable feature (i.e., the umbone [or hinge] of a bivalve) and dividing by the number of times that feature appears in an individual (for bivalves this would be the number of umbones divided by two). If a considerable number of complete or nearly complete shells are recovered, then size measurements (e.g., length, width, hinge thickness) and weight data should also be collected. This will aid in making MNI estimates from weight data, and gaining insight into collection techniques and resource depression trends. Size measurements will vary depending on the species. Considerable debate exists as to the correct method for measuring mussel in particular (Bell 2009; Campbell 2014, 2015a, 2015b; Campbell and Braje 2015; Glassow et al. 2016; Singh and McKechnie 2015; Whitaker 2008). The consensus favors measurement of individual shells rather than the use of a template.

Shellfish Seasonality

Shellfish seasonality studies use shells with a complete margin and sample along growth lines at millimeter increments (between 20 and 40 whole shells). Shell is pulverized during drilling, then run through a mass spectrometer which tallies the ratios of various stable isotopes, i.e., carbon and oxygen which vary with season due to changes in salinity and water temperature (Culleton et al. 2009; Eerkens et al. 2010, 2013, 2014, 2016). Archaeologists should work with labs that process such samples. The University of California campuses at Berkeley and Davis both have facilities that can run these analyses.

Minimal Reporting Criteria and Curation

- Identify volume from which shellfish were sampled and the mesh size through which identified samples were passed
- Tabulate weights and minimum number of individuals
- Measurements of complete specimens should be provided as an appendix
- Identify reference collection used for shellfish identifications

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16. PUBLIC OUTREACH

The NHPA directs the SHPO and Advisory Council to "provide public information, education, and training...in historic preservation" (Section 101(b)(3)(g)). Therefore, documentation beyond technical studies is a good and appropriate use of public funding, and encouraged for all substantial projects.

Furthermore, Attachment 6 of the PA requires the inclusion of a discussion in the Data Recovery Plan:

that explains why it is in the public interest to pursue answers to research questions. The discussion should indicate whether, why, and how the public may benefit from the scope and nature of the information developed through data recovery, and demonstrate that the costs of proceeding with the data recovery are prudent and reasonable.

As such, public outreach materials should make an effort to convey what is learned during a data recovery excavation in a way that demonstrates the importance of archaeological inquiry (and use of public funds to pursue it) and presents the results of analysis in an engaging way. In consultation with Caltrans, funds for public outreach should be a part of every budget, and innovative ideas should be encouraged. Involving Native American individuals in the public outreach program should always be a consideration and is especially relevant as one aspect of public outreach is the confidentiality of some information—e.g., site locations, sacred areas, plant-use areas.

IDEAS FOR PUBLIC OUTREACH

- Portable or permanent roadside exhibits
- Museum or historical society displays
- Public lectures or lecture series
- Popular-level articles, books, pamphlets, booklets, and flyers
- Films for web and broadcast
- Educational web sites
- Social media to reach younger audiences
- Video and audio recordings of Native speakers
- Compilations of traditional stories
- Production of botanical field guides
- Trailside interpretive panels
- News releases to local venues
- Posters
- Bookmarks
- Curriculum
- Classroom presentations
- Website exhibits, updates, interactive
- Incorporation of traditional messages or designs into parks, gardens, or other public places
- Archaeology Day activities
- Conference papers/posters
- Journal publications, books
- 3D photographs

No matter how good the product, to be effective, it must reach its intended audience. It is therefore imperative that any public outreach materials be appropriately advertised and distributed (i.e., to libraries, schools, community organizations, internet users).

Presented below is a series of outreach ideas, ranging from videos to bookmarks. We then offer a discussion of outreach utility, costs, and effectiveness, and, most importantly, marketing and distribution.

PHYSICAL DISPLAYS

The most easily recognizable method people have used to spread information about prehistory, history, or an important historical event has been to document and commemorate it through a physical marker.

Portable or Permanent Roadside Exhibits/Trailside Interpretive Panels/Kiosks

One of the most common and accessible public outreach formats is the roadside or trailside exhibit/interpretive panel; this road-focused outreach is particularly relevant to Caltrans. Roadside

displays can quickly and easily present the importance of the immediate region by a combination of written narrative and unique illustrations. For prehistoric archaeological sites, there can be artistic renditions of archaeological data (artifacts, profiles, buried sites), images of landscape change over time, or the evolution of an archaeological deposit. Another way to cultivate interest is to post an interpretive panel during ongoing investigations (Figure 66).

Museum or Historical Society Displays

Another effective way of reaching interested parties is to generate a display/exhibit at a local community museum, library, or historical society. While not as accessible as the road- or trail-side panel, creating an exhibit within a museum or historical society provides the opportunity to expand on educational options, including artifact displays, and interactive media (e.g., films, three-dimensional scans of artifacts).

Incorporation of Traditional Messages or Designs into Parks, Gardens, or other Public Access Areas

Perhaps one of the more unique ways to incorporate culture with the public is to integrate a unique design into a public works project. This type of design ensures an aesthetically pleasing way to highlight history (Figure 67).

PRESENTATIONS/PUBLICATIONS

Perhaps one of the most basic forms of public outreach is academic or public lecture series/ presentations, or publication of findings. Archaeological data are reported and interpreted, but are often left in repositories with restricted access (e.g., California Historical Resources Information System). However, publishing this information, and making it available in electronic and print media are excellent ways of reaching a wider audience and encouraging greater community input. These documents do not necessarily have to be published in journals, but can appear in local newspapers or as a community mailer/flyer, or as a public-oriented summary write-up of a technical document on the appropriate agency's web page, for example the Archaeology Program put out by the National Park Service¹¹.

Academic

Traditionally, results of archaeological inquiry are presented and shared among peers at professional conferences and through publications in journals and books. The goal of this format is often to share scientific methods and findings, rather than to reach the public at large. However, if creative mitigation is used during a CRM project, sharing out-of-the-box mitigation ideas in the customary presentation format is a unique way of sharing public outreach methods that can be applicable to other projects.

Conference Papers/Posters

Conference papers and posters provide a summary of the work completed, how it benefited the regional framework, and how those data should be applied to additional research. While these papers were once limited to attendees of the conference, redacted versions (i.e., to keep site location data safe) can be posted online to share with the public at large. The Society for American Archaeology and Society for California Archaeology are two professional organizations that hold annual conferences allowing archaeologists to share information about new discoveries, and provide workshops to share a skill. It also presents opportunities for archaeologists from diverse regions to meet and potentially collaborate on projects that may not have seen fruition without the opportunity to share research. It should be every archaeologist's obligation to present significant new data, methods, and findings at these conferences.

¹¹ https://www.nps.gov/archeology/



Entrance to Garden



Cental Seating Area



Toyon Label

Central Close-Up



Figure 67. Nomlaki Basketry Design on Bowman Bridge.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

Journal Publications, Books

Depending on the scope of an archaeological project—either academic or for-profit—results can often be published in professional journals or books to ensure a wider audience, and this information is available to other researchers. Examples of scientific journals include: *American Antiquity, American Journal of Archaeology, California Archaeology,* and *Journal of California and Great Basin Anthropology.*

Popular

Cultural resources managers and project proponents must take it upon themselves to create public interest in cultural history through the creation of general public project outreach, through posting information in local venues, or drafting public-friendly versions of presentations/lectures (provided to project-specific community support organizations, e.g., Rotary, Boy/Girl Scouts).

Posters/Banners

Posters, placed in the community or classrooms, are a great visual way to share information and photographs to engage readers. Posters are also a minimal production item and can be mass-produced for little cost and are easily distributed. There are also portable banners that are easy to transport and quick to set up, creating a bold display. They retract into their stand bases and store in canvas carrying cases with straps. Banners are typically 96 inches high with an 86-inch visual area and 33 inches wide. They can be printed on fabric, polyester film, or vinyl (Figures 68 and 69).

Books

One of the most versatile, creative mitigation ideas is the preparation of a book. Books can provide a broad range of information that can help preserve past cultures, and can be presented from the viewpoint of the archaeologists and Native Americans, often working together. Authors can present tales of archaeological investigations, methods, and findings in a public format, or offer generational knowledge on Native cultures. Books can be hard copy, available in libraries and book stores, but can also be on the internet, making them widely accessible. Books by Native Americans should be encouraged (e.g., Kathleen Smith's [2014] *Enough for All, Foods of My Dry Creek Pomo and Bodega Miwuk People.*, about food gathering and preparation; or *The Sugar Bear Story, California*, an illustrated traditional children's story presented in both English and Chumash, by Yee and Ygnacio-De Soto [2005]). A more extensive product to produce is a popular version of an archaeology project; i.e., *Life on the River – The Archaeology of an Early Native American Culture* (Hildebrandt and Darcangelo 2011) which has been used in classrooms but was out of print, so the publisher made it available online for instructors, students, and others curious about archaeology.

EDUCATION

Stressing the importance of cultural resources preservation through formal and informal education is another way to share the results of CRM efforts and prehistory/history (in general). Formal education can come through the creation of grade-school lesson plans, classroom presentations, participation in school-based career days, and distribution of education materials to the general public (e.g., bookmarks). Children are offered Native American history and prehistory in the 4th, 5th, and 6th grades.

The History of San Marcos Pass

For thousands of years, travelers have used the San Marcos Pass to cross the rugged hills and steep canyons of the Santa Ynez Mountains, moving between Santa Barbara County's coast and interior valleys.



Figure 68. Cold Springs Canyon Bridge Poster.



Figure 69. Cuyama Valley/Chumash Banners.

Bookmarks

Bookmarks are a simple, creative way to share information with the public that are easily distributed reproduced, and commonly used. They can contain photographs, minimal text, and quotes on Native Americans, and reference web pages for further study (Figure 70). These can be disseminated to schools, museum, libraries, and college campuses.

Timelines

People are fascinated by timelines, especially when comparing events in one part of the world with another. There are numerous web-based programs where timelines can be created, ranging from easy to complex¹². Christopher Pappas (2013), Founder of The eLearning Industry's Network, notes that "Timelines have become an indispensable part of the learning experience as they enable students to participate more actively in learning and acquire knowledge the easy way."

Curriculum

An inventive way to ensure that younger generations are interested in cultural resources and given the opportunity to explore archaeology, prehistory, and history is to create school curricula (varying by age level). This can be done through formalized lesson plans or through supplemental art activities or after-school programs. It should be noted, however, that while grade-school curriculum is an easy way to introduce children to archaeology, it is often difficult for teachers to accommodate lesson plans that do not contribute to state testing requirements. The way that curriculum is introduced to the classroom should be carefully considered. Primers and curriculums designed to meet 4th Grade Social Sciences Standards, when children are being introduced to archaeology, can be developed as partial mitigation for large archaeological excavation projects. Coloring books promoting history and cultural heritage can be distributed free to regional schools.

Given the difficulties of incorporating new curriculum into public schools, an alternative approach is to give classroom presentations on archaeology/cultural resources, in general, or about nearby projects that have taken place. Native American speakers should also be encouraged to participate and share traditional stories and language.

Display Artifacts in School Libraries

Artifacts recovered during archaeological excavations can be displayed at local school libraries with brief descriptions, in consultation with local Native Americans. The display can include information about the prehistory and history of the region, why the archaeological site was studied, and what was learned. To make the display more interactive, students could post questions about the exhibit/artifacts to a social media account (e.g., Facebook, Twitter) to be answered by project archaeologists and/or local Native American groups that may have been involved with the project.

Archaeology Day Activities/Open House/Tours of Archaeological Investigations

The public should be encouraged to be part of the archaeological process. Rather than relying on the public to be invested in a public outreach product or hearing about a project after it has been completed, one can consider actively engaging the public during an archaeological investigation. This can include opening the project site up for people to observe "archaeologists in action," training volunteers to help in the excavation or laboratory processes, or holding tours highlighting the different phases of

¹² https://elearningindustry.com/top-10-free-timeline-creation-tools-for-teachers





She passed on her know language

Ms. Cooper had one child, F cisco Felix Olivas. His descend: are active today in preser their culture. today in preser



Figure 70. Example of Bookmarks.

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Chumash Heritage

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fieldwork. Interested Native American participants can also be on-site to provide insight and context for the artifacts/sites/traditional cultural properties.

ELECTRONIC

With the proliferation of the internet and social media, electronic dissemination of information has become an optimal way of reaching the public as a way to mitigate impacts.

Educational Websites, Website Exhibits, Interactive

Generating a website to discuss a project is one of the simplest and easiest ways to broadcast information. Often times the sponsoring agencies (county/state public works departments) have webpages dedicate to sharing information about an upcoming or ongoing project. Information regarding cultural resources is easily added. Users can even sign up to receive notifications if updates occur. An important key to educational websites and exhibits is to ensure that they are interactive so as to engage the public.

Films for Web and Broadcast

Videos are routinely posted, shared, and viewed across a multitude of platforms (e.g., computer, tablets, and smart phones). Posting videos are usually free of charge and can be viewed by numerous people at once. This a great way to not only reach the immediate community, but also spread awareness to interested individuals nationally, or even globally. Two examples are *A Walk through Time: the Story of Anderson Marsh*, that preserves, through cinematic imagery and narration, the cultural, historical, and natural significance of the region in and around Anderson Marsh State Historic Park; or *Obsidian Trails*, an award-winning video that describes how obsidian found throughout California has informed what archaeologists know about trade and travel in prehistoric lifeways.

Video and Audio Recordings of Native Speakers

While the overarching goal of public outreach is to help the general public gain an understanding and appreciation of history, another important aspect is to ensure that history is not lost. Audio recordings of Native American languages not only preserve the language, but also spread awareness of these languages. Native languages are not something that the general public is intimately familiar, with popular movies serving as the only points of reference. Audio recordings of Native Speakers can be shared in the classroom, at public lectures, or as part of interactive museum displays.

Social Media (Facebook, Twitter, Smart Phone Apps)

The advent of social media has connected people not only on a local level, but also on national and international levels. Mitigation measures that tap into social media are a very resourceful and inexpensive way to reach disparate groups of people and engage them in conversation. Social media platforms can generate conversations about important issues, bring in new insights or ideas, and spread the word about what one community may be doing to bolster its local history/resources.

Smart phone apps are unique opportunities to provide an easily shareable and interactive activity that anyone can use. The purpose of each app is truly limitless and can be focused on school-aged children or adults.

Three-Dimensional (3-D) Photogrammetry

Photogrammetry makes measurements from photographs, recovering exact positions of surface points. The use of photogrammetry in CRM is endless. Archaeological features identified during data

recovery, or historical structures that may be demolished, can be digitally replicated, preserved, and shared with the public. This can also be used to create digital replicas of artifacts, allowing the public to view items without any harm coming to the original piece.

DISCUSSION

The above examples cover some of the more well-known mitigation measures that cultural resources managers have been using for years, along with some of the newer techniques available because of the internet and social media. The strongest and most effective mitigation measures are those that combine older methods with new forms of technology. These have the ability to reach a broader group of people, engage learners in different ways (visual, auditory, kinesthetic), and ensure that the project and its results are shared with as many people as possible and that each viewer benefits from the preservation process. In the end, mitigation is only limited by the imagination.

A means of rating these various outreach ideas is by scaling their cost, utility, effectiveness, and extent of distribution, always considering the intended audience. In Table 44, we summarize these aspects for each topic.

Cost

Initial funding should always be set aside (or seen as) part of a mitigation budget for appropriate—sized, unique, or significant projects. Initial budget costs vary depending upon the: (1) nature of the project being mitigated; (2) perceived value of the cultural resources being investigated; and (3) type of mitigation presented. A cost scale is used in the table to show the relative ranges of the each mitigation measure. They are of course estimates only; actual expenses will depend on the nature, difficulty, and intricacy of each project. We show these ranges in in the table as follows:

\$ – low cost, minimal budget set aside

\$\$ – moderate cost, more developed mitigation plan

\$\$\$ – high cost, several integrative approaches to mitigation

\$\$\$\$ – extensive mitigation plan

Recurring cost must be considered. Most mitigation costs are up front and will not need to be renewed or replenished. However, in the case of brochures, for example, additional copies will need to be ordered once the original stock has been depleted.

Utility

Utility is defined as the functionality and accessibility of each mitigation type:

(1) Very easy/simple

(2) Easy/simple

- (3) Hard/difficult
- (4) Very hard/difficult

Effectiveness

The effectiveness of the outreach portrays how successful each mitigation type is in reaching the general public, on a grading scale:
Level of outreach:

- Local immediate town/city in which the mitigation measure is displayed
- Regional public outreach applicable on a regional scale, i.e., San Francisco Bay-Delta Area
- State important to the public statewide; e.g., Gold Rush
- Nation applicable to the nation and in a platform that can reach national audiences

Rating the level of outreach:

- 1 Very likely
- 2 Likely
- 3 Neutral
- 4 Unlikely
- 5 Very unlikely

Marketing and Distribution

Given the endless ideas, there are only two restricting aspects: (1) awareness/marketing—people have to know about the product to access it; and (2) distribution—the product has to reach its intended audience. A marketing and distribution plan should be included in any public outreach budget so that the products, such as pamphlets, books, and teaching curricula, reach libraries, schools, and community organizations, or that items such as videos and publications are advertised appropriately. The intended audience should be made clear. As an example, to market school curricula, a teacher's workshop can be held; these can be used by the instructor for continuing education credit. The workshop would introduce the curriculum, present how to use it, and discuss any issues or problems.

One resource available to make educational projects more accessible is *Project Archaeology*, a national educational organization made up of archaeologists, educators, and concerned citizens:

Project Archaeology is a national leader in archaeology education and provides a way for federal agencies to fulfill Section 106 compliance goals. Project Archaeology develops and distributes high-quality education products in conjunction with Section 106 projects and delivers them to educators through professional development. The national reach of the program ensures wide-spread distribution of products. Because Project Archaeology is a permanent national program, new products will be distributed through the National Network of State and Regional Project Archaeology programs, through the Internet and direct sales to educators.

The Project Archaeology guidelines serve two purposes: guidance for planning a new state, local, or regional project archaeology program, and guidance for maintaining an existing project archaeology program (https://projectarchaeology.org/about).

Forms of continuing professional support employed by Project Archaeology include printed updates, newsletters, networking opportunities, Project Archaeology web site, awards, and additional learning experiences.

PUBLIC INTERPRETATION TYPE	Cost		UTILITY		EFFECTIVENESSC				
	Initial ^a	RECURRING	USE ^b	ACCESS ^b	LOCAL	Region	State N	Iational	– DISTRIBUTION AND MARKETING
PHYSICAL									
Road-/Trail-side Interpretive Panels	\$	No	1	1	1	2	4	5	Limited; chance encounter; can identify on Caltrans web
Museum/Historical Society Displays	\$\$\$	No	1	2	1	2	3	4	Moderate; can be advertised
Incorporation of Traditional Messages	\$\$\$\$	No	1	1	1	2	4	5	Incorporate into other outreach programs
PRESENTATIONS/PUBLICATIONS									
Academic									
Conference Papers/Posters	\$	No	1	2	1	1	1	5	Can be web-based; advertise
Journal Publications, Books	\$	No	2	3	3	3	3	5	Advertised by publisher, on-line
POPULAR									
News Releases to Local Venues	\$	No	1	2	1	2	5	5	Wider but short-lived
Posters	\$	No	2	2	2	3	3	4	Sufficient quantities; in museums, libraries, classrooms, public places
Books	\$\$	Yes	2	2	2	4	4	5	Advertised by publisher, on-line
Education									
Bookmarks	\$	Yes ^d	1	2	1	2	2	5	Large quantities; libraries, museums, classroom
Timelines	\$	Yes	2	2	2	2	2	5	Can be web-based; advertise
Curriculum	\$	Yes ^e	4	4	4	5	5	5	Limited to region; inform teachers; use Project Archaeology
Display Artifacts in School Libraries	\$	No	1	1	1	2	5	5	Limited, short-term
Archaeology Day Activities/Open House/ Tours	\$\$	Yes ^e	2	2	2	3	5	5	Broad audience; need volunteers
Electronic									
Websites	\$	No	1	1	1	2	3	5	Large audience; search engine
Films	\$\$\$	Yes ^d	1	1	1	1	2	2	Large audience; search engine
Video/Audio Recordings	\$\$	Yes ^d	1	1	1	2	5	5	Large audience; search engine
Social Media	\$	No	1	1	1	1	1	1	Large audience; control confidentiality
Three-Dimensional Models	\$\$	No	1	1	1	2	3	3	Limited; search engine

Table 44. Cost, Utility, and Effectiveness of Public Outreach Ideas.

Notes: ^a Cost: \$ – Low, minimal budget set aside (\leq 7,000), \$\$ – Moderate, more developed mitigation plan (\leq 20,000), \$\$\$ – High, several integrative approaches to mitigation (\leq 50,000), \$\$\$ – Extensive mitigation plan (\leq 80,000); ^b Utility: 1 – Very easy/simple; 2 – Easy/simple; 3 – Hard/difficult; 4 – Very hard/difficult; ^c Effectiveness: 1 – Very likely, 2 – Likely, 3 – Neutral, 4 – Unlikely, 5 – Very unlikely; ^d Costs associated with reproducing content; ^e May require non-reusable supplies.

SECTION 4 – REFERENCES

17. REFERENCES CITED

14CHRONO Marine Reservoir Database

2010 http://calib.qub.ac.uk/marine, accessed November 2015.

Acsádi, Györgi, and J. Nemeskéri

1970 History of Human Life Span and Mortality. Academy Kaidó, Budapest, Hungary.

Adam, David P.

- 1975 A Late Holocene Pollen Record from Pearson's Pond, Weeks Creek, Landslide, San Francisco Peninsula, California. *USGS Journal of Research* 3:721–731.
- 1988 Palynology of Two Upper Quaternary Cores from Clear Lake, Lake County, California. US Geological Survey Professional Paper 1363. US Geological Survey, Washington DC.

Adam, David P., and James G. West

1983 Temperature and Precipitation Estimates through the Last Glacial Cycle from Clear Lake, California. *Science* 219:168–170.

Adam, David P., Roger Byrne, and Edgar Luther

1981 A Late Pleistocene and Holocene Pollen Record from Laguna de las Trancas, Northern Coastal Santa Cruz County, California. *Madrono* 28(4):255–272.

Adler, M. A.

1989 Ritual Facilities and Social Integration in Nonranked Societies-4. In *The Architecture of Social Integration in Prehistoric Pueblos,* pp. 35–52. Crow Canyon Archaeological Center.

Adler, M. A., and R. H. Wilshusen

1990 Large-Scale Integrative Facilities in Tribal Societies: Cross-Cultural and Southwestern US Examples. *World Archaeology* 22(2):133–146.

Allen, Mark A.

2012 A Land of Violence. In *Contemporary Issues in California Archeology*, edited by Terry L. Jones and Jennifer E. Perry, pp. 197–216. Left Coast Press, Walnut Creek, California.

Allen, Mark W., and Terry L. Jones (editors)

2014 *Re-examining a Pacified Past: Violence and Warfare among Hunter-Gatherers.* Left Coast Press Inc.

Allen, Rebecca

1998 Native Americans at Mission Santa Cruz, 1791–1834, Interpreting the Archaeological Record. Perspectives in California Archaeology Vol. 5. Institute of Archaeology, University of California, Los Angeles.

- Allen, Rebecca, A. Medin, R. Scott Baxter, B. Wickstrom, C. Young Yu, Julia G. Costello, Greg White, Amy Huberland, H. M. Johnson, Jack Meyer, and Mark Hylkema
 - 1999 Upgrade of the Guadalupe Parkway, San Jose Historic Properties Treatment Plan. Past Forward, Richmond; KEA Environmental, Inc., Sacramento, California; Foothill Resources, Ltd., Mokelumne Hill, California; California State University, Chico; and Sonoma State University, Rohnert Park, California. Submitted to the California Department of Transportation, District 4, Oakland, California.
- Allen, R., R. S. Baxter, L. Hylkema, C. Blount, and S. D'Oro
 - 2010 *Uncovering and Interpreting History and Archaeology at Mission Santa Clara*. Submitted to Santa Clara University, Santa Clara, California.

Ambro, R. D.

- 1993 *Report of Archaeological Test Excavations at CA-ALA-46 on the Stoneridge Orchards Phase III Project Parcel, Pleasanton, Alameda County, California.* On file, Historical Resources Information System, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2003 They Danced in the Plaza: The Historical Archaeology of Notre Dame Plaza, Mission San Francisco de Asis (Dolores), 247 Dolores Street, San Francisco, California. Holman & Associates Archaeological Consultants, San Francisco, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Anastasio, Rebecca Loveland
 - 1988 Middle Horizon Sites in North San Jose. In *Proceedings of the Society for California Archaeology*, edited by S. M. Hector, L. E. Christenson, G. T. Gross, and M. D. Rosen, pp. 393–410. Society for California Archaeology, San Diego.
- Anastasio, Rebecca L., James C. Bard, Colin I. Busby, Raymond J. Dezzani, Donna M. Garaventa, Stuart A. Guedon, Robert M. Harmon, Mella J. Rothwell, Elin W. Smith, and Melody E. Tannam
 - 1988 Archaeological Programs at CA-SCL-204 and CA-SCL-312 for Proposed Improvements of the Expanded Edenvale Redevelopment Project City of San Jose, Santa Clara County, California. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Ancient Enterprises, Inc.

1980 *Task III Report on 4-SCL-124*. Ancient Enterprises, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Anderson, Marion Kat

- 1997 From Tillage to Table: The Indigenous Cultivation of Geophytes for Food in California. *Journal of Ethnobiology* 17(2):149–169.
- 2005 *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources.* University of California Press, Berkeley.

Anderson, William

2008 Construction Monitoring Report for the Delta Coves Project Archaeological Sites CA-CCO-1, CA-CCO-135/H and CA-CCO-377/H. Draft report prepared for SunCal Companies. Andrushko, Valerie A., Kate A. S. Latham, Diane L. Grady, Allen G. Pastron, and Phillip L. Walker

2005 Bioarchaeological Evidence for Trophy-Taking in Prehistoric Central California. *American Journal of Physical Anthropology* 127:375–384.

Andrushko, Valerie A., Kate A. Latham, Viviana Bellifemine, and Anna C. Engberg

2009 *Archaeological Investigations at CA-CCO-235, City of Lafayette, Contra Costa County, California, Volume II.* Coyote Press, Salinas, California.

Andrushko, Valerie A., Al W. Schwitalla, and Phillip L. Walker

2010 Trophy-Taking and Dismemberment as Warfare Strategies in Prehistoric Central California. *American Journal of Physical Anthropology* 141:83–96.

Archeo-Tec

1990 *Moscone Center Expansion Project: Archaeological Data Recovery Program*. Archeo-Tec, Oakland, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Arkush, Brooke S.

1993 Yokuts Trade Network and Native Culture Change in Central and Eastern California. *Ethnohistory* 40(4):619–640.

Arnold, Jeanne E.

- 1991 Transformation of a Regional Economy: Sociopolitical Evolution and the Production of Valuables in Southern California. *Antiquity* 65:953–962.
- 2004 The Archaeology of California. Journal of Archaeological Research 12(1):1–73.

Arnold, Jeanne E., and A. P. Graesch

2001 The Evolution of Specialized Shellworking among the Island Chumash. In *The Origins of a Pacific Coast Chiefdom, The Chumash of the Channel Islands*, pp. 71–112. University of Utah Press, Salt Lake City.

Arnold, Jeanne E., and Ann Munns

1994 Independent or Attached Specialization: The Organization of Shell Bead Production in California. *Journal of Field Archaeology* 21:473–489.

Arpaia, Angela

- 2015 Charred Plant Remains Assemblages in the Santa Clara Valley. Paper presented at the 80th Annual Meeting of the Society for American Archaeology, San Francisco, California.
- Arrigoni, Aimee, Drew Bailey, David Buckley, Angela Cook, Allen Estes, Paul Farnsworth, Melinda Hickman, and Eric Strother
 - 2008 Data Recovery, Burial Removal and Construction Monitoring at the Moffett Towers Project, CA-SCL-12/H Sunnyvale, Santa Clara County, California. William Self Associates, Inc., Orinda, California. Submitted to Jay Paul Company, San Francisco, California.

Asturias, M.

1971 *A Brief Account of Archaeology at 4-SMA-110*. Treganza Anthropology Museum Papers 8:49–55, edited by M. J. Moratto. San Francisco State College, San Francisco, California.

Atchley, Sara M.

1994 *A Burial Analysis of the Hotchkiss Site (CA-CCO-138).* Master's thesis, Department of Cultural Resources Management, Sonoma State University, Rohnert Park, California.

Atwater, Brian F.

1980 Attempts to Correlate Late Quaternary Climatic Records Between San Francisco Bay, The Sacramento-San Joaquin Delta and the Mokelumne River, California. Unpublished Ph.D dissertation, University of Delaware.

Atwater, Brian, Charles Hedel, and Edward Helley

- 1977 Late Quaternary Depositional History, Holocene Sea Level Changes, and Vertical Crustal Movement, Southern San Francisco Bay, California. US Geological Survey Professional Paper, No. 1014. US Government Printing Office, Washington, DC.
- Atwater, Brian F., Susan G. Conard, James N. Dowden, Charles W. Hedel, Roderick L. MacDonald, and Wayne Savage
 - 1979 History, Landforms, and Vegetation of the Estuary's Tidal Marshes. In San Francisco Bay: The Urbanized Estuary. Investigations into the Natural History of San Francisco Bay and Delta with Reference to the Influence of Man, edited by T. J. Conomos, A. E. Leviton, and M. Berson, pp. 347–386. Pacific Division of the American Association for the Advancement of Science, San Francisco, California.

Axelrod, Daniel I.

1981 Holocene Climatic Changes in Relation to Vegetation Disjunction and Speciation. *The American Naturalist* 117(6):847–870.

Bailey, Geoff, and Nicky Milner

2002/2003 Coastal Hunter-Gatherers and Social Evolution: Marginal or Central? Before Farming 4(1):1–22.

Baker, Suzanne M.

- 1978 *Report on the Fort Mason Archaeological Test Excavations.* Archaeological Consultants, San Francisco, California. Submitted to National Park Service, San Francisco, California.
- 1992 *Archaeological Test Excavations at CA-CCO-156, El Sobrante, California*. Archaeological Historical Consultants, Oakland, California. Submitted to Goldstar Investments, Richmond, California.
- 1994 *Archaeological Burial Recovery at CA-CCO-236, Contra Costa County, California.* Archaeological Historical Consultants, Oakland, California. Submitted to Casselton Group.

Banks, Peter M.

1981a Subsurface Archaeological Investigations at CA-SFR-7, the Griffith-Shafter Mound, and the Thomas-Hawes Mound, along the Sunnydale-Yosemite Alignment 2A-1, City and County of San Francisco, California. California Archaeological Consultants, Inc., Woodland, California. Prepared for the San Francisco Clean Water Program. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Banks, Peter M. continued

- 1981b Preliminary Subsurface Archaeological Investigations at Harney and Alana Ways, San Francisco Executive Park, San Francisco County, California. California Archaeological Consultants, Inc., Woodland, California. Prepared for Santina and Thompson Engineering, Planning Consultants. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1985 *Mitigation Measures at CA-ALA-12 and -13, Alameda County, California.* California Archaeological Consultants, Inc., Woodland, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Banks, Peter M., and Robert I. Orlins

- 1979 Final Report of the Testing of Cultural Resources within the Wildcat and San Pablo Creeks Flood Control and Water Resources Project, Contra Costa County, California. California Archaeological Consultants, Inc., Woodland, California. Submitted to US Army Corps of Engineers, San Francisco District, San Francisco, California.
- 1980 An Archaeological Investigation of Prehistoric Site CA-CCO-275 (Richmond I) Richmond, Contra Costa County, California. California Archaeological Consultants, Inc., Woodland, California. Submitted to Department of Public Works, City of Richmond, Richmond, California.
- 1981 Investigation of Cultural Resources within the Richmond Harbor Redevelopment Project 11-A, Richmond, Contra Costa County, California. California Archaeological Consultants, Inc., Woodland, California. Submitted to City of Richmond, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1985 Limited Archaeological Excavations at CA-CCO-299, A Stege Mount, Richmond, Contra Costa County, California. California Archaeological Consultants, Inc., Oakland, California. Submitted to Pacific Gas and Electric Company, San Francisco, California.

Banks, Peter M., R. Orlins, and H. McCarthy

- 1984 *Final Report, Walnut Creek Project: Test Excavation and Evaluation of Archaeological Site CA-CCO-*431, *Contra Costa County, California*. California Archaeological Consultants, Inc., Oakland, California. Submitted to US Army Corps of Engineers, Sacramento District, Sacramento, California.
- Bard, James C., and Sharon L. Brock
 - 1986 Archaeological Monitoring and Burial Report Ardenwood Technology Park, City of Fremont, County of Alameda, California. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Bard, James C., and Colin I. Busby
 - 1988 New Perspectives on the Archaeological Sequence in the Coyote Hills Area of the Southern San Francisco Bay: Sites, Components and Pieces of the Puzzle. *Proceedings of the Society of California Archaeology* 1:367–392.
- Bard, James C., and Larry S. Kobori
 - 1981 *An Archaeological Data Recovery at Site CA-SCL-302, Santa Clara County, California.* Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Bard, James C., Colin I. Busby, and Larry S. Kobori

- 1984 *Excavations at CA-SCL-6 East and CA-SCL-268: A Limited Data Recovery Operation, Santa Clara County, California.* Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1989 Archaeological Data Recovery Program of CA-ALA-60 Located on Route 580, Castro Valley, Alameda County. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Bard, James C., Colin I. Busby, Raymond J. Dezzani, and Donna M. Garaventa
 - 1985 Site Testing Report at Archaeological Site CA-SCL-68 as Part of the Guadalupe Transportation Corridor Compliance with 36 CFR Part 800. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Bard, James C., Colin I. Busby, Raymond J. Dezzani, John M. Findlay, and Donna M. Garaventa
 - 1986 Data Recovery at CA-SCL-6E/447 as Part of the Guadalupe Transportation Corridor Compliance with 36 CFR Part 800. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Bard, James C., R. J. Dezzani, D. M. Garaventa, M. J. Rothwell, M. E. Tannam, and C. I. Busby
 - 1987 Archaeological Data Recovery Program at Olympia 1/CA-ALA-466, Fremont, California. Basin Research Associates, Inc. Prepared for Signature/Olympia Properties. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Bard, James C., Colin I. Busby, Michael R. Fong, Robert M. Harmon, Melody E. Tannam, Donna M. Garaventa, Angela M. Banet, S. A. Jarvis, Steven J. Rossa, and Ranbir S. Sidhu
 - 1992 Archaeological Site Testing Report, CA-ALA-483, Laguna Oaks Project, Pleasanton, Alameda County, California. Basin Research Associates, Inc., San Leandro, California. On file, Northwest Information Center, California Historical Resources Information System, Sonoma State University, Rohnert Park, California.
- Bard, Edouard, Bruno Hamelin, Maurice Arnold, Lucien Montaggioni, Guy Cabioch, Gerard Faure, and Francis Rougherie
 - 1996 Deglacial Sea-Level Record from Tahiti Corals and the Timing of Global Meltwater Discharge. *Nature* 382:241–244.

Barlow, Renee, and M. Heck

2002 More on Acorn Eating during the Natufian: Expected Patterning in Diet and the Archaeological Record of Subsistence. In *Hunter-Gatherer Ethnobotony*, edited by L. R. Mason and J. G. Hather, pp 128–145. Institute of Archaeology, University College, London.

Barrett, Samuel A.

1908 The Geography and Dialects of the Miwok Indians. *University of California Publication in American Archaeology and Ethnology* 6(2):333–368.

Barrett, Samuel A., and Edward W. Gifford

1933 Miwok Material Culture: Indian Life of the Yosemite Region. *Bulletin of the Public Museum of the City of Milwaukee* 2(4):117–376. Milwaukee Museum, Milwaukee, Wisconsin. Bartelink, Eric J.

- 2006 *Resource Intensification in Pre-Contact Central California: A Bioarchaeological Perspective on Diet and Health Patterns among Hunter-Gatherers from the Lower Sacramento Valley and San Francisco Bay.* Ph.D. dissertation, Department of Anthropology, Texas A&M University, College Station, Texas.
- 2009 Late Holocene Dietary Change in the San Francisco Bay Area: Stable Isotope Evidence for an Expansion in Diet Breadth. *California Archaeology* 1:227–251.

Bartelink, E. J., M. M. Beasley, M. Atwood, K. S. Gardner, A. Leventhal, and R. Cambra

- 2012 Human diet and mortuary patterns in the southeastern San Francisco Bay area: stable isotope analysis of the Ryan Mound population (CA-ALA-329). *American Journal of Physical Anthropology* 147:91.
- Bartelink, Eric J., Valerie A. Andrushko, Viviana I. Bellifemine, Irina Nechayev, and Robert Jurmain
 - 2013 Violence and Warfare in the Prehistoric San Francisco Bay Area, California: Regional and Temporal Variations in Conflict. In *The Routledge Handbook of the Bioarchaeology of Human Conflict,* edited by Christopher Knüsel and Martin J. Smith, pp. 285–307. Routledge, New York.

Basgall, Mark E.

- 1987 Resource Intensification among Hunter-Gatherers: Acorn Economies in Prehistoric California. *Research in Economic Anthropology* 9:21–52. JAI Press, Greenwich, Connecticut.
- 1990 Hydration Dating of Coso Obsidian: Problems and Prospects. Proceedings of the 24th Annual Meeting of the Society for California Archaeology. Foster City, California.
- Basgall, Mark E., and M. Giambastiani
 - 1995 *Prehistoric Use of a Marginal Environment: Continuity and Change in Occupation of the Volcanic Tablelands, Mono and Inyo Counties, California.* Center for Archaeological Research at Davis Publications 12. University of California, Davis.
- Basgall, Mark E., and David W. Glover
 - 2012 Fieldwork Summary Report, Archaeological Data Recovery at CA-MRN-507/H and MRN-526W, Olompali State Historic Park, Marin County, California.
- Basgall, Mark E., and William R. Hildebrandt
 - 1989 Prehistory of the Sacramento River Canyon, Shasta County, California: Excavations at CA-SHA-1176, SHA-1175, SHA-476. Center for Archaeological Research at Davis Publications 9. University of California, Davis.
- Basgall, Mark E., and Kelly R. McGuire
 - 1988 *The Archaeology of CA-INY-30: Prehistoric Culture Change in the Southern Owens Valley, California.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 9, Bishop. On file, Eastern Information Center, Riverside, California.

Basgall, Mark, Wendy Pierce, and Shelly Tiley

2006 Between the Ocean and the Bay: Phase II Investigations at Ten Archaeological Sites along SR-101, Marin and Sonoma Counties, California (CA-MRN-192, MRN-194, MRN-195, MRN-196, MRN-197, MRN-325, MRN-327, MRN-507, and MRN-526. Prepared for California Department of Transportation, District 4.

Basgall, Mark E., David W. Glover, Bridget R. Wall, and Kenneth R. Bethard

 2015 Archaeological Investigations at Huichica Creek, Napa County, California: The Duhig Road Data Recovery Program: CA-NAP-189/H, NAP-190, NAP-795 (04-NAP-121, PM 0.3–2.0[KP 0.5–3.0]).
 On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Basin Research Associates, Inc.

- 1981 *Excavations at CA-SCL-300 and CA-SCL-302*. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2013 Archaeological Data Recovery Report (SMA-83) (ADRR) and Final Archaeological Resources Report (FARR), San Francisco Public Utilities Commission, Water System Improvement Program, Bay Division Pipeline Reliability Upgrade Project, East Bay and Peninsula. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Baumhoff, Martin A.

- 1953 Carbonized Basketry from the Thomas Site. *University of California Archaeological Survey Reports* 19:9–11.
- 1963 Ecological Determinants of Aboriginal California Populations. *University of California Publications in American Archaeology and Ethnology* 49(2):155–236.
- 1981 *The Carrying Capacity of Hunter-Gatherers*. Senri Ethnological Studies No. 9. National Museum of Ethnology, Osaka, Japan.

Bayham, F. E.

1979 Factors Influencing the Archaic Pattern of Animal Exploitation. *The Kiva* 44:219–235.

Bean, Lowell John

- 1974 Social Organization in Native California. In *ANTAP California Indian Political and Social Organization,* edited by Lowell John Bean and Thomas F. King. Ballena Press Anthropological Papers No. 2, Ramona, California.
- 1994 *The Ohlone: Past and Present: Native Americans of the San Francisco Bay Region.* Ballena Press Anthropological Papers No. 42, Menlo Park, California.

Bean, L. J., and T. Blackburn

1976 Native Californians: A Theoretical Retrospective. Ballena Press, Ramona, California.

Beardsley, Richard K.

- 1948 Cultural Sequences in Central California Archaeology. *American Antiquity* 14(1):1–28.
- 1954 *Temporal and Areal Relationships in Central California Archaeology*. University of California Archaeological Survey Reports 24 and 25. University of California, Department of Anthropology, Berkeley.

Beasley, Melanie M.

2008 Dietary Trends at the Ellis Landing Site (CA-CCO-295): Stable Carbon and Nitrogen Isotope Analysis of Prehistoric Human Remains from a San Francisco Bay Area Shellmound. Master's thesis, California State University, Chico.

Beasley, Melanie M., A. M. Martinez, D. D. Simons, and E. J. Bartelink

2013 Paleodietary Analysis of a San Francisco Bay Area Shellmound: Stable Carbon and Nitrogen Isotope Analysis of Late Holocene Humans from the Ellis Landing Site (CA-CCO-295). *Journal of Archaeological Science* 40(4):2084–2094.

Beaton, J. M.

1991 Extensification and Intensification in Central California Prehistory. *Antiquity* 65:946–952.

Beck, R.

2009 The Molecular Genetics of Prey Choice. *California Archaeology* 1(2):253-268.

Beck, Warren A., and Ynez D. Haase

1974 Historical Atlas of California. University of Oklahoma Press, Norman.

Beckwith, Brenda R.

1995 An Evaluation of the Cultural Significance of Plants Used by the Coast Miwok of Marin and Southern Sonoma Counties, with Emphasis on Olompali State Historic Park. Master's thesis, Department of Biological Sciences, California State University, Sacramento.

Bellifemine, Viviana

- 1997 Mortuary Variability in Prehistoric Central California: A Statistical Study of the Yukisma Site, CA-SCL-38. Master's thesis, Department of Interdisciplinary Studies, San Jose State University, San Jose, California.
- 1998 The Archaeology of the Yukisma Site: CA-SCL-38 (Alms House Mound), Located within the Elmwood Correctional Facility, City of Milpitas, Santa Clara County, California Vol. I, II, and III. Ohlone Families Consulting Services. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Bellifemine, Viviana, and Alan Leventhal

1998 *Final Laymans Reports, the Yukisma Mound: A Prehistoric Cemetery in the South Bay Area.* Ohlone Families Consulting Services. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Bender, B.

- 1978 Gatherer-Hunter to Farmer: A Social Perspective. World Archaeology 10:204–237.
- 1990 The Dynamics of Nonhierarchical Societies. In *The Evolution of Political Systems: Sociopolitics in Small-Scale Sedentary Societies*, edited by S. Upham, pp. 247–263. Cambridge University Press, Cambridge, United Kingdom.

Bennyhoff, James A.

1950 *Californian fish spears and harpoons.* University of California Press, Berkeley.

Bennyhoff, James A. continued

- 1977 *Ethnogeography of the Plains Miwok,* edited by R. Hughes. Center for Archaeological Research at Davis Publication 5.
- 1987 Variation within the Meganos Culture. In *Toward a New Taxonomic Framework for Central California Archaeology: Essays by James A. Bennyhoff and David A. Fredrickson,* edited by Richard E. Hughes, pp. 81–89. Contributions of the University of California Archaeological Research Facility 52, Berkeley, California. (Published in 1994).
- 1994a A Delta Intrusion to the Bay in the Late Middle Period in Central California. In *Toward a New Taxonomic Framework for Central California Archaeology: Essays by James A. Bennyhoff and David A. Fredrickson,* edited by Richard E. Hughes, pp. 7–13. Contributions of the University of California Archaeological Research Facility 52, Berkeley, California.
- 1994b Variation within the Meganos Culture. In *Toward a New Taxonomic Framework for Central California Archaeology: Essays by James A. Bennyhoff and David A. Fredrickson,* edited by Richard E. Hughes, pp. 81–89. Contributions of the University of California Archaeological Research Facility 52, Berkeley, California.
- 1994c Central California Augustine: Implications for Northern California Archaeology. In *Toward a New Taxonomic Framework for Central California Archaeology: Essays by James A. Bennyhoff and David A. Fredrickson,* edited by Richard E. Hughes, pp. 65-74. Contributions of the University of California Archaeological Research Facility 52, Berkeley, California.

Bennyhoff, James A., and David A. Fredrickson

- 1967 *A Typology of Shell and Stone Beads from Central California*. Manuscript on file, Anthropological Studies Center, Sonoma State University, Rohnert Park, California.
- 1994 Toward a New Taxonomic Framework for Central California Archaeology: Essays by James A. Bennyhoff and David A. Fredrickson. Contributions of the University of California Archaeological Research Facility 52, Berkeley, California.
- Bennyhoff, James A., and Robert F. Heizer
 - 1958 Cross-Dating Great Basin Sites by California Shell Beads. In *Current Views on Great Basin* Archaeology 42:60–92. University of California Archaeological Survey Reports.
- Bennyhoff, James A., and Richard E. Hughes
 - 1987 Shell Bead and Ornament Exchange Networks between California and the Western Great Basin. Anthropological Papers of the American Museum of Natural History 64(2). American Museum of Natural History, New York.
- Benson, Larry V., James W. Burdett, Steve P. Lund, Michaele Kashgarian, and Scott Mensing
 - 1997 Nearly Synchronous Climate Change in the Northern Hemisphere during the Last Glacial Termination. *Nature* 388:263–265.

Bergthold, Judith C.

1982 *Prehistoric Settlement and Trade Models in the Santa Clara Valley, California.* Master's thesis, Department of Anthropology, California State University, San Francisco.

Bernard, Julienne, David Robinson, and Fraser Sturt

2014 Points of Refuge in the South Central California Hinterlands. In *Indigenous Landscapes and Spanish Missions: New Perspectives from Archaeology and Ethnohistory*, edited by Lee M. Panich and Tsim D. Schneider, pp. 154–171. University of Arizona Press, Tucson.

Beta Analytic

2015 http://www.radiocarbon.com/marine-reservoir-effect.htm, accessed November 2015.

Bettinger, Robert L.

- 1981 *Archaeology of the Lee Vining Site, FS*#-05-04-51-219, (CA-MNO-446), Mono County, California. Bishop, California.
- 1982 Aboriginal Exchange and Territoriality in Owens Valley, California. In *Contexts for Prehistoric Exchange*, edited by J. E. Ericson and T. K. Earle, pp. 103–127. Academic Press, New York.
- 1987 Archaeological Approaches to Hunter-Gatherers. *Annual Review of Anthropology* 16:121–142.
- 1991 *Hunter-Gatherers: Archaeological and Evolutionary Theory.* Plenum Press, New York.
- 2001 Holocene Hunter-Gatherers. In *Archaeology at the Millenium*, edited by G. Feinman and D. T. Price. Kluwer Academic/Plenum Publishers, New York.
- 2013 Effect of the Bow on Social Organization in Western North America. *Evolutionary Anthropology: Issues, News, and Reviews* 22(3):118–123.
- 2015 Orderly Anarchy: Sociopolitical Evolution in Aboriginal California. University of California Press, Berkeley.

Bettinger, Robert L., and Martin A. Baumhoff

- 1982 The Numic Spread: Great Basin Cultures in Competition. *American Antiquity* 47(3):485-503.
- Bettinger, Robert L., and Jelmer Eerkens
 - 1999 Point Typologies, Cultural Transmission, and the Spread of Bow-and-Arrow Technology in the Prehistoric Great Basin. *American Antiquity* 64(2):231-242.
- Bettinger, Robert L., and Eric Wohlgemuth
 - 2011 Archaeological and Ethnographic Evidence for Indigenous Plant Use in California. In *The Subsistence Economies of Indigenous North American Societies*, edited by B. D. Smith, pp. 113– 129. Smithsonian Institution, Washington, DC.

Bettinger, Robert. L., Ripan Malhi, and Helen McCarthy

1997 Central Place Models of Acorn and Mussel Processing. *Journal of Archaeological Science* 24:887-899.

Bettinger, Robert L., Bruce Winterhalder, and Richard McElreath

2006 A Simple Model of Technological Intensification. Journal of Archaeological Science 33:538-545

Bevill, Russell

2009 *CA-TUO-4509, A High Altitude Lithic Cache from Parker Pass, Yosemite National Park, Tuolumne County, California.* URS Group, Inc., Chico, California. Submitted to Yosemite National Park, El Portal, California.

Bickel, P.

- 1976 Toward a Prehistory of the San Francisco Bay Area: The Archaeology of Sites ALA-328, ALA-12, and ALA-13. Unpublished Ph.D. dissertation, Department of Anthropology, Harvard University, Cambridge, Massachusetts.
- 1978 Changing Sea Levels along the California Coast: Anthropological Implications. *Journal of California Anthropology* 5(1):6–20.
- 1981 *San Francisco Bay Archaeology: Sites ALA-328, ALA-13 and ALA-12*. Contributions of the University of California Archaeological Research Facility 43. University of California Press, Berkeley.

Bieling, David G.

- 1998 Archaeological Investigations at CA-MRN-254, the Dominican College Site, San Rafael, Marin County, California. Holman & Associates Archaeological Consultants, San Francisco, California. Submitted to Dominican College, San Rafael, California.
- 1999 *Results of Archaeological Monitoring at CA-MRN-254, the Dominican College Site, San Rafael, Marin County, California.* Holman & Associates Archaeological Consultants, San Francisco, California. Submitted to Dominican College, San Rafael, California.
- 2000 *Archaeological Investigations at CA-MRN-255/H, Larkspur, Marin County, California.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2007 Notes on Excavation from CA-MRN-342. Unpublished notes in possession of the author.
- 2011 *An Archaeological Investigation at 34 San Rafael Avenue, Belvedere, Marin County, California.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Bieling, David G., and S. Psota

1989 *Archaeological Investigations at CA-MRN-127, San Rafael, Marin County, California*. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Binford, Lewis R.

- 1968 Post-Pleistocene Adaptations. In *New Perspectives in Archaeology*, edited by S. R. Binford and L. R. Binford, pp. 313–341. Aldine Press, Chicago, Illinois.
- 1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35(3):255-273.
- 1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4–20.
- 1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1(1):5–31.

Black, Stephen, and Alston Thoms

2014 Hunter-gatherer earth ovens in the archaeological record: fundamental concepts. *American Antiquity*, 79(2), 204-226.

Blackburn, T. C., and K. Anderson

1993 *Before the Wilderness: Environmental Management by Native Californians*. Ballena Press, Ramona, California.

Bloom, A. L.

1983 Sea level and coastal morphology of the United States through the late Wisconsin glacial maximum. *Late Quaternary Environments of the United States* 1:215–229.

Bocek, Barbara

- 1987 *Hunter-Gatherer Ecology and Settlement Mobility along San Francisquito Creek*. Ph.D. dissertation, Stanford University, Stanford, California. University Microfilms, Ann Arbor, Michigan.
- 1988 Sites and Site Clusters: Middle Period Archaeology of the San Francisquito Drainage. Proceedings of the Society for California Archaeology 1:299–310.
- 1991 Prehistoric Settlement Pattern and Social Organization on the San Francisco Peninsula, California. In *Between Bands and States*, edited by Susan A. Gregg, pp. 58–86. Center for Archaeological Investigations Occasional Paper No. 9, Southern Illinois University.
- 1992 Subsistence, Settlement and Tribelet Territories on the Eastern San Francisco Peninsula. *Proceedings of the Society for California Archaeology* 5:269–297.

Bocek, Barbara, and John Rick

1986 Archaeological Significance of Stanford West Areas A and B: A Report for the Stanford University Archaeology Task Force. Stanford University, Palo Alto, California.

Bocquet-Appel, J.-P.

- 2002 Paleoanthropological Traces of a Neolithic Demographic Transition. *Current Anthropology* 43(4):637–650.
- 2011 When the World's Population Took Off: The Springboard of the Neolithic Demographic Transition. *Science* 333:560–561.

Bocquet-Appel, J.-P., and S. Naji

2006 Testing the Hypothesis of a Worldwide Neolithic Demographic Transition: Corroboration from American Cemeteries. *Current Anthropology* 47(2):341–365.

Botkin, S.

1980 Effects of Human Exploitation on Shellfish Populations at Malibu Creek, California. In Modeling Change in Prehistoric Subsistence Economies, edited by T. K. Earle and A. L. Christenson, pp. 121–136. Academic Press, New York.

Bouey, P. D.

- 1987 The Intensification of Hunter-Gatherer Economies in the Southern North Coast Ranges of California. *Research in Economic Anthropology* 9:53–101.
- 1995 Final Report on the Archaeological Analysis of CA-SAC-43, Cultural Resources Mitigation for the Sacramento Urban Area Levee Reconstruction Project, Sacramento County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to US Army Corps of Engineers, Sacramento District, Sacramento, California.

Bowen, O. E., Jr.

1962 *Rocks and Minerals of the San Francisco Bay Region.* California Natural History Guide No. 5. University of California Press, Berkley.

Boyd, Robert, and Peter J. Richerson

1985 *Culture and the Evolutionary Process.* University of Chicago Press, Chicago.

Breschini, Gary S.

- 1977 *The Physical Anthropology of the Holiday Inn Site (CA-SCL-128). Part 1—Basic Physical Anthropology and Osteometric Analysis.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1983 Models of Population Movements in Central California Prehistory. Coyote Press, Salinas, California.
- Breschini, Gary S., and Trudy Haversat
 - 1986 Symposium: A New Look at Some Old Sites. Coyote Press Archives of California Prehistory 6.
 - 2005 *Radiocarbon Dating and Cultural Models on the Monterey Peninsula*. California Pacific Coast Archaeological Society.

Breschini, Gary S., Trudy Haversat, and Jon Erlandson

1996 California Radiocarbon Dates, Eighth Edition. Coyote Press, Salinas, California.

Brink, Laura, Jelmer Eerkens, Alex DeGeorgey, and Jeffrey Rosenthal

- 2015 Reconstructing Mobility in the San Francisco Bay Area: Strontium and Oxygen Isotope Analysis at Two California Late Period Sites, CA-CCO-297 and CA-SCL-919. Paper presented at the Society of America Archaeology Meeting, San Francisco, California.
- Brock, Sharon L.
 - 1986 Burials 4–7 and other Human Remains from the Jefferson School Site (CA-SCL-317/H) City of San Jose, Santa Clara County, California. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Brooks, Sheilagh, and Richard H. Brooks

1993 Comparative Mortality and Frequencies of Selected Non-Metric Traits in Skeletal Series from East San Francisco Bayshore Archaeological Sites. In *There Grows a Green Tree: Papers in Honor of David A. Fredrickson*, edited by Greg White, Pat Mikkelsen, William R. Hildebrandt, and Mark E. Basgall, pp. 411–423. Center for Archaeological Research at Davis, Publication 11, University of California, Davis.

Broughton, J. M.

- 1988 Archaeological Patterns of Prehistoric Fish Exploitation in the Sacramento Valley. Unpublished Master's thesis, Department of Anthropology, California State University, Chico.
- 1994a Declines in Mammalian Foraging Efficiency during the Late Holocene, San Francisco Bay, California. *Journal of Anthropological Archaeology* 13:371–401.
- 1994b Late Holocene Resource Intensification in the Sacramento Valley, California: The Vertebrate Evidence. *Journal of Archaeological Science* 21:501–514.
- 1994c Prehistoric Human Impacts on California Birds: Evidence from the Emeryville Shellmound Avifauna. Ornithological Monographs 56.

Broughton, J. M. continued

- 1997 Widening Diet Breadth, Declining Foraging Efficiency, and Prehistoric Harvest Pressure: Ichthyofaunal Evidence from the Emeryville Shellmound, California. *American Antiquity* 71(274):845–862.
- 1999 *Resource Depression and Intensification during the Late Holocene, San Francisco Bay: Evidence from the Emeryville Shellmound Vertebrate Fauna.* University of California Publications Anthropological Records 32.
- 2000 Terminal Pleistocene Fish Remains from Homestead Cave, Utah, and Implications for Fish Biogeography in the Bonneville Basin. *Copeia* (3):645–656.
- 2002 Prey Spatial Structure and Behavior Affect Archaeological Tests of Optimal Foraging Models: Examples from the Emeryville Shellmound Vertebrate Fauna. *World Archaeology* 34:60–83.
- 2004 *Prehistoric Human Impacts on California Birds: Evidence from the Emeryville Shellmound Avifauna.* Ornithological Monographs 56.

Broughton, Jack M., and Frank E. Bayham

2003 Showing Off, Foraging Models, and the Ascendance of Large-Game Hunting in the California Middle Archaic. *American Antiquity* 68(4):783–789.

Broughton, Jack M., Daniel Mullins, and Tamara Ekker

2007 Avian Resource Depression or Intertaxonomic Variation in Bone Density? A Test with San Francisco Bay Avifaunas. *Journal of Archaeological Science* 34:374–391.

Broughton, J. M., R. K. Beck, J. B. Coltrain, D. H. O'Rourke, and A. R. Rogers

2013 A Late Holocene Population Bottleneck in California Tule Elk (*Cervus elaphus nannodes*): Provisional Support from Ancient DNA. *Journal of Archaeological Method and Theory* 20(3):495– 524.

Broughton, Jack M., E. P. Martin, Brian McEneaney, Thomas Wake, and Dwight D. Simons

2015 Late Holocene Anthropogenic Depression of Sturgeon in San Francisco Bay, California. *Journal of California and Great Basin Anthropology* 35(1):3–27.

Buikstra, Jane E., and Douglas H. Ubelaker

1994 Documentation of Sex Differences and Age Changes in Adults. In Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at The Field Museum of Natural History. Arkansas Archeological Survey Research Series 44. http://tiwanakuarcheo.net/ KwMsGr2011/4%20-%20Buikstra%20Ubelaker%20Documentation%20of %20Sex%20Differences%2039-46.pdf, accessed June 2016.

Buonasera, Tammy Y.

- 2013 More than Acorns and Small Seeds: A Diachronic Analysis of Mortuary Associated Ground Stone from the South San Francisco Bay Area. *Journal of Anthropological Archaeology* 32(2):190– 211.
- 2015 Modeling the Costs and Benefits of Manufacturing Expedient Milling Tools. *Journal of Archaeological Science* 57:335-344.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

Burcham, Levi Turner

1957 *California Range Land: An Historico-Ecological Study of the Range Resource of California*. California Division of Forestry, Sacramento, California.

Burson, Elizabeth

1998 *Taxa Diversity and Prehistoric Foraging along the San Francisquito Watershed, California: A* 4,000-*Year Record of Resource Use.* Master's thesis, Department of Anthropology, Stanford, California.

Burton, Margie

2003 Gas Chromatography/Mass Spectrometry Analysis of Organic Residues in Ceramic and Ground Stone Artifacts from INY-1317 and INY-1991. In *Lacustrine Lifestyles along Owens Lake: NRHP Evaluation of 15 Prehistoric Sites for the Olancha/Cartago Four-Lane Project, US Route 395, Inyo County, California.* Prepared for California Department of Transportation.

Busby, Colin I., Larry S. Kobori, James C. Bard, and Patricia M. Ogrey

1982 *The Recovery and Analysis of an Aboriginal Burial from Site CA-SCL-302, Santa Clara County, California.* Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Byrd, Brian F.

- 1989 The Natufian: Settlement Variability and Economic Adaptations in the Levant at the End of the Pleistocene. *Journal of World Prehistory* 3(2):159–197.
- 1994 Public and Private, Domestic and Corporate: The Emergence of the Southwest Asian Pillage. *American Antiquity* 58(4):639–666.
- 2005 Reassessing the Emergence of Village Life in the Near East. *Journal of Archaeological Research* 13:231–290.
- 2008 Subsistence Patterns in a Regional Context. In San Francisco-Oakland Bay Bridge East Span Seismic Safety Project – Archaeological Analysis of CA-SFR-4/H, Yerba Buena Island, San Francisco and Alameda Counties, California, by Sally Morgan and Sean Dexter, pp. 105–117. URS Corporation, Oakland, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted by Parson Brinkerhoff, San Francisco, California. Submitted to California Department of Transportation, District 4, Toll Bridge Program, Oakland, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Byrd, Brian, and John Berg

2009 *Phase II Excavations in the Caltrans Right-of-Way at CASCL-12/H, Santa Clara County, California.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 4, Oakland, California.

Byrd, Brian F., and Philip Kaijankoski

2011 Archaeological Excavations of the Late Period Site CA-SFR-171, San Francisco County, California. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for Parsons on behalf of FTW and Peninsula Corridor Joint Powers Board. Byrd, Brian F., and Anna Petersen

2008 Spacing Behavior: A Geospatial Study of Shell Mounds in North San Francisco Bay. Paper Presented at the Society for California Archaeology Meetings, Pasadena, California.

Byrd, Brian F., and L. Mark Raab

2007 Recent Advances in Coastal Archaeology along the Southern California Bight. In *Colonization, Culture, and Complexity: California's Chaotic Prehistory,* edited by T. L. Jones and K. A. Klar, pp. 215–228. Altamira Press, Walnut Creek, California.

Byrd, Brian F., and Jeffrey Rosenthal

2016 Celebrating the Dead: Placing Prehistoric Mortuary Practices in Broader Social Context. In *Archaeological Variability and Interpretation in Global Perspective* edited by Alan P. Sullivan III and Deborah Irene Olszewski, pp. 233-265. University of Colorado Press, Boulder.

Byrd, Brian F., and Stephen Wee

- 2008 *Cultural Resources Alternatives Assessment for the Plan Formulation Phase of the Upper San Joaquin River Basin Storage Investigation, Fresno and Madera Counties, California.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to MWH Americas, Inc., and US Bureau of Reclamation, Sacramento, California.
- Byrd, Brian F., Paul Brandy, William R. Hildebrandt, Stephen Wee, Mark Beason, and Toni Webb
 - 2008 *Cultural Resources Alternatives Assessment for the Shasta Lake Water Resources Investigation, Shasta and Tehama Counties, California.* Far Western Anthropological Research Group, Inc., Davis, California. Prepared for the Bureau of Reclamation, Sacramento, California.
- Byrd, Brian F., Philip Kaijankoski, Jack Meyer, Adrian Whitaker, Rebecca Allen, Meta Bunse, and Bryan Larson
 - 2010 Archaeological Research Design and Treatment Plan for the Transit Center District Plan Area, San Francisco, California. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for Reuben and Junius on behalf of San Francisco Planning Department.
- Byrd, Brian F., John E. Berg, and Philip Kaijankoski
 - 2012 Archaeological Investigations for the State Route 82 Signal Interconnect and Intersection Modification Project, San Mateo County, California. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for California Department of Transportation, District 4, Oakland, California.
- Byrd, Brian F., Jack Meyer, Naomi Scher, Rebecca Allen, R. Scott Baxter, Bryan Larson, Chris McMorris, and Meta Bunse
 - 2013 Archaeological Research Design and Treatment Plan for the Moscone Center Expansion, San Francisco, California. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for ESA and submitted to City of San Francisco Major Environmental Analysis.
- Byrne, Roger, B. Lynn Ingram, Scott Starratt, Frances Malamud-Roam, Joshua N. Collins, and Mark E. Conrad
 - 2001 Carbon-Isotope, Diatom, and Pollen Evidence for Late Holocene Salinity Change in a Brackish Marsh in the San Francisco Estuary. *Quaternary Research* 55:66–76.

Cail, Hannah S.

2011 Feasting on Fido: Cultural Implications of Eating Dogs at Bridge River. Unpublished Master's thesis, Department of Anthropology, University of Montana, Missoula.

California Department of Fish and Wildlife. California Interagency Wildlife Task Group.

2015 Version 9.0 of the California Wildlife Habitat Relationships System and Bioview. Sacramento, California.

California Department of Transportation (Caltrans)

2015 *Caltrans Standard Environmental Reference: Volume 2 – Cultural Resources*. California Department of Transportation, Sacramento. http://www.dot.ca.gov/ser/vol2/vol2.htm, accessed June 2016.

California Office of Historic Preservation (OHP)

- 1993 *Guidelines for the Curation of Archaeological Collections*. Manuscript on file at the California Office of Historic Preservation. http://ohp.parks.ca.gov/pages/1054/files/guide93.pdf, accessed June 2016.
- 1995 *Instructions for Recording Historical Resources*. Office of Historic Preservation, Sacramento, California. http://ohp.parks.ca.gov/pages/1074/files/attribute%20codes.pdf, accessed June 2016.

Cambra, Rosemary, Ben Ananian, and Alan Leventhal

- 1988 Subsurface Archaeological Test Excavation and Soils Report from Prehistoric Site: CA-SCL-343, Located on the Lands of Oyama, Parcel # APN – 241-01-034, City of San Jose, Santa Clara County, California. NWIC report no. S-010505. Ohlone Families Consulting Services.
- Cambra, Rosemary, Alan Leventhal, Laura Jones, Julia Hammett, Les Field, Norma Sanchez, and Robert Jurmain
 - 1996 Archaeological Investigations at Kaphan Umux (Three Wolves) Site, CA-SCL-732: A Middle Period Prehistoric Cemetery on Coyote Creek in Southern San Jose, Santa Clara County, California. Ohlone Families Consulting Services and San Jose State Academic Foundation, San Jose, California. Submitted to the Santa Clara County Traffic Authority and the California Department of Transportation, District 4.

Campbell, G.

- 2014 Size prediction in archaeomalacology: the common mussel, Mytilus edulis L., as an example. *Archaeological and Anthropological Sciences* 6(3):305-318.
- 2015a "We want to go, where everyone knows, mussels are all the same...": a comment on some recent zooarchaeological research on Mytilus californianus size prediction. *Journal of Archaeological Science* 63:156-159.
- 2015b "What do I do with all these shells?" Basic guidance for the recovery, processing and retention of archaeological marine shells. *Quaternary International* 427(A):1-250.

Campbell, Breana, and Todd J. Braje

2015 Estimating California Mussel (*Mytilus californianus*) Size from Hinge Fragments: A Methodological Application in Historical Ecology. *Journal of Archaeological Science* 58:167–174.

- Carignan, Kelly S., Lisa A. Taylor, Barry W. Eakins, R. Jason Caldwell, Dorothy Z. Friday, Pamela R. Grothe, and Elliot Lim
 - 2011 Digital Elevation Models of Central California and San Francisco Bay: Procedures, Data Sources, and *Analysis*. NOAA Technical Memorandum NESDIS NGDC 52.
- Carré, Matthieu, Laurent Klaric, Danièle Lavalleé, Michèle Julien, Ilhem Bentaleb, Michel Fontugne, and Orest Kawka
 - 2009 Insights into Early Holocene Hunter-Gatherer Mobility on the Peruvian Southern Coast from Mollusk Gathering Seasonality. *Journal of Archaeological Science* 2009:1173–1178.

Carrico, Judy, and Robert Cartier

- 1987 The Archaeological Recovery at the Elk Site, CA-SCL-619, at the Mill Creek Improvement Project in the City of Santa Clara, County of Santa Clara. Archaeological Resource Management. NWIC: S-009233.
- Carrico, Judy, Marsha Shaiman, and Jan England
 - 1987 *Testing Evaluation for Building 24 at the Mansion Grove Project in the City of Santa Clara*. NWIC report no. S-009490. Archaeological Resource Management.

Cartier, R. R.

- 1988 The Eastridge Site, CA-SCI-327. *Proceedings of the Society for California Archaeology* 1:355–366.
- 1993 The Scotts Valley Site: CA-SCr-177. Santa Cruz Archaeological Society, Santa Cruz, California.
- 1996 *The Hiller Site: CA-SMA-160.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Results of Archaeological Monitoring and Salvage Burial Recovery Excavations at the Parkside Glen
 Apartments Project (CA-SCL-548) in the City of San Jose. Archaeological Resource Management.
 On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2000 *The Ross Woods Shell Midden: An Archaeological Salvage and Recovery Program at CA-SMA-335/H in the City of Belmont.* Archaeological Resource Management. Prepared for Regis Homes of Northern California, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2002 The Sunnyvale Red Burial: CA-SCL-832. In *Proceedings of the Society of California Archaeology, Volume* 15. Society for California Archaeology.
- 2004 An Archaeological Monitoring and Burial Recovery Program for the Belmont City Hall Expansion Project in Belmont, California. Archaeological Resource Management. Prepared for the City of Belmont. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2006 Archaeological Monitoring and Burial Recovery Program on Sanborn Avenue (SNI WA03: Alma Improvements Project) in the City of San Jose. Archaeological Resource Management. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Cartier, Robert, and Judy Carrico

1988 The Tarleton Site – CA-SMA-248. *Proceedings of the Society for California Archaeology* 1:283–298.

Cartier, Robert, Lorna Pierce, Francoise Sweeney, and Glory Anne Laffey

- 1986 Burial Recovery at Berryessa Creek in the City of Milpitas, County of Santa Clara. Archaeological Resource Management. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Cartier, Robert, Glory Anne Laffey, and Richard San Filippo
 - 1988a Archaeological Study of the Elmwood Detention Facility. Archaeological Resource Management. NWIC: S-010215.
 - 1988b Archaeological Excavation at CA-SCL-600 on Adobe Creek in the City of Palo Alto, County of Santa Clara. NWIC report no. S-010077. Archaeological Resource Management.
- Cartier, Robert, Laurie Crane, Paul Etheridge, Glory Anne Laffey, Lorna Pierce, Jeanelle Rusmisel, Richard San Filippo, Victoria Spillman, Irene Van Zandt, and James Welch
 - 1990 *Archaeological Excavations at CA-SCL-6W, the Lick Mill Boulevard Site*. Archaeological Resource Management. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Cartier, Robert, Laurie Crane, Paul Etheridge, Glory Anne Laffey, Lorna Pierce, Jeanelle Rusmisel, Richard San Filippo, Victoria Spillman, Irene Van Zandt, James Welch, and Glen Wilson
 - 1993 *Archaeological Excavations at CA-SCL-6W: The Lick Mill Boulevard Site.* Archaeological Resource Management. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Cartier, Robert, Elena Reese, and Julie C. Wizorek
 - 1994 *Evaluation of Prehistoric Resources and Determination for National Register Eligibility for the Calabazas Creek Flood Control Project.* NWIC report no. S-016689. Archaeological Resource Management.
- Cartier, Robert, Jason Bass, and Scott Ortman
 - 2003 *The Archaeology of the Guadalupe Corridor*. The Santa Clara County Archaeological Society in Conjunction with Archaeological Resource Management. NWIC report no. S-15131. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Chacon, Richard J., and David H. Dye (editors)

- 2007a The Taking and Displaying of Human Body Parts as Trophies by Amerindians. Springer, New York.
- 2007b Supplemental Data on Amerindian Trophy Taking. In *The Taking and Displaying of Human Body Parts as Trophies by Amerindians*, edited by Richard J. Chacon and David H. Dye, pp. 618–629. Springer, New York.

Chagnon, Napoleon A.

- 1970 Ecological and Adaptive Aspects of California Shell Money. *Annual Reports of the University of California Archaeological Survey* 12:1–25.
- Chard, C., E. N. Johnson, and R. F. Heizer
 - n.d. *The Archaeology of the Hotchkiss Site, CCO-138.* Collection of Manuscripts from the Archaeological Archives of the Phoebe A. Hearst Museum of Anthropology 14. Phoebe Hearst Museum of Anthropology, Berkeley, California.

Chartkoff, Joseph L., and Kerry Kona Chartkoff

1984 The Archaeology of California. Stanford University Press, Palo Alto, California.

Chattan, Cassandra, Dea Bacchetti, and William Roop

1997 *Archaeological Monitoring and Recovery Procedures During the Dixon Flood Control Pond "1B" Excavation.* Submitted to the City of Dixon.

Chattan, Cassandra, Sally Evans, William Roop, Lisa Pesnichak, Kristel Daunell, and Amy Schilling

2005 *Results of an Archaeological Monitoring Program at 10 North Point Circle, on the Site of CA-MRN-*39, *Belvedere, Marin County, California*. Archaeological Resource Service. Prepared for David and Kamala Berry.

Chavez, David

- 1976 *The Archaeology of 4-MRN-170: A Marin County Shellmound*. Master's thesis, Anthropology Department, San Francisco State University, San Francisco, California.
- 1995 Archaeological Test Excavations at CA-MRN-464, CA-MRN-465 and CA-MRN-495, Big Rock Ranch, Marin County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Clark, G. A.

1993 Paradigms in Science and Archaeology. Journal of Archaeological Research 1(3):203–234.

Clark, Matthew R.

- Archaeological Investigations of the Mussel Rock Site, CA-SMA-72, San Mateo County, California.
 Holman and Associates Archaeological Consultants, San Francisco, California. On file,
 Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1989 Evaluative Archaeological Investigations at the San Bruno Mountain Mound Site, CA-SMA-40, South San Francisco, California. Holman and Associates Archaeological Consultants, San Francisco, California. Prepared for Sterling Pacific Management Services, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1992 Evaluative Report of Test Excavations at Sites CA-MRN-529 and CA-MRN-530/530E for National Register of Historic Places Eligibility for the Novato Creek Flood Control Project, Marin County, California. Holman and Associates Archaeological Consultants, San Francisco, California. Prepared for Marin County Flood Control and Water Conservation District, Marin County Public Works Department, San Rafael, California.
- 1998 Report of the Discovery of a Prehistoric Archaeological Site in the Crissy Field Restoration Project Area, Presidio of San Francisco, Golden Gate National Recreation Area. Holman and Associates Archaeological Consultants, San Francisco, California. Prepared for Golden Gate National Parks Association. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2001 Crissy Field Restoration Project; Final Report of Archaeological Investigations at the Crissy Field Prehistoric Site, CA-SFR-129, Presidio of San Francisco, Golden Gate National Recreation Area.
 Holman and Associates Archaeological Consultants, San Francisco, California. Submitted to Golden Gate National Recreation Area, National Park Service, San Francisco, California.

Clark, Matthew R., David G. Bieling, and Sunshine Psota

1995 Archaeological Data Recovery at CA-MRN-530E/H, the "Diablo Bridge Site" and "Our House" Historic Site, for the Novato Flood Control Project, Novato, Marin County, California. Holman and Associates Archaeological Consultants, San Francisco, California. Prepared for Marin County Flood Control and Water Conservation District, Marin County Public Works Department, San Rafael, California.

Cleland, James H.

1995 Prehistory of the Middle Pit River, Northeastern, California: Archaeological Investigations at Lake Britton, Pit 3, 4 and 5 Project: Volume II Technical Appendices. KEA Environmental, Inc., San Diego, California, and Dames & Moore, Chico, California. Submitted to Pacific Gas and Electric Company, San Francisco, California.

Clewlow, C. William, Jr., and H. F. Wells

1981 Radiocarbon Dates from CA-MRN-152. *Journal of California and Great Basin Anthropology* 3(1):143–144.

Coberly, Mary B.

1973 *The Archaeology of the Ryan Mound, Site ALA-329: A Central California Coastal Village Site.* University of Northern Colorado Occasional Publications in Anthropology Archaeology Series No. 4. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Codding, Brian F., and Terry L. Jones

2013 Environmental Productivity Predicts Migration, Demographic, and Linguistic Patterns in Prehistoric California. *Proceedings of the National Academy of Sciences* 110:14569–14573.

Cohen, M. N.

1981 *Pacific Coast Forager: Affluent or Overcrowded.* Senri Ethnological Studies No. 9. National Museum of Ethnology, Osaka, Japan.

Coleman, Jason A.

- 2012 *Lindsey Slough Freshwater Tidal Marsh Enhancement Project, Solano County, California*. Prepared for the Solano Land Trust. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Coleman, Jason A., Charlane Gross, and Brian Ludwig
 - 2014 Archaeological Investigation at CA-SOL-364: Final Report for the Tower Mart Store #99 Project, Solano County, California. Solano Archaeological Services, Suisun City, California. Prepared for Tower Energy Group, Torrance, California.

Colligan, Kaely, Adrian R. Whitaker, and William Hildebrandt

2015 Where the Pavement Ends: An Assessment of the Paucity of *Haliotis rufescens* in the Archaeological Record on California's North Coast. *California Archaeology* 7(1):33–58.

- Colton, R. H., C. G. Lebow, C. Denardo, R. L. McKim, D. R. Harro, C. H. Miksicek, and B. Bowser
 - 1999 *Hunter-Gatherer Land Use in the San Antonio Creek Drainage*. California State Water Project, Coastal Branch Series, Paper Number 11. San Luis Obispo County Archaeological Society, San Luis Obispo, California.

Compas, Lynn, Gregory White, and W. Dworkin

1994 Appendix A: Supplemental Investigation at the Rechann Locality, CA-LAK-509/881, Anderson Marsh State Historic Park, Lake County, California. Anthropological Studies Center, Sonoma State University. Prepared for Caltrans Environmental Division, Sacramento.

Cook, Sherburne F.

- 1943 The Conflict between the California Indians and White Civilization Vol. 2, the Physical and Demographic Reaction of the Non-mission Indians in Colonial and Provincial California. In *Ibero-Americana* 22. University of California Press, Berkeley.
- 1955 *The Aboriginal Population of the San Joaquin Valley, California.* University of California Anthropological Records 16(2). University of California, Berkeley.
- 1976 *The Population of California Indians, 1769–1970.* University of California Press, Berkley.

Cook, Sherburne F., and Albert B. Elsasser

1956 Burials in the Sand Mounds of the Delta Region of the Sacramento - San Joaquin River System. *University of California Archaeological Survey Reports* 35:26–46.

Cook, Sherburne F., and Robert F. Heizer

1968 Relationships among Houses, Settlement Areas, and Population in Aboriginal California. In *Settlement Archaeology*, edited by K. C. Chang. National Press Books, Palo Alto, California.

Cope, Carole R.

1985 *The Mammalian Fauna of the Emeryville Shellmound, CA-ALA_309.* Master's thesis, Special Major, Sonoma State University, Rohnert Park, California.

Cowart, Alicia, and Roger Byrne

- 2013 A Paleolimnological Record of Late Holocene Vegetation Change from the Central California Coast. *California Archaeology* 5(2):337–352.
- Craft, C., C. Teixeira, and N. Woods
 - 1978 *Investigation of the Escalante Site*. Manuscript on file, Department of Anthropology, San Jose State University, San Jose State, California.

Crawford, Karen L.

2005 Final Archaeological Data Recovery Report for the San Francisco Central Freeway Replacement Project – Alternative 8B, City and County of San Francisco, California. Jones and Stokes, Sacramento, California. Prepared for California Department of Transportation, District 4, Oakland, California.

Crespí, Juan

[1772] 1927 Fray Juan Crespí: Missionary Explorer on the Pacific Coast 1769–1774, edited by R. E. Bolton. University of California Press, Berkeley. Culleton, Brendan J., Douglas J. Kennett, and Terry L. Jones

- 2009 Oxygen Isotope Seasonality in a Temperate Estuarine Shell Midden: A Case Study from CA-ALA-17 on the San Francisco Bay, California. *Journal of Archaeological Science* 36:1354–1363.
- Cuthrell, R.Q.
 - 2013 Archaeobotanical Evidence for Indigenous Burning Practices and Foodways at CA-SMA-113. *California Archaeology* 5(2):265–290.

Cuthrell, Rob Q., Mark G. Hylkema, and Laurel Collins

- 2013 Natural Resources, Geomorphology, and Archaeology of Site CA-SMA-113 in Quiroste Valley Cultural Preserve, California. *California Archaeology* 5(2):247–264.
- Cuthrell, Rob Q., Lee M. Panich, and Oliver R. Hegge
 - 2016 Investigating native Californian tobacco use at Mission Santa Clara, California, through morphometric analysis of tobacco (Nicotiana spp.) seeds. *Journal of Archaeological Science: Reports* 6:451-462.

D'Alpoim Guedes, Jade, and Robert Spengler

- 2014 Sampling Strategies in Paleoethnobotanical Analysis. In *Method and Theory in Paleoethnobotany*, edited by J. M. Marston, J. D. Guedes, and C. Warinner. University of Colorado Press, Boulder.
- Davis, James T. (editor)
 - 1961 Trade Routes and Economic Exchange among the Indians of California, edited by R. F. Heizer. University of California Archaeological Survey Reports 54:1–71. University of California, Department of Anthropology, Berkeley.

Davis, James T., and A. E. Treganza

- 1959 *The Patterson Mound: A Comparative Analysis of the Archaeology of Site ALA-328.* University of California Archaeological Survey Reports 47. University of California, Department of Anthropology, Berkeley.
- Davis, Owen K.
 - 1999 Pollen Analysis of Tulare Lake, California: Great Basin-like Vegetation in Central California During the Full-Glacial and Early Holocene. *Review of Palaeobotany and Palynology* 107:249– 257.
- DeGeorgey, Alex
 - 2007 Final Report on Archaeological Investigations at CA-MRN-44/H Angel Island State Park, Marin County, California. Sentinel Archaeological Research, LLC.
 - 2013 Final Report on Archaeological Investigations at a Stege Mound (CA-CCO-297), City of Richmond, Contra Costa County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
 - 2016 Archaeological Excavation of the Stege Mound (CA-CCO=297), A Late Period Shell Mound Located on the San Francisco Bayshore. Prepared for Sucessor Agency to the Richmond Community Redevelopment Agency.

DeLancey, S., and Victor Golla

1997 The Penutian Hypothesis: Retrospect and Prospect. *International Journal of American Linguistics* 63:171–202.

Desmond, Lawrence G.

1998 *Report of Archaeological Monitoring and Excavations at CA-ALA-343 East of Tule Pond within the Project Area of M. H. Podell Company*. Holman and Associates Archaeological Consultants, San Francisco, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Diekmann, Lucy, Lee Panich, and Chuck Striplen

2007 Native American Management and the Legacy of Working Landscapes in California. *Rangelands* 29(3):46–50.

Dietz, Stephen A.

1985 Preliminary Report of Archaeological Test Excavations at CA-ALA-453 Union City, Alameda County, California. Archaeological Consulting and Research Services, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Dixon, Roland B., and Alfred L. Kroeber

1919 Linguistic Families in California. *University of California Publications in American Archaeology and Ethnology* 16(3).

Dore, Christopher D., Stephen Bryne, Michael McFaul, and Garry L. Running, IV

2004 Why Here? Settlement, Geoarchaeology, and Paleoenvironment at the West Berkeley Site (CA-Ala-307). *Proceedings of the Society for California Archaeology* 17:27–33.

Dortch, C. E.

2002 Modeling Past Aboriginal Hunter-Gatherer Socio-Economic Territorial Organization in Western Australia's Lower South-West. *Archaeology in Oceania* 37:1–21.

Dougherty, John W.

1990 *The Obsidian Projectile Points of the King-Brown Site: CA-SAC-29, Sacramento County, California,* Master's thesis, Department of Anthropology, California State University, Sacramento.

Drake, Robert J.

- 1942 *Archaeological Investigations of the San Bruno Shellmound*. Prepared for Museum of the San Mateo Historical Association, San Mateo Junior College.
- 1948 Archaeology Investigations of the San Bruno Shellmound, San Mateo County, California. *El Palacio* 11:317–323.

Driver, H. E.

1937 Culture Element Distributions, VI: Southern Sierra Nevada. *University of California Anthropological Records* 1:53–154.

Duke, Phillip

1995 Working through Theoretical Tensions in Contemporary Archaeology: A Practical Attempt from Southwestern Colorado. *Journal of Archaeological Method and Theory* 2:201–229.

Duncan, Faith L.

1992 *Botanical Reflections of the Encuentro and the Contact Period in Southern Marin County, California.* Ph.D. dissertation, Department of Anthropology, University of Arizona, Tucson.

EcoAtlas Information System

2012 Bay Area EcoAltas Historical Baylands GIS dataset, July 2012. San Francisco Estuary Institute, Oakland, California.

Edwards, Rob

1973 *Evaluation of Archaeological Resources, Tract 5188 (Oral Report Transcript)*. Cabrillo College, Aptos, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Eerkens, Jelmer W.

2001 *The Origins of Pottery Among Late Prehistoric Hunter-Gatherers in California and the Western Great Basin.* Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

Eerkens, Jelmer W., and Eric J. Bartelink

2013 Sex-Biased Weaning and Early Childhood Diet Among Middle Holocene Hunter–Gatherers in Central California. *American Journal of Physical Anthropology* 152:471–483.

Eerkens, Jelmer W., Gregory S. Herbert, Jeffrey S. Rosenthal, and Howard J. Spero

- 2005 Provenance Analysis of *Olivella biplicata* Shell Beads from the California and Oregon Coast by Stable Isotope Fingerprinting. *Journal of Archaeological Science* 32:1501–1514.
- Eerkens, Jelmer W., Jeffrey S. Rosenthal, Howard J. Spero, Ryoji Shiraki, and Gregory S. Herbert
 - 2007 Shell Bead Sourcing: A Comparison of Two Techniques on *Olivella biplicata* Shell Beads from Western North America. In *Archaeological Chemistry: Analytical Techniques and Archaeological Interpretation,* edited by Michael D. Glascock, Robert J. Speakman, and Rachel S. Popelka-Filcoff. American Chemical Society, Washington, DC.
- Eerkens, Jelmer W., Jeffrey S. Rosenthal, Howard J. Spero, Nathan E. Stevens, Richard Fitzgerald, and Laura Brink
 - 2009 The Source of Early Horizon *Olivella* Beads: Isotopic Evidence from CCO-548. In *Proceedings* of the Society for California Archaeology 23.
- Eerkens, Jelmer W., Jeffrey S. Rosenthal, Nathan E. Stevens, Amanda Cannon, Eric L. Brown, and Howard J. Spero
 - 2010 Stable Isotope Analysis of *Olivella* Shell Beads from the Los Angeles Basin and San Nicolas Island. *Journal of Island and Coastal Archaeology* 5:105–119.

Eerkens, Jelmer W., Ada G. Berget, and Eric J. Bartelink

2011 Estimating Weaning and Early Childhood Diet from Serial Micro-Samples of Dentin Collagen. *Journal of Archaeological Science* 38(11):3101–3111.

- Eekens, Jelmer W., Shannon Tushingham, K. Lentz, J. Black, D. Ardura, M. Palazoglu, and O. Fiehn
 - 2012 GC/MS analysis of residues reveals nicotine in two late prehistoric pipes from CA-ALA-554. *Proceedings of the Society for California Archaeology* 26:21.
- Eerkens J., E. J. Bartelink, K. Gardner, and R. Wiberg
 - 2013a The Evolution of a Cemetery: Rapid Change in Burial Practices in a Middle Holocene Site in Central Alta California. *California Archaeology* 5(1):3-35.
- Eerkens, J. W., B. F. Byrd, H. J. Spero, and A. K. Fritschi
 - 2013b Stable Isotope Reconstructions of Shellfish Harvesting Seasonality in an Estuarine Environment: Implications for Late Holocene San Francisco Bay Settlement Patterns. *Journal* of Archaeological Science 40(4):2014–2024.
- Eerkens, Jelmer W., Eric J. Bartelink, Karen S. Gardner, and Traci Carlson
 - 2014a Stable Isotope Perspectives on Hunter-Gatherer Violence: In *Who's Fighting Whom? Re-Examining a Pacified Past: Violence and Warfare among Hunter-Gatherers,* edited by Mark W. Allen and Terry L. Jones, pp. 296–313. Left Coast Press, Inc., Walnut Creek, California.

Eerkens, Jelmer W., Gary H. Barfod, Gina A. Jorgenson, and Chris Peske

- 2014b Tracing the Mobility of Individuals Using Stable Isotope Signatures in Biological Tissues: "Locals" and "Non-Locals" in an Ancient Case of Violent Death from Central California. *Journal of Archaeological Science* 41:474–481.
- Eerkens, Jelmer W., Traci Carlson, Ripan S. Malhi, Jennifer Blake, Eric J. Bartelink, Gry H. Barfod, Alan Estes, Ramona Garibay, Justin Glessner, Alexandra M. Greenwald, Kari Lentz, Hongjie Li, and Charla K. Marshall
 - 2015 Isotopic and Genetic Analyses of a Mass Grave in Central California: Implications for Precontact Hunter-Gatherer Warfare. *American Journal of Physical Anthropology*, in press.

Eerkens, Jelmer, Eric Bartelink, Laura Brink, Richard Fitzgerald, and Ramona Garibay

2016 Trophy Heads or Ancestor Veneration? A Stable Isotope Perspective on Disassociated and Modified Crania in Precontact Central California. *American Antiquity* 81(1): 114-131.

Elsasser, Albert B.

- 1978 Development of Regional Prehistoric Cultures. In *California*, edited by Robert F. Heizer, pp. 37–57. Handbook of North American Indians Vol. 8, William C. Sturtevant, general editor. Smithsonian Institution, Washington, DC.
- 1986 *Review of the Prehistory of the Santa Clara Valley Region, California*. Archives of California Prehistory 7. Coyote Press, Salinas, California.

Ericson, Jonathon E.

- 1977 Egalitarian Exchange Systems in California. In *Exchange Systems in Prehistory*, edited by T. K. Earle and J. E. Ericson. Academic Press, New York.
- 1981 *Exchange and Production Systems in California Prehistory: The Results of Hydration Dating and Chemical Characterization of Obsidian Sources 110.* British Archaeological Reports, International Series 110. Oxford, England.

Ericson, Jonathon E. continued

1982 Production for Obsidian Exchange in California. In *Contexts for Prehistoric Exchange*, edited by J. E. Ericson and T. K. Earle, pp. 129–148. Academic Press, New York.

Erlandson, J. M., and T. C. Rick

2010 Archaeology Meets Marine Ecology: The Antiquity of Maritime Cultures and Human Impacts on Marine Fisheries and Ecosystems. *Annual Review of Marine Science* 2:231–251.

Erlandson, Jon M., Torben C. Rick, Douglas J. Kennett, and Philip L. Walker

- 2001 Disease: Cultural Contacts and Possible Evidence for Old World Epidemics among the Protohistoric Island Chumash. *Pacific Coast Archaeological Society Quarterly* 37(3):11–26.
- Erlandson, Jon M., Torben C. Rick, Terry L. Jones, and Judith F. Porcasi
 - 2007a One if by Land, Two if by Sea: Who Were the First Californians? In *California Prehistory: Colonization, Culture, and Complexity,* edited by Terry L. Jones and Kathryn Klar, pp. 53–62. Altamira Press, Walnut Creek, California.
- Erlandson, Jon M., Michael H. Graham, Bruce J. Bourque, Debra Corbett, James A. Estes, and Robert S. Steneck
 - 2007b The Kelp Highway Hypothesis: Marine Ecology, the Coastal Migration Theory, and the Peopling of the Americas. *Journal of Island & Coastal Archaeology* 2:161–174.
- Eschmeyer, William N., and Jaqueline Schonewald
 - 1981 *Identification and Faunal Analysis of Fort Mason Osteological Remains, Archaeological Sites SFR-29,* 30, and 31. National Park Service, US Department of the Interior.
- Eshleman, Jason A., and David Glenn Smith
 - 2007 Prehistoric Mitochondrial DNA and Population Movements. In *California Prehistory: Colonization, Culture, and Complexity,* edited by Terry L. Jones and Kathryn Klar, pp. 291–298.
 Altamira Press, Walnut Creek, California.

ESRI

2015 Hydrology Toolset. ArcMap version 10.3. ESRI, Redlands, California.

Estes, Allen L., Eric Strother, Anna Engberg, and William Self

2001 Archaeological Monitoring, Testing, and Data Recovery Program—560 Mission Street Project, San Francisco. William Self Associates, Orinda, California. Submitted to Hines Interests Group, San Francisco, California.

Estes, Allen, Eric Strother, Kyle Brown, Nancy Summerlin, Marin Pilloud, James Allan, and William Self

2002 Report on the Catellus Hercules Project, Data Recovery, Burial Removal, and Construction Monitoring at the Site CA-CCO-474/H, Hercules, California. William Self Associates, Orinda, California. Submitted to CRG Constructors, Newport Beach, California.

Estes, Allen, Melanie A. Medeiros, and James Allan (editors)

2012 *Report on Archaeological Data Recovery at CA-ALA-554, Pleasanton, California Volume I: Data Recovery.* William Self Associates, Inc., Orinda, California.

Evans, Sally R.

2014 *Auditory Exostosis: A Marker of Behavior in Pre-contact Populations from the San Francisco Bay Region of California.* Master's thesis, Cultural Resources Management, Sonoma State University, Rohnert Park, California.

Evans, Sally R., and Craig P. Smith

2009 Results of an Archeological Monitoring Program for the Construction of the Fireside Inn Affordable Housing Project, at the Site of CA-MRN-05/H, 115 Shoreline Highway, Mill Valley, Marin County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Evett, Rand R., and Robert Q. Cuthrell

2013 Phytolith Evidence for a Grass-Dominated Prairie Landscape at Quiroste Valley on the Central Coast of California. *California Archaeology* 5(2):319–335.

Farnsworth, Paul, Eric Strother, Charlotte Sunseri, Angela Cook, and Rhonda Robichaud

2010 Data Recovery, Burial Removal and Construction Monitoring Report for the Terremark Data Center Project, CA-SCL-134, 2970 and 3000 Corvin Drive City and County of Santa Clara, California. Prepared by William Self Associates, Inc. for Terremark Technology Contractors, Inc.

Fergusson, G. J., and W. F. Libby

1964 UCLA Radiocarbon Dates, III. Radiocarbon 6:318–339.

Fewkes, J. W.

1896 Pacific coast shells from prehistoric Tusayan pueblos. *American Anthropologist* 9(11):359-368.

Finstad, K. M., B. L. Ingram, P. Schweikhardt, K. G. Lightfoot, E. M. Luby, and G. R. Coles

2013 New Insights about the Construction and Use of Shell Mounds from the Geochemical Analysis of Mollusks: An Example from the Greater San Francisco Bay. *Journal of Archaeological Science* 40(6):2648–2658.

Fitzgerald, Richard

- n.d. *Radiocarbon Report on an* Olivella *Grooved Rectangle Bead from MER-295*. Report in author's possession.
- 1993 *Archaic Milling Cultures of the Southern San Francisco Bay Region,* edited by Gary S. Breschini and Trudy Haversat. Coyote Press Archives of California Prehistory No. 35. Coyote Press, Salinas, California.
- 2000 *Cross Creek: An Early Holocene/Millingstone Site.* California State Water Project, Coastal Branch Series, Paper Number 12. San Luis Obispo County Archaeological Society, San Luis Obispo, California.
- 2005 Archaeological Investigations at CA-SMA-368/H for the Ravenswood Biological Mitigation Project 04-SMA-84, PM 41.9/47.1, EA 04-015113, San Mateo County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Fitzgerald, R. T., and G. J. Gmoser

1987 *Archaeological Investigations at the Islais Creek Shellmound CA-SFR-17.* Prepared for California Department of Transportation, District 4, Oakland, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Fitzgerald, Richard T., Terry L. Jones, and Adella Schroth

2005 Ancient Long-Distance Trade in Western North America: New AMS Radiocarbon Dates from Southern California. *Journal of Archaeological Science* 32(3):423–434.

Flannery, Kent V.

- 1972 The Origins of the Village as a Settlement Type in Mesoamerica and the Near East: A Comparative Study. In *Man, Settlement and Urbanism,* edited by P. J. Ucko, R. Tringham, and G. W. Dimbleby, pp. 23–53. Duckworth, London.
- 1976 The Early Mesoamerican Village. Academic Press, New York.

Flint, Sandra S., Barry A. Price, Randy Baloian, Mary Clark Baloian, and Kathleen Jernigan

2004 Archaeological Investigations at CA-SMA-109/H, CA-SMA-151, and CA-SMA-347, Pillar Point Air Force Station, Santa Mateo County, California. Applied Earth Works, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Flynn, Kathryn

1986 Unpublished notes on CA-MRN-171.

Fogelin, Lars

2007 Inference to the Best Explanation: A Common and Effective Form of Archaeological Reasoning. *American Antiquity* 72:603–626.

Follet, Wilbur Irving

Fish Remains from a Shellmound in Marin County, California. *American Antiquity* 23(1):68–71.

Fong, Michael R., and David G. Brittin

1994 Skeletal and Dental Abnormalities at a Prehistoric Central California Site. *Proceedings of the Society for California Archaeology* 7:117-134.

Fong, Michael R., Angela M. Banet, Michael D. Meyer, Melody E. Tannam, and Jill G. James

1988 Phase III South Archaeological Monitoring Results at CA-SCL-68 and CA-SCL-294 as Part of the Guadalupe Transportation Corridor Compliance with 36 CFR Part 800. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Fong, Michael R., Angela M. Banet, Robert M. Harmon, and Melody E. Tannam

1989 Phase V Archaeological Monitoring Finds at CA-SCL-68 and CA-SCL-137 as Part of the Guadalupe Transportation Corridor Compliance with 36 CFR Part 800. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California. Fong, Michael R., Angela M. Banet, and James C. Bard

1990 Analysis of Native American Skeletal Remains Recovered during Emergency Disinterment at CA-ALA-514/H, the Hidden Valley Ranch Site, City of Fremont, Alameda County, California. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Fong, Michael R., Stuart A. Guedon, Steve J. Rossa, and Angela M. Banet

- 1991a Historic Properties Survey Report for the Street Widening and I-580/First Street Interchange Modifications Project, Phase I, City of Livermore, Alameda County, California. Basin Research Associates, Inc., San Leandro, California. Submitted to David J. Powers and Associates Inc, San Jose, California. NWIC report no. S-13870. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1991b Historic Property Survey Report for the First Street Widening and I-580/First Street Interchange Modifications Project, Phase 2, City of Livermore, Alameda. Basin Research Associates, Inc., San Leandro, California. Submitted to David J. Powers and Associates Inc, San Jose, California. NWIC report no. S-13871. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Foster, Daniel G., and Linda C. Sandelin

2003 *Techniques for Discovering Prehistoric Archaeological Sites during Survey of CDF Projects.* California Department of Forestry and Fire Protection. http://calfire.ca.gov/resource_mgt/ archaeology-foster_reports.php, accessed January 2005 (updated January 2012).

Fredrickson, David A.

- 1966 *CCO-308: The Archaeology of a Middle Horizon Site in Interior Contra Costa County, California.* Master's thesis, Department of Anthropology, University of California, Davis.
- 1968 *Archaeological Investigations at CCO-30 near Alamo, Contra Costa County, California.* Center for Archaeological Research at Davis Publication 1. University of California, Davis.
- 1973 *Early Cultures of the North Coast Ranges, California*. Ph.D. dissertation, University of California, Davis.
- 1974a Cultural Diversity in Early Central California: A View from the North Coast Ranges. *Journal of California Anthropology* 1(1):41–54.
- 1974b Social Change in Prehistory: A Central California Example. In *Antap: California Indian Political and Economic Organization,* edited by Lowell J. Bean and Thomas F. King, pp. 57–73. Ballena Press Anthropological Papers No. 2. Ramona, California.
- 1994 Archaeological Taxonomy in Central California Reconsidered. In *Toward a New Taxonomic Framework for Central California Archaeology*, Richard Hughes, pp. 91–103. Contributions of the University of California Archaeological Research Facility 52, Berkeley.

Fredrickson, David A., and Thomas M. Origer

1995 Temporally Sensitive Attributes of Late Period Serrated Arrow Points in Sonoma County, California. Paper Presented at the Plenary Session Symposium in Honor of James A Bennyhoff, 29th Annual Meeting of the Society for California Archaeology, Eureka, California. Fretwell, Stephen D.

1972 *Populations in a Seasonal Environment (MPB-5) Vol. 5.* Princeton University Press, Princeton, New Jersey.

Fretwell, Stephen D., and Henry L. Lucas

1970 On territorial behavior and other factors influencing habitat distribution in birds. *Acta Biotheoretica* 19(1):16–36.

Friedman, Irving, and Robert L. Smith.

1960 Part I, The Development of the Method. *American Antiquity* 25(4):476–493.

Galloway, James P.

1976 An Analysis of Burial Data from CA-SMA-125. Unpublished Master's thesis, Department of Anthropology, San Francisco State University, San Francisco, California.

Galvin, John (editor)

1971 *The First Spanish Entry into San Francisco Bay,* 1775. John Howell Books, San Francisco, California.

Gamble, Lynn

2012 A Land of Power: The Materiality of Wealth, Knowledge, Authority, and the Supernatural. In Contemporary Issues in California Archaeology, edited by Terry L. Jones and Jennifer E. Perry, pp. 175–196. Left Coast Press, Walnut Creek, California.

Gamble, Lynn H., Phillip L. Walker, and Glenn S. Russell

2001 An Integrative Approach to Mortuary Analysis: Social and Symbolic Dimensions of Chumash Burial Practices. *American Antiquity* 66(2):185–212.

Gardner, J. V., L. E. Heusser, P. J. Quinterno, S. M. Stone, J. A. Barron, and R. Z. Poore

1988 Clear Lake record vs. the adjacent marine record; A correlation of their past 20,000 years of paleoclimatic and paleoceanographic responses. *Geological Society of America Special Papers* 214:171–182.

Gardner, Karen Smith

2013 Diet and Identity among the Ancestral Ohlone: Integrating Stable Isotope Analysis and Mortuary Context at the Yukisma Mound (CA-SCL-38). Master's thesis, Chico State University, Chico, California.

Gardner, Karen Smith, Alan Leventahl, Rosemary Cambra, Eric J. Bartelink, and Antoinette Martinez

- 2011 Mothers and Infants in the Prehistoric Santa Clara Valley: What Stable Isotopes Tell Us About Ancestral Ohlone Weaning Practices. *Proceedings of the Society for California Archaeology* 25:1– 14.
- Garfinkel, Alan P., Jeanne Day Binning, Elva Younkin, Craig Skinner, Tom Origer, Rob Jackson, Jan Lawson, and Tim Carpenter
 - 2004 The Little Lake Biface Cache, Inyo County, California. *Society for California Archaeology Proceedings* 17:87–101.
Gary, Mark A., and Deborah L. McLear-Gary

1992 The Caballo Blanco Biface Cache, Mendocino County, California (CA-MEN-1608). *Journal of California and Great Basin Anthropology* 12(1):19–27.

Gayton, Anna H.

1948 Yokuts and Western Mono Ethnography II: Northern Foothill Yokuts and Western Mono. *University of California Press Anthropological Records* 10(2):143–301.

Gerow, Bert A.

1981 Amino Acid Dating and Early Man in the New World: A Rebuttal. In *Contributions to Western Archaeology*. Occasional Papers of the Society for California Archaeology 3:1–12.

Gerow, Bert A., with Roland W. Force

1968 *An Analysis of the University Village Complex: With a Reappraisal of Central California Archaeology.* Stanford University Press, Stanford, California.

Gesch, D. B.

2007 The National Elevation Dataset. In *Digital Elevation Model Technologies and Applications: The DEM User's Manual, 2nd Edition,* edited by D. Maune, pp. 99–118. American Society for Photogrammetry and Remote Sensing, Bethesda, Maryland.

Gesch, D. B., M. Oimoen, S. Greenlee, C. Nelson, M. Steuck, and D. Tyler

2002 The National Elevation Dataset. *Photogrammetric Engineering and Remote Sensing* 68(1):5–11.

Gifford, Edward W.

- 1916 Composition of California Shellmounds. *University of California Publications in American Archaeology and Ethnography* 12:1-29.
- 1926 Miwok Cults. University of California Publications in American Archaeology and Ethnology 18(3):391–408.
- 1936 California Balanophagy. In *Essays in Anthropology Presented to Alfred L. Kroeber in Celebration of his Sixtieth Birthday*, pp. 27-29. University of California Press, Berkeley.
- 1940 *Californian Bone Artifacts*. University of California Anthropological Records 3(2). http://digitalassets.lib.berkeley.edu/anthpubs/ucb/text/ucar003-003.pdf, accessed June 2016.
- 1947 *California Shell Artifacts*. Anthropological Records 9:1–114. University of California Press, Berkeley.
- 1955 Central Sierra Miwok Ceremonies. University of California Anthropological Records 14(4):261– 318.

Gifford, Edward W., and Alfred L. Kroeber

1939 Culture Element Distributions IV: Pomo. *University of California Publications in American Archaeology and Ethnology* 37(4):117–254.

Gifford-Gonzalez, D., C. M. Boone, and R. E. Reid

2013 The Fauna from Quiroste: Insights into Indigenous Foodways, Culture, and Land Modification. *California Archaeology* 5(2):291–317.

Gilbert, Karl Grove

1917 *Hydraulic-Mining Debris in the Sierra Nevada*. US Geological Survey Professional Paper 105. Government Printing Office, Washington, DC.

Gilreath, Amy J., and William R. Hildebrandt

- 1997 *Prehistoric Use of the Coso Volcanic Field*. Contributions of the University of California Archaeological Research Facility 56. University of California, Berkeley.
- 2011 Current Perspectives on the Production and Conyeyance of Coso Obsidian. In *Perspectives on Prehistoric Trade and Exchange in California and the Great Basin,* edited by Richard E Hughes, pp. 171–188. University of Utah Press, Salt Lake City.
- 2017 *The Hay Ranch Biface Cache.* Far Western Anthropological Research Group, Inc., Davis, California. Draft report prepared for Bureau of Land Management, Ridgecrest, California.

Glassow, Michael A.

- 1991 Early Holocene Adaptations on Vandenberg Air Force Base, Santa Barbara County. In Hunter-Gatherers of Early Holocene Coastal California, edited by Jon M. Erlandson and Roger H. Colten, pp. 113–124. Perspectives in California Archaeology 1. Institute of Archaeology, University of California, Los Angeles.
- 1996 The Significance to California Prehistory of the Earliest Mortars and Pestles. *Pacific Coast Archaeological Society Quarterly* 32(4).

Gmoser, Glenn

- 1988 Boundary Development in Northwestern California—an Ecological Approach to Cultural History. Master's thesis, Sonoma State University, California.
- 1993 Co-evolution of Adaptation and Linguistic Boundaries in Northwest California In *There Grows a Green Tree: Papers in honor of David A. Fredrickson,* edited by Greg White, Pat Mikkelsen, William R. Hildebrandt, Mark E. Basgall, Mildred Dickemann, and Thomas Origer. Center for Archaeological Research at Davis Publication 11.

Glassow, Michael, Elizabeth A. Sutton, Carola Flores Fernandez, and Heather B. Thakar.

- 2016 Proxy measurements of California Mussel valve length. *Advances in Archaeological Practice* 4(1):31-40.
- Gmoser, Glenn, Jeffrey Rosenthal, William Hildebrandt, and Patricia Mikkelsen
 - 1999 Archaeological Survey of the I-680 Corridor between Dublin and Milpitas in Alameda and Santa Clara Counties for the "Sunol Grade" Southbound Improvement Project with Results of Extended Phase I/Phase II Archaeological Investigations at CA-ALA-574, CA-ALA-575, and CA-ALA-576. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 4, Oakland, California.
- Gmoser, Glenn, Jeffrey S. Rosenthal, William R. Hildebrandt, Patricia J. Mikkelsen, and Sharon A. Waechter
 - 2007 Archaeological Evaluation Report for CA-SON-159, SON-1695, and SON-921: State Route 116 Roadway Rehabilitation Project, Sonoma County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the California Department of Transportation, District 4, Oakland, California.

Gobalet, Kenneth W.

- 1992 Inland Utilization of Marine Fishes by Native Americans along the Central California Coast. *Journal of California and Great Basin Anthropology* 14(1):72–84.
- 2009 Fish. In *Phase II Excavations in the Caltrans Right-of-Way at CA-SCL-12/H, Santa Clara County, California,* edited by Brian F. Byrd and John Berg, pp. 131–138. Prepared for California Department of Transportation, District 4.

Gobalet, Kenneth W., P. D. Schulz, T. A. Wake, and N. Siefkin

- 2004 Archaeological Perspectives on Native American Fisheries of California with Emphasis on Steelhead and Salmon. *Transactions of the American Fisheries Society* 133(4):801–833.
- Goebel, T., M. R. Waters, and D. H. O'Rourke
 - 2008 The Late Pleistocene Dispersal of Modern Humans in the Americas. *Science* 319:1497–1502.

Goerke, Betty

- 1994 *Uncovering the Past at College of Marin.* MAPOM Occasional Papers 7. Miwok Archaeological Preserve of Marin, San Rafael, California.
- 2007 Chief Marin: Leader, Rebel, and Legend. Heyday Books, Berkeley, California.
- 2012 *The Alto Site: CA-MRN-12 1858–2012, Mill Valley, California*. College of Marin, Kentfield, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Goerke, Elizabeth B., and Richard A. Cowan

1983 The Pacheco Site (Marin-152) and the Middle Horizon in Central California. *Journal of New World Archaeology* 6(1):1–98.

Goldberg, Paul, and Richard Macphail

2006 Practical and Theoretical Geoarchaeology. Blackwell, Oxford.

Goldman, Harold B.

1969 *Geologic and Engineering Aspects of San Francisco Bay Fill.* California Division of Mines and Geology, San Francisco, California.

Goldschmidt, W. R.

1951 Nomlaki Ethnography. University of California Publications in American Archaeology and Ethnology 42(4):303–443.

Golla, Victor

- 2007 Linguistic Prehistory. In *California Prehistory: Colonization, Culture, and Complexity,* edited by Terry L. Jones and Kathryn Klar, pp. 71–82. Altamira Press, Walnut Creek, California.
- 2011 *California Indian Languages*. University of California Press, Berkley.

Goman, Michelle, and Lisa Wells

2000 Trends in River Flow Affecting the Northeastern Reach of the San Francisco Bay Estuary over the past 7000 years. *Quaternary Research* 54:206–217.

Goodwin, David H., Andrew N. Cohen, and Peter D. Roopnarine

2010 Forensics on the Half Shell: A Sclerochronological Investigation of a Modern Biological Invasion in San Francisco Bay, United States. *PALAIOS* 25:742–753.

Graham, Margaret

2006 A Diachronic View of South San Francisco Bay Prehistoric Ohlone Diet: New Evidence from Santa Clara University. In *Revealing Santa Clara University's Prehistoric Past: CA-SCL-755 Evidence from the Arts & Sciences Building Project*, edited by Russell K. Skowronek and Lorna C. Pierce. Research Manuscript Series on the Cultural and Natural History of Santa Clara No. 15. Santa Clara University, Santa Clara, California.

Graham, N. E.

2004 Late-Holocene Telecommunications Between Tropical Pacific Climate Variability and Precipitation in the western USA: Evidence from Proxy Records. *The Holocene* 14(3):436-447.

Greengo, Robert E.

1951 *Molluscan Studies in California Shell Middens*. Reports of the University of California Archaeological Survey 13. University of California, Berkeley.

Greenwald, Alexandra M., and Gregory R. Burns

2016 *Reconstructing Lifeways in Ancient California: Stable Isotope Evidence of Foraging Behavior, Life History Strategies, and Kinship Patterns.* Center for Archaeological Research at Davis Publication 18. Davis, California.

Gremillion, Kristen J.

- 2002 Foraging Theory and Hypothesis Testing in Archaeology: An Exploration of Methodology Problems and Solutions. *Journal of Anthropological Archaeology* 21:142-164.
- 2004 Seed processing and the origins of food production in eastern North America. *American Antiquity* 69(2):215-233.

Griffin, Mark C.

2014 Biocultural Implications of Oral Pathology in an Ancient Central California Population. *American Journal of Physical Anthropology* 154:171–188.

Griffin, Mark C., Kathryn Entriken, Julie Hodel, and Theresia C. Weston

2006 Osteological Analysis of the Human Skeletal Remains from the Filoli Site, San Mateo County, California (CA-SMA-125). *Society for California Archaeology* 40(1):32–35.

Grimstead, Deanna N.

2005 Tracking Artiodactyl Hunting Across Late Period Northern California: An Assessment of Traditional and Geochemical Methods. Unpublished Master's thesis, California State University, Chico.

Grimstead, Deanna N., Jay Quade, and Mary C. Stiner.

2016 Isotopic Evidence for Long-Distance Mammal Procurement, Chaco Canyon, New Mexico, USA. *Geoarchaeology* 31(5):335-354.

Grosscup, Gordon L.

1960 *The Culture History of Lovelock Cave*. University of California Archaeological Survey Reports 52. University of California, Berkeley.

Grove, Matt

2009 Hunter-Gatherer Movement Patterns: Causes and Constraints. *Journal of Anthropological Archaeology* 28(2):222–233.

Groza, Randall Gannon

2002 *An AMS Chronology for Central California* Olivella *Shell Beads*. Master's thesis, Department of Anthropology, San Francisco State University, San Francisco, California.

Groza, Randall, Jeffrey Rosenthal, John Southon, and Randall Milliken

2011 A Refined Shell Bead Chronology for Late Holocene Central California. *Journal of California and Great Basin Anthropology* 31(2):13–32.

Guyton, Bill

1998 *Glaciers of California: Modern Glaciers, Ice Age Glaciers, the Origin of Yosemite Valley, and a Glacier Tour in the Sierra Nevada.* California Natural History Guides, 59. University of California Press, Berkeley, California.

Haag, William G., and Robert F. Heizer

1953 A Dog Burial from the Sacramento Valley. American Antiquity 18:263–265.

Hale, Micah

- 2001 Technological Organization of the Millingstone Pattern in Southern California. Unpublished M.A. thesis, Department of Anthropology, California State University, Sacramento.
- 2010a Santa Barbara and San Diego: Contrasting Adaptive Strategies on the Southern California Coast. Unpublished Ph.D. dissertation, University of California, Davis.
- 2010b Modeling Socioeconomic Discontinuity in Southern Alta California. *California Archaeology* 2(2):223–270.

Hale, A., and R. A. Salls

2000 The Canine Ceremony: Dog and Fox Burials of San Clemente Island. *Pacific Coast Archaeological Society Quarterly* 36(4):80–95.

Hall, Jeffery T.

1985 *Results of an Archaeological Subsurface Testing Program at CA-ALA-343.* Center for Anthropological Research, San Jose State University, San Jose, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Hall, Matthew C., and Robert J. Jackson

1989 Obsidian Hydration Rates in California. In *Current Directions in California Obsidian Studies*, edited by Richard E. Hughes, pp. 31–58. Contributions of the University of California Archaeological Research Facility 48. University of California, Berkeley. Hall, Jeffrey T., Robert Jurmain, and James S. Nelson

1988 Preliminary Description of Cemetery Complex at CA-AlA-343. *Proceedings of the Society for California Archaeology* 1:321–333.

Hamilton, Jerome

1936 *Indian Shell Mounds of San Mateo Creek and Vicinity*. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Hansen, David T., G. James West, Barbara Simpson, and Pat Welch

2004 *Modeling Spatial Uncertainty in Analysis of Archeological Site Distribution*. US Bureau of Reclamation, Mid Pacific Region, Sacramento, California. http://gis.esri.com/library/userconf/ proc02/pap0287/p0287.htm, accessed January 2005.

Hansen, R.

1970 *An Application of Systems Analysis: Archaeology of MRN-192.* Master's thesis, Department of Anthropology, San Francisco State, San Francisco, California.

Harding, Juliana M., Howard J. Spero, Roger Mann, Gregory S. Herbert, and Jennifer L. Sliko

2010 Reconstructing Early 17th Century Estuarine Drought Conditions from Jamestown Oysters. *Proceedings of the National Academy of Sciences* 107:10549–10554.

Hargrave, Eve A., Shirley J. Schermer, Kristin M. Hedman, Robin M. Lillie

2015 Transforming the Dead. University of Alabama Press, Tuscaloosa.

Harold, Laura B., Jelmer W. Eerkens, and Candice Ralston

2016 Patrilocal Post-Marital Residence and Bride Service in the Early Period: Strontium Isotope Evidence from CA-SJO-112. In *Reconstructing Lifeways in Ancient California: Stable Isotope Evidence of Foraging Behavior, Life History Strategies, and Kinship Patterns,* edited by Alexandra M. Greenwald and Gregory R. Burns. Center for Archaeological Research at Davis, No. 18, University of California, Davis.

Harrington, John P.

- 1921-1929 Chochenyo Fieldnotes. Manuscript on file in the National Anthropological Archives, Smithsonian Institution, Washington, DC.
 - 1942 Culture Elements Distribution, XIX: Central California Coast. *University of California Anthropological Records* 7(1):1–46.
- Hattori, Eugene M., and Allen G. Pastron
 - n.d. Prehistory of the Yerba Buena Site, San Francisco, California.
 - 1993 An Alternative View of California Archaeology. *Proceedings of the Society for California Archaeology* 6:15–21.

Hayden, Brian

1990 Nimrods, Piscators, Pluckers and Planters: The Emergence of Food Production. *Journal of Anthropological Archaeology* 9(1):31–69.

Hayden, Brian continued

- 1995 Pathways to Power: Principles for Creating Socioeconomic Inequalities. In *Foundations of Social Inequality*, edited by T. D. Price and G. M. Feinman, pp. 15–78. Plenum Press, New York.
- 2001 Richman, Poorman, Beggarman, Chief: The Dynamics of Social Inequality. In *Archaeology at the Millennium: A Source Book*, edited by G. M. Feinman and T. D. Price, pp. 231–272. Kluwer Academic Plenum Publishers, New York.

Hayes, John F., and David A. Fredrickson

1981 *An Archaeological Test Excavation at CA-SON-1082, D Street, Petaluma, California.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Haynes, Gregory M.

2002 *The Early Settlement of North America: The Clovis Era.* Cambridge University Press, Cambridge, United Kingdom.

Hegmon, Michelle

2003 Setting Theoretical Egos Aside; Issues and Theory in North American Archaeology. *American Antiquity* 68:213–244.

Heizer, Robert F.

- 1938 A Folsom Type Point from Sacramento Valley. *The Masterkey* 12(5):180–182.
- 1940 The introduction of Monterey shells to the Indians of the northwest coast. *The Pacific Northwest Quarterly* 31(4):399-402.
- 1950 *Archaeology of CCO-137, the "Concord Man" Site*. University of California Archaeological Survey Reports 9:1–5. University of California, Berkeley.
- 1951 Indians of the San Francisco Bay Area. In *Geologic Guidebook of the San Francisco Bay Counties*, pp. 39–56. California Division of Mines Bulletin 154.
- 1953 *The Archaeology of the Napa Region*. University of California Anthropological Records 12(6):225–358.
- 1958 Radiocarbon Dates from California of Archaeological Interest. *Reports of the University of California Archaeological Survey* 44:1–16. University of California, Berkeley.
- 1966 *Languages, Territories, and Names of California Indian Tribes.* University of California Press, Berkeley.
- 1978 Trade and Trails. In *California*, pp. 690-693, edited by Robert F Heizer. Handbook of North American Indians 8. Smithsonian Institution, Washington D.C.

Heizer, R. F., and J. A. Graham

1967 *A guide to field methods in archaeology: Approaches to the anthropology of the dead.* National Press, Palo Alto, California.

Heizer, Robert F., and Gordon W. Hewes

1940 Animal Ceremonialism in Central California in the Light of Archaeology. *American Anthropologist* 42:587–603.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

Heizer, R. F., and T. D. McCown

1950 *The Stanford Skull: A Probable Early Man from Santa Clara County, California.* University of California Archaeological Survey Reports 6.

Heizer, Robert F., and Adan E. Treganza

1944 Mines and Quarries of the Indians of California. *California Journal of Mines and Geology* 40(3):291–359.

Helley, Edward J., Kenneth R. LaJoie, W. E. Spangle, and Lynda M. Bair

1979 Flatland Deposits of the San Francisco Bay Region, California – Their Geology and Engineering Properties, their Importance to Comprehensive Planning. Department of the Interior, US Geological Survey, Washington, DC.

Henderson, J.

- 1930 Ancient shell trade routes. *The Nautilus* 43:109-110.
- Hendy, I. L., L. Dunn, A. Schimmelmann, and D. K. Pak
 - 2013 Resolving Varve and Radiocarbon Chronology Differences during the Last 2,000 Years in the Santa Barbara Basin Sedimentary Record, California. *Quaternary International* 310:155–168.

Henn, Winfield, and R. E. Schenk

1970 An Archaeological Analysis of Skeletal Material Excavated from the Civic Center Station of BART. Society for California Archaeology 11.

Henn, Winfield, Thomas Jackson, and J. Schlocker

1972 Buried Human Bones at the 'Bart' Site, San Francisco. *California Geology* 25(9):208–209.

Henry, Louis

1976 *Population: Analysis and Models.* Edward Arnold, London. (Translated from the French by Etienne van de Walle and Elisa F. Jones)

Heusser, Linda E

1978 Pollen in Santa Barbara, California: A 12,000 Year Record. *Geological Society of America Bulletin* 89:673–678.

Hickman, R. W.

1991 Mussel Cultivation. In *The Mussel Mytilus: Ecology, Physiology, Genetics, and Culture*, edited by E. Gosling, pp. 465–510. Developments in Aquaculture and Fisheries Science Vol. 25. Elsevier, Amsterdam, Netherlands.

Hildebrandt, William R.

1983 Archaeological Research of the Southern Santa Clara Valley Project: Based on a Data Recovery Program from Sites CA-SCl-54, CA-SCl-163, CA-SCl-178, CA-SCl-237, and CA-SCl-241 Located in the Route 101 Corridor, Santa Clara County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 4, San Francisco, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California. Hildebrandt, William H., and Michael Darcangelo

- 2008 *Life on the River: The Archaeology of an Ancient Native American Culture.* Heyday Books, Berkeley, California.
- Hildebrandt, William R., and John F. Hayes
 - 1983 *Archaeological Investigations on Pilot Ridge, Six Rivers and Shasta-Trinity National Forests.* Submitted to Six Rivers National Forest, Eureka, California.
- Hildebrandt, William R., and Terry L. Jones
 - 1992 Evolution of Marine Mammal Hunting: A View from the California and Oregon Coasts. *Journal of Anthropological Archaeology* 11:360–401.
- Hildebrandt, William R., and Philip Kaijankoski
 - 2011 Archaeological and Architectural Site Evaluations for the Hamilton City Flood Damage Reduction and Ecological Restoration Area, Glenn County, California. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for the US Army Corps of Engineers, Sacramento, California.

Hildebrandt, William R., and Kelly R. McGuire

- 2002 The Ascendance of Hunting during the California Middle Archaic: An Evolutionary Perspective. *American Antiquity* 67(2):231–256.
- 2012 A Land of Prestige. In *Contemporary Issues in California Archaeology*, edited by T. Jones and J. Perry, pp. 133–151. Left Coast Press, Walnut Creek, California.

Hildebrandt, William R., and Patricia J. Mikkelsen

1995 Projectile Point Typology. In Archaeological Investigations PGT-PG&E Pipeline Expansion Project Idaho, Washington, Oregon, and California, Vol. V, edited by Robert U. Bryson, Craig E. Skinner, and Richard M. Pettigrew, pp. 1–40. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Pacific Gas Transmission Company, Portland, Oregon.

Hildebrandt, William R., Jeffrey S. Rosenthal, and Glenn Gmoser

2009 Shellfish Transport, Caloric Return Rates, and Prehistoric Feasting on the Laguna De Santa Rosa, Alta California. *California Archaeology* 1(1):55–78.

Hildebrandt, William, Jack Meyer, Julia Costello, Patricia Mikkelsen, and John Berg

- 2012 Survey and Extended Phase I Investigations for the Solano 80 Corridor Project, Solano County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 4, Oakland, California.
- Hill, Erica
 - 2000 The Contextual Analysis of Animal Interments and Ritual P in Southwestern North America. *Kiva* 65:361–398.

Hines, Philip W.

1982 *Burial Excavation at CA-MRN-45.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Hines, Philip W. continued

1983 *Archaeological Investigations in Conjunction with Construction at Angel Island State Park, 1982.* California Department of Parks and Recreation, Sacramento, California.

Hines, Philip, Glenn Farris, and Thomas Wheeler

1996 *Results of Phase II Archaeological Testing at Olompali State Historic Park for the Proposed Marin Municipal Water District Pipeline Project.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Hitchcock, R.

1987 Sedentism and Site Structure: Organizational Changes in Kalahari Bosarwa Residential Locations. In *Method and Theory for Activity Area Research: An Ethnoarchaeological Approach,* edited by S. Kent, pp. 374–423. Columbia University Press, New York.

Hittell, John S.

1878 *A History of the City of San Francisco and Incidentally of the State Of California.* A. L. Bancroft, San Francisco, California.

Hodder, Ian

1990 *The Domestication of Europe: Structure and Contingency in Neolithic Societies.* Basil Blackwell, Oxford, United Kingdom.

Hollimon, Sandra E.

- 2004 Bear Shamanism and Social Control in Native California Societies. *Society for California Archaeology Newsletter* 8(3):26-31.
- 2009 Sex, Gender and Health among the Chumash of the Santa Barbara Channel Area. *Proceedings* of the Society for California Archaeology 9:205–208.

Hollimon, Sandra E., and Daniel F. Murley

2012 A Land of Many Genders. In *Contemporary Issues in California Archaeology*, edited by Terry L. Jones and Jennifer E. Perry, pp. 295–301. Left Coast Press, Walnut Creek, California.

Holman, Miley Paul

- 1981 *Archaeological Subsurface Testing of the Mayhew Landing Project, Newark, California.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Holman, Miley P., Leo Barker, Linda Reynolds, and Jack Miller
 - 1977 *The Sutro Baths Sites: A Preliminary Archaeological Investigation.* San Francisco State University, San Francisco, California.
- Holman, Miley Paul, Matthew R. Clark, S. E. Slater, R. S. Wiberg, R. Mozesson, H. Brandli, R. J. Jackson, P. D. Bouey, and Randall Milliken
 - 1982 *Cultural Resource Evaluation of Keller Ranch, Clayton, California. Part I: Archaeological Investigations at the Keller Ranch Site, CA-CCo-222. Part II: An Archaeological Investigations at the Keller Ranch Site, CA-CCo-222.* Holman and Associates Archaeological Consultants, San Francisco, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Holman, Miley, Matthew Clark, and Randy Wiberg

1987 *A Summary of Findings from Test Excavations at CA-MRN-174, Novato, Marin County, California.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Holson, John

2009 *The San Hill Corridor Project*. On file at the Northwest Information Center, Rohnert Park, California.

Holson, John, L. Shapiro, S. Goddard, and J. Bennyhoff

1993 National Register of Historic Places Determination of Eligibility Report for Prehistoric Sites on Holland Tract, Contra Costa County, California. BioSystems Analysis, Inc., Tiburon, California. Submitted to Jones and Stokes Associates, Inc., Sacramento, California.

Holson, John, Thomas L. Jackson, Elena Reese, Julia Hammett, and Heather Price

- 1999 Archaeological Monitoring, Testing and Data Recovery Plan for the San Hill Corridor Project, Stanford, California. On file, Far Western Anthropological Research Group, Inc., Davis, California.
- Holson, John, R. Gargett, S. Anton, L. Hager, R. Milliken, T. Jackson, J. Bennyhoff, S. Goddard, R. Orlins, E. Alexander, K. Gobalet, D. Simons, S. Skinner, and P. Ainsworth
 - 2000 Data Recovery Excavations for the Wildcat and San Pablo Creeks Flood Control and Water Resources Project at CA-CCO-269, -270, -600, and -601, Contra Costa County, California Volume I: Final Report. Pacific Legacy, Inc., and California Archaeological Consultants, Inc., Woodland, California. Submitted to US Army Corps of Engineers, Sacramento, California.
- Horsfall, G. A.
 - 1987 Design Theory and Grinding Stones. In *Lithic Studies Among the Contemporary Highland Maya*, edited by Brian Hayden. Academic Press, New York.
- Howard, A. D.
 - 1979 *Geologic History of Middle California*. University of California Press, Berkeley and Los Angeles.

Howard, W. J., and L. M. Raab

1993 *Olivella* Grooved Rectangle Beads as Evidence of a Mid-Holocene Southern Channel Islands Interaction Sphere. *Pacific Coast Archaeological Society Quarterly* 29(3):1–11.

Hughes, Malcolm K., and Peter M. Brown.

1992 Drought frequency in central California since 101 BC recorded in giant sequoia tree rings." *Climate Dynamics* 6(3–4):161–167.

Hughes, Richard

- California Archaeology and Linguistic Prehistory. *Journal of Anthropological Research* 48:317–338.
- 1994 Toward a New Taxonomic Framework for Central California Archaeology: Essays by James A. Bennyhoff and David A. Fredrickson. Contributions of the University of California Archaeological Research Facility 52. University of California, Davis.

Hughes, Richard continued

2011 *Perspectives on Prehistoric Trade and Exchange in California and the Great Basin.* University of Utah Press, Salt Lake City.

Hughes, Richard E., and Randall Milliken

2007 Prehistoric Material Conveyance. In *California Prehistory: Colonization, Culture, and Complexity,* edited by Terry L. Jones and Kathryn A. Klar, pp. 259–271. Altamira Press, Lanham, Maryland.

Hull, Kathleen

- 2001 Reasserting the Utility of Obsidian Hydration Dating: A Temperature-Dependent Empirical Approach to Practical Temporal Resolution with Archaeological Obsidians. *Journal of Archaeological Science* 28(10):1025–1040.
- 2012 A Land of Many People: Population Dynamics as Context and Catalyst. In *Contemporary Issues in California Archaeology*, edited by T. L. Jones and J. E. Perry. Left Coast Press, Walnut Creek.

Hull, Kathleen L., and W. Joseph Mundy

1985 The 1984 Yosemite Archaeological Surveys. The South Entrance, Mariposa Grove, Tioga Road, Crane Flat, and Glacier Point Road Areas. US Department of the Interior, National Park Service, Yosemite Research Center, Publications in Anthropology.

Hylkema, Linda

2009 Pre-Contact Native American Presence at Santa Clara University. *Proceedings of the Society for California Archaeology* 21:9–20.

Hylkema, Mark G.

- 1991 *Prehistoric Native American Adaptations along the Central California Coast of San Mateo and Santa Cruz Counties.* Master's thesis, San Jose State University, San Jose, California.
- 1995 Archaeological Investigations at the Third Location of Mission Santa Clara de Asís: The Murguía Mission, 1781–1818 (CA-SCL-30/H). California Department of Transportation, District 4, Environmental Planning, Oakland, California.
- 1998 Seal Cove Prehistory: Archaeological Excavations at CA-SMA-134, Fitzgerald Marine Preserve, San Mateo County Park, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2002 Tidal Marsh, Oak Woodlands, and Cultural Florescence in the Southern San Francisco Bay Region. In *Catalysts to Complexity: Late Holocene Societies of the California Coast*, edited by Jon M. Erlandson and Terry L. Jones, pp. 205–232. Perspectives in California Archaeology 6, series editor J. E. Arnold. Institute of Archaeology, University of California, Los Angeles.
- 2007 Santa Clara Valley Prehistory: Archaeological Investigations at CA-SCL-690, the Tamien Station Site, San Jose, California. Center for Archaeological Research at Davis, University of California, Davis. Submitted to California Department of Transportation, District 4, Oakland, California.
- 2015 Discussant Comments. San Francisco Bay Area Symposium. Society for American Archaeology Meetings, San Francisco.

Hylkema, Mark G., and Rebecca Allen

- 2009 Archaeological Investigations at the Third Mission Site, Santa Clara University, and a Comparison of Shell Bead Assemblages with Recent Mission-Era Findings. *Proceedings of the Society for California Archaeology* 21:28–35.
- Hylkema, Mark G., and J. T. Hall
 - 1985 *Preliminary Report on the Archaeological Data Recovery Excavation at CA-SMA-115, Montara State Beach.* On file, California Department of Parks and Recreation, San Francisco, California.

Ingram, B. Lynn

- 1998 Differences in Radiocarbon Age between Shell and Charcoal from a Holocene Shellmound in Northern California. *Quaternary Research* 49(1):102–110.
- Ingram, B. Lynn, and R. Byrne
 - 1998 A High Resolution Analysis of Salinity Change and Wetland Development in the San Francisco Estuary: 1000 B.P. to the Present. National Institute for Global Environmental Change, Western Regional Center, Annual Progress Report for FY 97/98. Electronic document, http://nigec.ucdavis.edu/publications/ar/annual98/western/project81.html, accessed February 2003.

Ingram, B. Lynn, and Donald J. DePaolo

1993 A 4,300-Year Strontium Isotope Record of Estuarine Paleosalinity in San Francisco Bay, California. *Earth and Planetary Science Letters* 119:103–119.

Ingram, B. Lynn, and John R. Southon

- 1996 Reservoir Ages in Eastern Pacific Coastal and Estuarine Waters. *Radiocarbon* 38:573–582.
- Ingram, B. Lynn, James C. Ingle, and Mark E. Conrad
 - 1996 Stable Isotope Record of Late Holocene Salinity and River Discharge in San Francisco Bay, California. *Earth and Planetary Science Letters* 141:237–248.

Ives, R. L.

- 1961 Kino's Route across Baja California. *Kiva* 26(4):17-29.
- Jackson, R., and D. Fredrickson
 - 1979 An Archaeological Investigation within the Proposed Delta Coves Development, Bethel Island, Contra Costa County, California. Report S-1426, on file, Northwest Information Center of the California Historical Resources Information System, California State University, Sonoma, Rohnert Park.

Jackson, Thomas L.

- 1974a San Jose Village, A Northern Marin County Site—A Preliminary Report on 1972 Excavations. Mapom Papers 1. Miwok Archaeological Preserve of Marin, San Rafael, California.
- 1974b The Economics of Obsidian in Central California Prehistory: Applications of X-Ray Fluorescence Spectrography in Archaeology. Master's thesis, San Francisco State University, San Francisco, California.

Jackson, Thomas L. continued

- 1986 *Late Prehistoric Obsidian Exchange in Central California*. Ph.D. dissertation, Department of Anthropology, Stanford University, Palo Alto, California.
- 1988 Amending Models of Trans-Sierran Obsidian Tool Production and Exchange. *Journal of California and Great Basin Anthropology* 10:62–71.
- 1991 Pounding Acorn: Women's Production as Social and Economic Focus. In *Engendering Archaeology*, edited by J. M. Gero and M. W. Conkey. asil Blackwell, Oxford, United Kingdom.

Jackson, Robert J., and H. S. Ballard

1999 Once Upon a Micron: A Story of Archaeological Site CA-ELD-145 Near Camino, El Dorado County, California. Pacific Legacy, Inc., Cameron Park, California. Prepared for the California Department of Transportation, District 3, Marysville, California.

Jackson, Thomas L., and Jonathon E. Ericson

1994 Prehistoric Exchange Systems in California. In *Prehistoric Exchange Systems in North America*, edited by T. Baugh and Jonathon E. Ericson. Plenum Press, New York.

James, Jill G., Colin I. Busby, James C. Bard, and Rebecca L. Anastasio

- 1987 Native American Burials Recovered from CA-SCL-581 during Archaeological Monitoring of Improvements to Murphy Avenue Between Old Oakland Road and Lundy Avenue, San Jose, Santa Clara County, California. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- James, Jill G., Angela M. Banet, Michael R. Fong, Michael D. Meyer, and Melody E. Tannam
 - 1988 Phase III North and Phase IV Archaeological Monitoring Results at CA-SCL-128, The Holiday Inn Site, as Part of the Guadalupe Transportation Corridor. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- James, Jill G., Michael R. Fong, James C. Bard, Angela M. Banet, Melody E. Tannam, Colin I. Busby, and Rebecca L. Anastasio
 - 1990 Analysis of Native American Skeletal Remains Recovered during Emergency Disinterment at CA-SCL-678, City of Milpitas, Santa Clara County, California. Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Jameson, E. W. and Hans J. Peeters

2004 Mammals of California. University of California Press, Berkeley.

Janzen, Anneke, and Tsim D. Schneider

2009 Analysis of Fauna from the Thomas Site (CA-MRN-115), a Shell Mound in Marin County, California. *Proceedings of the Society for California Archaeology* 23.

Jazwa, Christopher S., Douglas J. Kennett, and Bruce Winterhalder

2013 The Ideal Free Distribution and Settlement History at Old Ranch Canyon, Santa Rosa Island, California. In *California's Channel Islands: The Archaeology of Human-Environment Interactions,* edited by Christopher Jazwa and Jennifer Perry, pp. 75–96. University of Utah Press, Salt Lake City. Jazwa, Christopher S., Douglas J. Kennett, and Bruce Winterhalder continued

2015 A Test of Ideal Free Distribution Predictions Using Targeted Survey and Excavation on California's Northern Channel Islands. *Journal of Archaeological Method and Theory*, 1–43.

Johnson, Donald Lee

- 1977 The Late Quaternary Climate of Coastal California: Evidence for an Ice Age Refugium. *Quaternary Research* 8:154–179.
- Johnson, E. N.
 - 1940 The Serrated Points of Central California. *American Antiquity* 6:167-169.

Johnson, John R., Brian M. Kemp, Ara Monroe, and Joseph G. Lorenz

2012 A Land of Diversity: Genetic Insights into Ancestral Origins. In *Contemporary Issues in California Archeology*, edited by Terry L. Jones and Jennifer E. Perry, pp. 49–72. Left Coast Press, Walnut Creek, California.

Johnson, Patti J.

1978 Patwin. In *California*, edited by R. F. Heizer, pp. 350–360. Handbook of North American Indians Volume 8. Smithsonian Institution, Washington, DC.

Johnston, Cheryl A.

2002 *Culturally Modified Human Remains From The Hopewell Mound Group*. Unpublished Ph.D. dissertation, Ohio State University.

Jones, Barbara L.

2010 Mythical Implications of Faunal Assemblages from Three Ohlone Sites. Unpublished Master's thesis, Anthropology Department, San Francisco State University, San Francisco, California.

Jones, Deborah A., Jack Meyer, and Jeffrey Rosenthal

2000 Phase II Archaeological Test Excavations at CA-SCR-313, Highway 17, Santa Cruz County, California. Far Western Anthropological Research Group, Inc., Davis, California.

Jones, Laura

- 1997 *Report of Archaeological Findings at CA-SCL-613, Children's Health Council, Santa Clara County, California.* On file, Far Western Anthropological Research Group, Inc., Davis, California.
- Jones, M., P. J. Sheppard, and D. G. Sutton
 - 1997 Soil Temperature and Obsidian Hydration Dating: A Clarification of Variables Affecting Accuracy. *Journal of Archaeological Science* 24(6):505–516.

Jones, Terry L.

1996 Mortars, Pestles and Division of Labor in Prehistoric California: A View from Big Sur. *American Antiquity* 61(2):243–264.

Jones, Terry L., and Jennifer Darcangelo

2007 *Archaeological Data Recovery at CA-ALA-17, Alameda County, California*. California Polytechnic State University, San Luis Obispo, California. Submitted to California Department of Transportation, District 4, Oakland, California.

Jones, Terry L., and L. M. Raab

2004 The Rediscovery of California Prehistory. In *Prehistoric California: Archaeology and the Myth of Paradise*, edited by L. M. Raab and T. L. Jones. University of Utah Press, Salt Lake City.

Jones, Terry L., and Georgie Waugh

- 1997 Climatic Consequences of Population Pragmatism?: A Middle Holocene Prehistory of the Central California Coast. In *Archaeology of the California Coast during the Middle Holocene*, edited by J. M. Erlandson and M. A. Glassow. Los Angeles: Institute of Archaeology, University of California.
- Jones, Terry, L. Weigel, and D. A. Fredrickson
 - 1980 An Archaeological Investigation of Selected Areas in the Delta Coves Project, Contra Costa County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Jones, Terry L., G. M. Brown, L. M. Raab, J. L. McVickar, W. G. Spaulding, D. J. Kennett, A. York, and P. L. Walker
 - 1999 Environmental Imperatives Reconsidered: Demographic Crises in Western North America during the Medieval Climatic Anomaly. *Current Anthropology* 40(2):137–170.
- Jones, Terry L., Richard T. Fitzgerald, Douglas J. Kennett, Charles H. Miksicek, John L. Fagan, John Sharp, and Jon M. Erlandson
 - 2002 The Cross Creek Site (CA-SLO-1797) and Its Implications for New World Colonization. *American Antiquity* 67(2):213–230.

Jones, Terry, D. J. Kennett, J. P. Kennett, and B. F. Codding

2008 Seasonal Stability in Late Holocene Shellfish Harvesting on the Central California Coast. *Journal of Archaeological Science* 35:2286–2294.

Jones and Stokes

2002 Phase I Extended Survey Report/Phase II Evaluation Report; Doyle Drive Corridor Project Presidio of San Francisco National Historic Landmark District City and County of San Francisco, California. Jones and Stokes Associates, Inc., Sacramento, California.

Jorgenson, Gina A., Jelmer W. Eerkens, Gry H. Barfod, and Eric J. Bartelink

2009 Migration Patterns in the Prehistoric California Delta: Analysis of Strontium Isotopes. In *Proceedings of the Society for California Archaeology* 23.

Jurmain, Robert

1983 *The Skeletal Biology of CA-ALA-342*. Department of Anthropology, San Jose State University, San Jose, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Jurmain, Robert continued

2001 Paleoepidemiolgical Patterns of Trauma in a Prehistoric Population from Central California. In *American Journal of Physical Anthropology* 115:13–23.

Jurmain, Robert, and Viviana Ines Bellifemine

1997 Patterns of Cranial Trauma in a Prehistoric Population from Central California. In *International Journal of Osteoarchaeology* 7:43–50.

Kaijankoski, Phillip, and Jeffrey S. Rosenthal

- In prep Holocene Landscape Evolution and Human Occupation within the Lower Penitencia Creek Watershed: Archaeological Investigations for the Silicon Valley Rapid Transit, Berryessa Extension Project, Milpitas and San Jose, California. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for Santa Clara Valley Transportation Authority.
- Kaijankoski, Philip, Patricia Mikkelsen, Rebecca Kellawan, Jack Meyer, Joseph Freeman, Stephen Wee, and Julia Costello
 - 2012 Addendum: Cultural Resources Survey Report for the Hercules Intermodal Transit Center. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to HDR Engineering, Inc., Environmental Sciences, Sacramento, California.

Kearns, Alicia Elaine

2010 *Ohlone Burning: Evidence of Anthropogenic Fire in the San Francisco Bay Area*. Master's thesis, Department of Anthropology, San Francisco State University, San Francisco, California.

Keeley, Lawrence H.

- 1988 Hunter-Gatherer Economic Complexity and "Population Pressure": A Cross-Cultural Analysis. *Journal of Anthropological Archaeology* 7:373–411.
- 1999 The Use of Plant Foods among Hunter-Gatherers: A Cross-Cultural Survey. In Prehistory of Agriculture: New Experimental and Ethnographic Approaches, edited by P. C. Anderson, pp. 29– 38. Institute of Archaeology Monograph 40. University of California, Los Angeles.

Kelly, Isabel

1978 Coastal Miwok. In *California*, edited by R. F. Heizer, pp. 414–425. Handbook of North American Indians Volume 8. Smithsonian Institution, Washington, DC.

Kelly, Isabel T., Mary E. T. Collier, Tom Smith, and Maria Copa

1991 Interviews with Tom Smith and Maria Copa: Isabel Kelly's Ethnographic Notes on the Coast Miwok Indians of Marin and Southern Sonoma Counties, California, edited by Mary E. T. Collier and Sylvia Barker Thalman. Miwok Archeological Preserve.

Kelly, Robert

- 1983 Hunter-Gatherer Mobility Strategies. Journal of Anthropological Research 39:277–306.
- 1992 Mobility/Sedentism: Concepts, Archaeological Measures, and Effects. *Annual Review of Anthropology* 21:43–66.
- 1995 *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways.* Smithsonian Institution Press, Washington, DC.

Kelly, Robert continued

- 2000 Elements of a Behavioral Ecological Paradigm for the Study of Prehistoric Hunter-Gatherers. In *Social Theory in Archaeology*, edited by M. B. Schiffer, pp. 63–78. University of Utah Press, Salt Lake City.
- 2013 The Lifeways of Hunter-Gatherers. Cambridge University Press, Cambridge, United Kingdom.

Kennett, D.

- 1998 Behavioral Ecology and the Evolution of Hunter-Gatherer Societies on the Northern Channel Islands, California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.
- 2005 *The Island Chumash: Behavioral Ecology of a Maritime Society.* University of California Press, Berkeley.

Kennett, D., and J. P. Kennett

2000 Competitive and Cooperative Responses to Climatic Instability in Coastal Southern California. *American Antiquity* 65:379–396.

Kennett, Douglass J., Atholl Anderson, and Bruce Winterhalder

2006 The Ideal Free Distribution, Food Production, and the Colonization of Oceania, In *Behavioral Ecology and the Transition to Agriculture*, edited by D. J. Kennett and B. Winterhalder, pp. 265– 288. University of California Press, Berkeley.

Kennett, Douglas J., Patricia M. Lambert, John R. Johnson, and Brendan J. Culleton

2013 Sociopolitical Effects of Bow and Arrow Technology in Prehistoric Coastal California. *Evolutionary Anthropology* 22:124–132.

Kennett, James P., and B. Lynn Ingram

1995 A 20,000-year Record of Ocean Circulation and Climate Change from the Santa Barbara Basin. *Nature* 377:510–514.

Kent, Susan

1991 The Relationship between Mobility Strategies and Site Structure. In *The Interpretation of Archaeological Spatial Patterning*, edited by Ellen M. Kroll and T. Douglas Price, pp. 33–59. Plenum Press, New York.

King, Chester D.

- 1968 *Excavations at ALA-342: A Summary Report*. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1978 Protohistoric and Historic Archaeology. In *California*, edited by Robert F. Heizer, pp. 58–68. Handbook of North American Indians, Vol. 8, William C. Sturtevant, general editor.
- 1981 *The Evolution of Chumash Society: A Comparative Study of Artifacts Used in Social System Maintenance in the Santa Barbara Channel Region before AD 1804.* Ph.D. dissertation, Department of Anthropology, University of California, Davis.
- 1990 *Evolution of Chumash Society: A Comparative Study of Artifacts Used for Social System Maintenance in the Santa Barbara Channel Region before A.D. 1804.* The Evolution of North American Indians. Garland, New York.

King, J. H., W. R. Hildebrandt, and J. S. Rosenthal

2011 Trans-Sierran Movement of Bodie Hills Obsidian. In *Perspectives on Prehistoric Trade and Exchange in California and the Great Basin,* edited by Richard Hughes, pp. 148–170. University of Utah Press, Salt Lake City.

King, Thomas F.

- 1970 The Dead at Tiburon: Mortuary Customs and Social Organization on Northern San Francisco Bay.
- 1974 The Evolution of Status Ascription around San Francisco Bay. In *ANTAP California Indian Political and Social Organization,* edited by Lowell John Bean and Thomas F. King. Ballena Press Anthropological Papers 2. Ramona, California.
- King, Tom, Ward Upson, and Ralph Milner
 - 1966 *Archaeological Investigations in the San Antonio Valley, Marin and Sonoma Counties, California.* Occasional Papers 1. Northwestern California Archaeological Society.
- Klein, R. G., G. Avery, K. Cruz-Uribe, D. Halkett, J. E. Parkington, T. E. Steele, T. P. Volman, and R. Yates
 - 2004 The Ysterfontein 1 Middle Stone Age Site, South Africa, and Early Human Exploitation of Coastal Resources. *Proceedings of the National Academy of Science* 101(16):5708–5715.

Kniffen, Fred B.

- 1939 Pomo Geography. University of California Publications in American Archaeology and Ethnology 36(6):353–400.
- Knudsen, Keith L., Janet M. Sowers, Robert C. Witter, Carl M. Wentworth, and Edward J. Helley
 - 2000 Preliminary Maps of Quaternary Deposits and Liquefaction Susceptibility, Nine-County San Francisco Bay Region, California: A Digital Database. http://pubs.usgs.gov/of/2000/of00-444/, accessed June 2013. Updated September 22, 2005.

Kobori, Larry S., and James C. Bard

1980 *CA-SCL-418: An Archaeological Data Recovery Program at a Middle Horizon Site in the Rincon de los Esteros Area of San Jose, California.* Basin Research Associates, Inc. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Kohler, T. A., and K. M. Reese

- 2014 Long and Spatially Variable Neolithic Demographic Transition in the North American Southwest. *Proceeding of the National Academy of Sciences* 111(28):10101–10106.
- Kohler T. A., M. P. Glaude, J. P. Bocquet-Appel, and B. M. Kemp
 - 2008 The Neolithic Demographic Transition in the U.S. Southwest. *American Antiquity* 73(4):645–669.

Kowalewski, Stephen A.

2008 Regional Settlement Pattern Studies. Journal of Archaeological Research 16:225–285.

Kroeber, Alfred L.

1925 *Handbook of the Indians of California.* Bureau of American Ethnology Bulletin 78. Smithsonian Institution, Washington, DC.

San Francisco Bay-Delta Regional Context and Research Design for Native American Archaeological Resources, Caltrans District 4

Kroeber, Alfred L. continued

- 1932 The Patwin and Their Neighbors. In *University of California Publications in American Archaeology and Ethnology* 29(4):253–423.
- 1939 Cultural and Natural Areas of Native North America. *University of California Publications in American Archaeology and Ethnology* 38:1–242.
- 1962 The Nature of Land-holding Groups in Aboriginal California. In *Two Papers on the Aboriginal Ethnography of California,* edited by Del H. Hymes and Robert F. Heizer, pp. 19-58. University of California Archaeological Survey Reports 56, Berkeley, California.

Küchler, Alfred W.

- 1976 *California Vegetation Map Catalog.* Metadata for Vegetation Dataset: Küchler Vegetation Potential for California.
- Kyle, Douglas E. (editor)
 - 1990 Historic Spots in California. Stanford University Press, Stanford, California.
- LaJeunesse, Roger M., and John H. Pryor
 - 1996 *Skyrocket Chronology and Bifaces Appendices*. California State University, Fresno. Manuscript in possession of author.
- Lajoie, Kenneth R., Etta Peterson, and Bert A. Gerow
 - 1980 Amino Acid Bone Dating: A Feasibility Study, South San Francisco Bay Region, California. In *Biochemistry of Amino Acids*, edited by P. E. Hare, pp. 477–489. Wiley, New York.

Lambert, Patricia M.

- 1993 Health in Prehistoric Populations of the Santa Barbara Channel Islands. *American Antiquity* 58(3):509–522.
- 1994 War and Peace on the Western Front: A Study of Violent Conflict and its Correlates in Prehistoric Hunter-Gatherer Societies of Coastal Southern California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.
- Patterns of Violence in Prehistoric Hunter-Gatherer Societies of Coastal Southern California.
 In *Troubled Times: Violence and Warfare in the Past, War and Society* Vol. 6, edited by D. L.
 Martin and D. W. Frayer, pp. 77–109. Gordon and Breach Publishers, Amsterdam.
- 1998 The Archaeology of the Yukisma Site: CA-SCL-38 (Alms House Mound) Located within the Elmwood Correctional Facility, City of Milpitas, Santa Clara County, California. Ohlone Families Consulting Services, San Jose, California. Prepared for the County of Santa Clara, California.
- 2002 The Archaeology of War: A North American Perspective. *Journal of Archaeological Research* 10(3)207–241.
- 2007 Ethnographic and Linguistic Evidence for the Origins of Human Trophy Taking in California. In *The Taking and Displaying of Human Body Parts as Trophies by Amerindians*, edited by R. J. Chacon and D. H. Dye, pp. 65–89. Springer, New York.

Lambert, Patricia M., and P. L. Walker

1991 The Physical Anthropological Evidence for the Evolution of Social Complexity in Coastal Southern California. *Antiquity* 65:963–973.

Langenwalter, Paul E., II

- 1996 Animal Burials from the Skyrocket Village Site (CA-CAL-629/630), Calaveras County, California. In Skyrocket Faunal and Floral Appendix, edited by Roger Marks La Jeunesse and John H. Pryor. Prepared by California State University, Fresno.
- 2005 A Late Prehistoric Dog Burial Associated with Human Graves in Orange County, California. *Journal of Ethnobiology* 25:1–25.

Latta, Frank

1977 *The Handbook of the Yokuts Indians*. Santa Cruz, California: Second edition (revised and enlarged). Bear State Books.

Lee, R.

1969 Chemical Temperature Integration. *Journal of Applied Meteorology* 8:423–430.

Lee, Charles H., and Michael Praszker

- 1969 Bay Mud Developments and Related Structural Foundations. In *Geologic and Engineering Aspects of San Francisco Bay Fill*, edited by Harold B. Goldman, pp. 41–85. Special Report 197, California Division of Mines and Geology, San Francisco, California.
- Lennstrom, Heidi A., and Christine A. Hastorf
 - 1995 Interpretation in Context: Sampling and Analysis in Paleoethnobotany. *American Antiquity* 60(4):701-721.

Lentz, Kari

2009 Flaked and Ground Stone Technology at CA-ALA-554: Mortar Bowls and Stockton Points. *Proceedings of the Society for California Archaeology* 26:192–211.

Lesure, R. G., L. S. Martin, K. J. Bishop, B. Jackson, and C. M. Chykerda

2014 The Neolithic Demographic Transition in Mesoamerica. *Current Anthropology* 55(5):654–664.

Leventhal, Alan

- 1987 Final Report on the Human Skeletal Remains Recovered from Prehistoric Site: CA-SMA-273, Coyote Point Marina, San Mateo, CA. San Jose State University, San Jose, California. Prepared for Department of General Services, County of San Mateo, Redwood City, California.
- 1993 *A Reinterpretation of Some Bay Area Shell Mounds: A View from the Mortuary Complex, ALA-329.* Master's thesis, Department of Social Sciences, San Jose State University, San Jose, California.
- 1998 The Paleodemography of the Yukisma Site, CA-SCL-38 (Alms House Mound), Located within the Elmwood Correctional Facility, City of Milpitas, Santa Clara County, California. Ohlone Families Consulting Services, Campbell, California. Prepared for the County of Santa Clara.

Leventhal, Alan, and George Seitz

1989 Experimental Archaeology. Mortar Replication Study: Description and Analysis—Big Sur Coast Immediate Public Use Facility Project, Big Sur District, Central Coast Region. On-file Northwest Information Center, California Historical Resources Information System, Rohnert Park.

- Leventhal, Alan, Rosemary Cambra, and Norma Sanchez
 - 1987 Final Report on the Archaeological Data Recovery Program of a Portion of Prehistoric Site: CA-ALA-479, Union City, CA. Ohlone Family Consultant Services. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Leventhal, Alan, Rosemary Cambra, Norma Sanchez, and Beverly Domenech
 - Final Report on the Archaeological Data Recovery Program of the Southern Portion of Prehistoric Site:
 CA-SCL-581 Lands of Oki, PDC-86–11–101, San Jose, CA. Ohlone Families Consulting Services.
 On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Leventhal, Alan, Benjamin Ananian, Rosemary Cambra, and Norma Sanchez
 - 1989 Final Report on the Archaeological Data Recovery Program within a Portion of Prehistoric Site: CA-ALA-428/H, Sunol Regional Wilderness, Alameda County, California. Ohlone Families Consulting Services. Prepared for East Bay Regional Park District, Oakland, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Leventhal, Alan, Melynda Atwood, Diane DiGiuseppe, Stephanya Freckleton, David Grant, Rosemary Cambra, Monica V. Arellano, Suzanne Rodriguez, Sheila Guzman-Schmidt, Gloria E. Arellano-Gomez, and Norma Sanchez
 - 2007 Final Report of the Archaeological Recovery of a Pre-Contact Ohlone Burial from Prehistoric Site CA-SCL-867 (Riipin Wareeptak) Located at 1170 Coolidge Avenue, San Jose, Santa Clara County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Leventhal, Alan, Diane DiGiuseppe, Melynda Atwood, David Grant, Susan Morley, Rosemary Cambra, Dr. Les Field, Charlene Nijmeh, Monica V. Arellano, Susanne Rodriguez, Sheila Guzman-Schmidt, Gloria E. Gomez, and Norma Sanchez
 - 2010 Final Report on the Burial and Archaeological Data Recovery Program Conducted on a Portion of a Middle Period Ohlone Indian Cemetery, Yuki Kutsuimi Šaatoš Inūxw [Sand Hill Road] Sites: CA-SCL-287 and CA-SMA-263, Stanford University, California (Volume I). Ohlone Families Consulting Services. Prepared for Stanford University, Stanford, California.
- Leventhal, Alan, Diane DiGuiseppe, Melynda Atwood, David Grant, Rosemary Cambra, Charlene Nijmeh, Monica V. Arellano, Sheila Guzman-Schmidt, Gloria E. Gomez, Norma Sanchez, Mark Hylkema, Eric J. Bartelink, Kevin Richlin, and Linda Hylkema
 - 2011 Final Report on the Burial and Archaeological Data Recovery Program Conducted on a Portion of the Mission Santa Clara Indian Neophyte Cemetery (1781–1818): Clareño Muwékma Ya Túnnešte Nómmo [Where the Clareno Indians are Buried] Site (CA-SCL-30/H). Ohlone Families Consulting Services. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Leventhal, Alan, Lynn Ferris, Diane DiGiuseppe, David Grant, Melynda Atwood, Susan Morley, Rosemary Cambra, Charlene Nijmeh, Monica Arellano, Sheila Guzman-Schmidt, and Gloria Gomez
 - 2012 Report on the Reanalysis & AMS Dating of a Burial Recovered from the Tupiun Táareštak Site (Place of the Fox Man) (CA-SCL-894/CA Fox Theatre) Located in the City of San Jose, Santa Clara County, CA. Ohlone Families Consulting Services. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

- Leventhal, Alan, Emily McDaniel, Diane DiGiuseppe, Melynda Atwood, David Grant, Colin Jaramillo Rosemary Cambra, Monica V. Arellano, Sheila Guzman-Schmidt, Gloria E. Gomez, and Norma Sanchez
 - 2014 Final Report on the Burial and Archaeological Data Recovery Program Conducted on a Portion of an Early Bay Period Ohlone Indian Cemetery, Loškowiš 'Awweš Táareštak [White Salt Man Site] (CA-SMA-267), Located at 1416 Bay Road, East Palo Alto, San Mateo County, California. Prepared for the Sanitation District, City of East Palo Alto, Palo Alto, California.

Levulett, Valerie A., William R. Hildebrandt, and Deborah A. Jones

2002 *Middle Holocene Adaptations on Goleta Slough: A View from the Corona Del Mar Site (CA-SBA-54).* Far Western Anthropological Research Group, Inc., Davis, California and California Department of Transportation, District 5, San Luis Obispo.

Levy, Richard S.

- 1978a Costanoan. In *California*, edited by R. F. Heizer, pp. 485–495. Handbook of North American Indians Volume 8. Smithsonian Institution, Washington, DC.
- 1978b Eastern Miwok. In *California*, edited by R. F. Heizer, pp. 398–413. Handbook of North American Indians Volume 8. Smithsonian Institution, Washington, DC.

Lewis, Henry T.

1973 *Patterns of Indian Burning in California*. Ballena Press Anthropological Papers 1.

Lightfoot, Kent G.

- 1993 Long-Term Developments in Complex Hunter-Gather Societies: Recent Perspectives from the Pacific Coast of North America. *Journal of Archaeological Research* 1(3):167–201.
- 1995 Culture Contact Studies: Redefining the Relationship between Prehistoric and Historical Archaeology. *American Antiquity* 60(2):199–217.
- 1997 Cultural Construction of Coastal Landscapes: A Middle Holocene Perspective from San Francisco Bay. In Archaeology of the California Coast during the Middle Holocene, edited by Jon M. Erlandson and Michael A. Glassow, pp. 129–142. Perspectives in California Archaeology 4, general editor, Jeanne E. Arnold. Institute of Archaeology, University of California, Los Angeles.
- 2005 Indians, Missionaries, and Merchants: The Legacy of Colonial Encounters on the California Frontiers. University of California Press, Berkeley.

Lightfoot, K. G., and V. Lopez

2013 The Study of Indigenous Management Practices in California: An Introduction. *California* Archaeology 5(2):209–219.

Lightfoot, Kent G., and Edward M. Luby

2002 Late Holocene in the San Francisco Bay Area: Temporal Trends in the Use and Abandonment of Shell Mounds in the East Bay. In *Catalysts to Complexity: Late Holocene Societies of the California Coast*, edited by Jon M. Erlandson and Terry L. Jones, pp. 263–281. Perspectives in California Archaeology 6, series editor, Jeanne E. Arnold. Cotsen Institute of Archaeology, University of California, Los Angeles. Lightfoot, Kent G., and Edward M. Luby continued

- 2012 Mound Building by California Hunter-Gatherers. In *The Oxford Handbook of North American Archaeology*, edited by Timothy R. Pauketat, pp. 212–223. Oxford University Press, Oxford.
- Lightfoot, Kent G., and Otis Parrish
 - 2009 *California Indians and their Environment: An Introduction*. University of California Press, Berkeley.
- Lightfoot, K. G., and W. S. Simmons
 - 1998 Culture contact in protohistoric California: Social contexts of native and European encounters. *Journal of California and Great Basin Anthropology* 20(2):138-170.
- Lightfoot, Kent G., Sara L. Gonzalez, and Tsim D. Schneider
 - 2006 Refugees and Interethnic Residences: Examples of Colonial Entanglements in the North San Francisco Bay Area. *Pacific Coast Archaeological Society Quarterly* 42(1):1–22.
- Lightfoot, K. G., E. M. Luby, and L. Pesnichak
 - 2011 Evolutionary Typologies and Hunter-Gatherer Research: Rethinking the Mounded Landscapes of Central California. In *Hunter-Gatherer Archaeology as Historical Process*, edited by Kenneth E. Sassaman and Donald H. Holly Jr., pp. 55–78. University of Arizona Press, Tucson.
- Lightfoot, Kent, Rob Cuthrell, Chuck Striplen, and Mark Hylkema
 - 2013a Rethinking the Study of Landscape Management Practices among Hunter-Gatherers in North America. *American Antiquity* 78(2):285–301.
- Lightfoot, K. G., L. M. Panich, T. D. Schneider, and S. L. Gonzalez
 - 2013b European colonialism and the Anthropocene: a view from the Pacific Coast of North America. *Anthropocene* 4:101–115.
- Lillard, Jeremiah B., Richard F. Heizer, and Franklin Fenenga
 - 1939 *An Introduction to the Archaeology of Central California*. Sacramento Junior College Department of Anthropology Bulletin 2. Board of Education of the Sacramento City Unified School District, Sacramento, California.

Lippel, Jennifer, Jennifer Blake, Kari Lentz, David Buckley, Aimee Arrigoni, and Paul Farnsworth

2012 Addendum to Data Recovery, Burial Removal and Construction Monitoring Report for the Terremark Data Center Project, CA-SCL-134, 2970 and 3000 Corvin Drive, City and County of Santa Clara, California. NWIC report no. S-038643. William Self Associates, Inc.

Liritzis, Ioannis

2014 Obsidian Hydration Dating. In *Encyclopedia of Scientific Dating Methods*, pp. 1–23.

Little, Barbara, Erika M. Seibert, Jan Townsend, John H. Sprinkle, Jr., and John Knoerl

2000 *Guidelines for Evaluating and Registering Archeological Properties*. National Register Bulletin 36. National Register of Historic Places, History and Education, National Park Service, U.S. Department of the Interior, Washington, DC. Lloyd, Janine M., Thomas M. Origer, and David A. Fredrickson

2002 The Effects of Fire and Heat on Obsidian. Paper presented in symposium at the 33rd annual meeting of the Society for California Archaeology. Society for California Archaeology.

Loeb, E. M.

- 1932 The Western Kuksu Cult. University of California Publications in American Archaeology and Ethnology 33:1–137.
- 1933 The Eastern Kuksu Cult. *University of California Publications in Archaeology and Ethnology* 33(2):139–232.

Lotchin, Roger W.

1974 San Francisco, 1846–1856: From Hamlet to City. Oxford University Press, New York.

Loud, L. L.

- 1912 Notes on the Castro Mound. University of California Archaeological Research Facility 361.On file, Lowie Museum, University of California, Berkley.
- 1915 Field notes on excavations at the Princeton site, SMA-22. On file, Archaeological Archives of the Phoebe A. Hearst Museum of Anthropology, University of California, Berkeley.

Louderback, George D.

1951 Geologic History of San Francisco Bay. In Geologic Guidebook of the San Francisco Bay Counties: History, Landscape, Geology, Fossils, Minerals, Industry, and Routes to Travel. State of California Department of Natural Resources Bulletin 154:75–94. Division of Mines, San Francisco, California.

Luby, E. M.

- 1992 Social Organization and Symbolism at the Paterson Mound, ALA-328, Alameda County, California. *California Anthropologist* 18(2):45–52.
- 1994 Excavations at East Marin Island (MRN-611), 1992. *Proceedings of the Society for California Archaeology* 7:105–115.
- 1995 Preliminary Report on the Archaeological Investigations in the Sunol Valley, Alameda County, California. *Proceedings of the Society for California Archaeology* 8:167–174.
- 2004 Shell Mounds and Mortuary Behavior in the San Francisco Bay Area. *North American Archaeologist* 25:1–33.

Luby, Edward M., and Mark F. Gruber

- 1999 The Dead Must be Fed: Symbolic Meanings of the Shellmounds of the San Francisco Bay Area. *Cambridge Archaeological Journal* 9:95–108.
- Luby, E. M., C. D. Drescher, and K. G. Lightfoot
 - 2006 Shell Mounds and Mounded Landscapes in the San Francisco Bay Area: An Integrated Approach. *Journal of Island & Coastal Archaeology* 1(2):191–214.

Madsen, D. B. (editor)

2004 *Entering America: Northeast Asia and Beringia before the Last Glacial Maximum.* University of Utah Press, Salt Lake City.

Madsen, David B., Thomas R. Scott, and Byron Loosle

2000 *Differential Transport Costs and High-Altitude Occupation Patterns in the Uinta Mountains, Northeastern Utah,* edited by David B. Madsen and Michael D. Metcalf. University of Utah Anthropological Papers 122. University of Utah Press, Salt Lake City.

Malamud-Roam, Frances, and B. Lynn Ingram

2004 Late Holocene δ¹³C and Pollen Records of Paleosalinity from Tidal Marshes in the San Francisco Bay Estuary, California. *Quaternary Research* 62:134–145.

Malamud-Roam, Frances, B. Lynn Ingram, Malcolm Hughes, and Joan L. Florsheim

2006 Holocene Paleoclimate Records from a Large California Estuarine System and its Watershed Region: Linking Watershed Climate and Bay Conditions. *Quaternary Science Reviews* 25:1570– 1598.

Malamud-Roam, Frances, Michael Dettinger, B. Lynn Ingram, Malcolm K. Hughes, and Joan L. Florsheim

2007 Holocene Climates and Connections between the San Francisco Bay Estuary and its Watershed: A *Review.* San Francisco Estuary and Watershed Science Publication.

Maloney, A. B.

- 1943 Fur Brigade to the Bonaventura: John Work's California Expedition of 1832–1833 for the Hudson's Bay Company. *California Historical Society Quarterly* 22.
- 1944 Fur Brigade to the Bonaventura: John Work's California Expedition of 1832–1833 for the Hudson's Bay Company. *California Historical Society Quarterly* 23.

Marinebio.org

2015 Bat Rays, *Myliobatis californica* ~ MarineBio.org. MarineBio Conservation Society. http://marinebio.org/species.asp?id=101, accessed October 2015.

Martin, T.

 2006 Archaeological Testing/Data Recovery Investigations at the Prehistoric Deposit of CA-SFR-154/H, San Francisco-Oakland Bay Bridge West Approach Replacement Project, San Francisco, California.
 Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Prepared for the California Department of Transportation, District 4, Oakland, California.

Martin, Thomas, and Jack Meyer

2005 Archaeological Data Recovery at the Napa Creek Site (CA-NAP-916), State Route 29, Napa California. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Submitted to California Department of Transportation, District 4, Oakland, California.

Martisius, Naomi L.

2011 Ancient DNA and Genetic Relations at a 4000-year-old Archaeological Site (CA-CCO-548) in the California Delta. *Explorations: The UC Davis Undergraduate Research Journal* 14.

Matson, R. G.

1985 The Relationship between Sedentism and Status Inequalities among Hunters and Gatherers. In Status, Structure, and Stratification: Current Archaeological Reconstructions, edited by M. Thompson, M. T. Garcia, and F. J Kense, pp. 245–252. University of Calgary Archaeological Association, Calgary, Alberta, Canada.

Matthes, F. E.

1939 Report of committee on glaciers, April 1939. *Eos, Transactions American Geophysical Union* 20(4):518–523.

McBeath, John

1965 *Archaeology of the Novato Highway By-Pass Site, Marin County, California.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

McCrossin, M. L.

1981 Paleoecological Inferences from a Faunal Analysis of CA-SFR-07. *Journal of California and Great Basin Anthropology* 4(1).

McGeein, D. G., and W. C. Mueller

1955 A Shellmound in Marin County, California. *American Antiquity* 21(1):52–62.

McGuire, Kelly R.

1995 Test Excavations at CA-FRE-61, Fresno County, California. In *California State University*, *Bakersfield Museum of Anthropology Occasional Papers in Anthropology, Number 5.*

McGuire, Kelly R., and William R. Hildebrandt

- 1994 The Possibilities of Women and Men: Gender and the California Milling Stone Horizon. *Journal of California and Great Basin Anthropology* 16(1):41–59.
- 2004 The Possibilities of Men and Women: Gender and the California Milling Stone Horizon. In *Prehistoric California: Archaeology and the Myth of Paradise*, edited by L. M. Raab and T. L. Jones, pp. 162–171. University of Utah Press, Salt Lake City.
- 2005 Re-thinking Great Basin Foragers: Prestige Hunting and Costly Signaling during the Middle-Archaic Period. *American Antiquity* 70(4):695-712.

McGuire, K. R., W. R. Hildebrandt, and K. L. Carpenter

2007 Costly Signaling and the Ascendance of No-Can-Do Archaeology: A Reply to Codding and Jones. *American Antiquity* 72(2):358–365.

McKern, W. C.

- 1922 Functional Families of the Patwin. *University of California Publications in American Archaeology and Ethnology* 13(7):235–258.
- 1923 Patwin Houses. University of California Publications in American Archaeology and Ethnology 20(10):159–171.

Meacham, Charla M.

1979 *Haliotis Ornaments of the Windmiller Culture, Central California*. Master's thesis, Department of Anthropology, California State University, Sacramento.

Meighan, Clement W.

- 1953 Preliminary Excavation at the Thomas Site, Marin County. *University of California Archaeological Survey Reports* 19:1-39.
- 1987 Reexamination of the Early Central California Culture. *American Antiquity* 52(1):28–36.

Meighan, Clement W., and C. Vance Haynes, Jr.

- 1970 The Borax Lake Site Revisited. *Science* 167(3922):1213–1221.
- Meko, David M., Matthew D. Therrell, Christopher H. Baisan, and Malcolm K. Hughes
 - 2001 Sacramento River Flow Reconstructed to AD 869 from Tree Rings. *Journal of the American Water Resources Association* 37 (4):1029–1040.

Melander, Ronald N., and Charles M. Slaymaker, III

1969 The Salvage Archaeology of 4-MRN-168: The Pacific Telephone Site, Ignacio, California. San Francisco State College Archaeological Survey, San Francisco, California. Submitted to Pacific Telephone Company, San Francisco, California.

Mensing, Scott, and Roger Byrne

2000 Invasion of Mediterranean Weeds into California before 1769. Fremontia 27(3):6–9.

Meyer, C., N. Nicklisch, P. Held, B. Fritsch, and K. W. Alt

2011a Tracing patterns of activity in the human skeleton: an overview of methods, problems, and limits of interpretation. *HOMO-Journal of Comparative Human Biology* 62(3):202-217.

Meyer, Jack

- 1996 *Geoarchaeological Implications of Holocene Landscape Evolution in the Los Vaqueros Area of Eastern Contra Costa County, California.* Master's thesis, Cultural Resources Management, Department of Anthropology, Sonoma State University, Rohnert Park, California.
- 1998 An Archaeological Investigation of Artifacts and Human Remains from CA-CCO-637, Los Vaqueros Project Area, Contra Costa County, California. ASC, Sonoma State University.
- 2000 An Archaeological Evaluation of CA-CCO-320/H, with Updates for CA-CCO-397, and CA-CCO-544, Los Vaqueros Area, Contra Costa County, California. Prepared by ASC, Sonoma State University, Rohnert Park, California.
- 2005 *Geoarchaeological Study of the Marsh Creek Site (CA-CCO-18 and CA-CCO-548) Eastern Contra Costa County, California.* Anthropological Studies Center, Sonoma State University, Rohnert Park, California.
- 2008 A Geoarchaeological Overview and Assessment of Caltrans District 3—Cultural Resources Inventory of Caltrans District 3 Rural Conventional Highways. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the California Department of Transportation, District 3, North Region, Marysville, California.
- 2013 A Geoarchaeological Overview and Assessment of Northeast California: Cultural Resources Inventory of Caltrans District 2 Rural Conventional Highways: Lassen, Modoc, Plumas, Shasta, Siskiyou, Tehama, and Trinity Counties. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 2, Redding, California.

Meyer, Jack continued

- 2014a Geoarchaeological Research. In *Archaeological Data Recovery at CA-MRN-67 Larkspur, Marin County, California,* edited by Al W.Schwitalla and Christopher Powell, pp. 5.2–5.12. Holman & Associates, San Francisco, California. Submitted to Larkspur Land & Owner, LLC, Walnut Creek, California.
- 2014b Grandfather Midden: Natural and Cultural Stratigraphy of CA-MRN-67 in Larkspur. Paper presented at the Society for California Archaeology, Annual Meeting, Visalia, California.
- 2015 Phase II Archaeological Testing and Evaluation of Site P-01-011556 (Fremont Site) for the PG&E Line 107 Project, Alameda County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Pacific Gas & Electric Company, San Ramon, California.
- n.d. Geoarchaeological Context for Report on Transbay Man. Manuscript in Possession of the Author.

Meyer, Jack, and Graham Dalldorf

2004 *Geoarchaeological Studies along Portions of the East Sonora Bypass Corridor, Tuolumne County, California.* Anthropological Studies Center, Sonoma State University, Rohnert Park. Submitted to the California Department of Transportation, District 10, Stockton, California.

Meyer, Jack, and Michael Meyer

2000 Archaeological Monitoring and Investigations for the Road 3A and Habitat Mitigation Construction Projects, Los Vaqueros Area, Contra Costa County, California. Prepared by ASC, Sonoma State University, Rohnert Park, California.

Meyer, Jack, and Jeffrey S. Rosenthal

- 1995 Archaeological Investigations at the Crazy Creek Sites, CA-LAK-1682 and CA-LAK-1683, Lake County, California. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Prepared for Winzler and Kelly, Consulting Engineers, Santa Rosa, California.
- 1997 Archaeological and Geoarchaeological Investigations at Eight Prehistoric Sites in the Los Vaqueros Reservoir Area, Contra Costa County. In Los Vaqueros Project Final Report. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Submitted to the Contra Costa Water District, Concord. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1998 An Archaeological Investigation of Artifacts and Human Remains from CA-CCO-637, Los Vaqueros Project Area, Contra Costa County, California. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Submitted to Contra Costa Water District, Concord, California.
- 2007 *A Geoarchaeological Overview for the Nine Bay Area Counties of Caltrans District* 4. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 4, Oakland, California.
- 2008 A Geoarchaeological Overview and Assessment of Caltrans District 3—Cultural Resources Inventory of Caltrans District 3 Rural Conventional Highways. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the California Department of Transportation, District 3, North Region, Marysville, California.

Meyer, Jack, D. Craig Young, and Jeffrey S. Rosenthal

2010 A Geoarchaeological Overview and Assessment of Caltrans Districts 6 and 9. Cultural Resources Inventory of Caltrans Districts 6/9, Rural Conventional Highways. Far Western Anthropological Research Group, Inc. Davis. On file, California Department of Transportation, District 6, Fresno, California.

Meyer, Jack, Philip Kaijankoski, and Jeffrey S. Rosenthal

2011 A Geoarchaeological Overview and Assessment of Northwest California – Cultural Resources Inventory of Caltrans District 1 Rural Conventional Highways: Del Norte, Humboldt, Mendocino, and Lake Counties. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the California Department of Transportation, District 1, Eureka, California.

Meyer, Jack, Julia Costello, Patricia Mikkelsen, Melissa Johnson, and Naomi Scher

2013 Suisun Marsh Habitat Management, Preservation, and Restoration Plan Cultural Resources Contextual Report – Volume I: Archaeological Resources. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Bureau of Reclamation, Mid Pacific Region, Sacramento, California.

Mikkelsen, Patricia

- 1985 *A Study of Millingtool Form and Function Applied to the North Coast Ranges, California.* Master's thesis, Department of Anthropology, Sonoma State University, Rohnert Park, California.
- 2013 Temporal Components. *Proceedings of the Society for California Archaeology* 27:149–161.

Mikkelsen, Patricia, and Deborah Jones

2010 Test and Data Recovery Excavations at Sites CA-MNT-216, 217/H, and -263, for the Point Lobos State Reserve Bird Island Trail Accessibility Improvements Project, Monterey County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California State Parks, Monterey District, Monterey, California.

Mikkelsen, Patricia, Randall Milliken, and Patricia Welsh

1995 *Report on 1995 Testing and Monitoring at Archaeological Site CA-SOL-25/H, Solano County, California.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to William A. Saks & Company Investment and Development, Benicia, California.

Miller, G. R.

1982 *Final Report of Archaeological Test Excavations at CA-ALA-60, Located on Route 580, Castro Valley, Alameda County, Califor*nia, P.M. 26.0/29.0. Institute of Cultural Resources, California State University, Hayward, California. Submitted to California Department of Transportation, District 4, Oakland, California.

Miller, Teresa

1977 Permit No. 4764791159, 04-Mrn0-3.09-3.23 ± Tiburon Blvd. at San Rafael Avenue. Archaeological Resource Service, Novato, California. Letter report to PG&E Land Department, San Rafael, California, dated 8 February 1977. On file, Northwest Information Center of the California Historical Resources Information System, Sonoma State University, Rohnert Park, California.

Milliken, Randall

- 1981 The Protohistoric Inhabitants of the Richmond Area. In *Investigation of Cultural Resources within the Richmond Harbor Redevelopment Project 11-A, Richmond, Contra Costa County, California,* edited by Peter M. Banks and Robert I. Orlins, pp. 4.1–4.99. California Archaeological Consultants, Inc., Woodland, California. Submitted to City of Richmond. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1983 *The Spatial Organization of Human Population on Central California's San Francisco Peninsula at the Spanish Arrival*. Master's thesis, Cultural Resource Studies, Sonoma State University, Rohnert Park, California.
- 1987 *Rumsen Ethnohistory*. Papers in Northern California Anthropology 2. Northern California Anthropological Association. Coyote Press, Salinas, California.
- 1995 A Time of Little Choice: The Disintegration of Tribal Culture in the San Francisco Bay Area 1769– 1810, edited by T. C. Blackburn. Ballena Press Anthropological Papers No. 43. Menlo Park, California.
- 2006 The Central California Ethnographic Community Distribution Model, Version 2.0, with Special Attention to the San Francisco Bay Area: Cultural Resources Inventory of Caltrans District 4 Rural Conventional Highways. Prepared by Consulting in the Past and Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Office of Cultural Resource Studies, California Department of Transportation District 4, Environmental Division.
- 2008 Native Americans at Mission San Jose. Malki-Ballena Press, Banning, California.
- 2009 *Ethnohistory and Ethnogeography of the Coast Miwok and their Neighbors, 1783–1840.* Prepared for National Park Service, Golden Gate National Recreation Area, San Francisco, California.
- 2010 The Contact-Period Native California Community Distribution Model: A Dynamic Digital Atlas and Wiki Encyclopedia. Far Western Anthropological Research Group, Inc., Davis, California.
- 2012 Part II. Replica Set Typology and Commentary. In *California and Great Basin Olivella Shell Bead Guide,* edited by Randall Milliken and Al Schwitalla. Left Coast Press, Walnut Creek, California.

Milliken, Randall T., and James A. Bennyhoff

1993 Temporal Changes in Beads as Prehistoric California Grave Goods. In *There Grows a Green Tree: Essays in Honor of D. A. Fredrickson,* edited by Greg White, Pat Mikkelsen, William R. Hildebrandt, and Mark E. Basgall, pp. 381–395. Center for Archaeological Research at Davis Vol. 11. University of California, Davis.

Milliken, Randall, and John R. Johnson

2005 An Ethnogeography of Salinan and Northern Chumash Communities – 1769 to 1810. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 5, San Luis Obispo, California.

Milliken, Randall, and A. Schwitalla

2012 California and Great Basin Olivella Shell Bead Guide. Left Coast Press, Walnut Creek, California.

- Milliken, Randall, Richard T. Fitzgerald, Mark G. Hylkema, Randy Groza, Tom Origer, David G. Bieling, Alan Leventhal, Randy S. Wiberg, Andrew Gottsfield, Donna Gillette, Viviana Bellifemine, Eric Strother, Robert Cartier, and David A. Fredrickson
 - 2007 Punctuated Culture Change in the San Francisco Bay Area. In *California Prehistory: Colonization, Culture, and Complexity,* edited by Terry L. Jones and Kathryn Klar, pp. 99–124. Altamira Press, Walnut Creek, California.

Milliken, Randall, Laurence H. Shoup, and Beverly R. Ortiz

- 2009 Ohlone/Costanoan Indians of the San Francisco Peninsula and their Neighbors, Yesterday and Today. Prepared for National Park Service, Golden Gate National Recreation Area, San Francisco, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Milliken, Randall, William Bloomer, Susan Stratton, Jim Nelson, D. Furlong, D. Craig Young, Eric Wohlgemuth, Julia Costello, Pat Mikkelsen, Tim Carpenter, and Debbie Jones
 - 1997 The Taylors Bar Site (CA-CAL-1180/H): Archaeological and Ethnohistoric Investigations in Calaveras County, California. Prepared by Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Calaveras County Water District, San Andreas, California. Report on file at the Central California Information Center, California State University, Stanislaus, Turlock, California.

Minnich, R. A.

- 2008 *California's Fading Wildflowers: Lost Legacy and Biological Invasions.* University of California Press, Berkeley.
- Monaghan, G. William, Kathryn C. Egan-Bruhy, Michael J. Hambacher, Daniel R. Hayes, Michael F. Kolb, Steve R. Kuehn, Staffan Peterson, James A. Robertson, and Nelson R. Shaffer
 - 2006 *Minnesota Deep Test Protocol Project*. Commonwealth Cultural Resources Group, Inc., Jackson, Michigan. Submitted to the Minnesota Department of Transportation and Federal Highway Administration.

Monks, G. G.

- 1981 Seasonality Studies. In *Advances in Archaeological Method and Theory*, Vol. 4, edited by M. B. Schiffer, pp. 177–240. Academic Press, New York.
- Monroe, Cara, Karen S. Gardner, Eric L. Lenci, Alan Leventhal, Rosemary Cambra, Eric J. Bartelink, and Brian M. Kemp
 - 2013 Mystery Men of Yukisma: Ancient DNA and Stable Isotope Data used To Deduce the Origin and Relationship of an Unusual Group Burial at CA-SCL-38. Paper presented at the 47th Annual Meeting of the Society for California Archaeology, Berkeley, CA, March 7–10.

Montague, Suzanna

 2005 Research Proposal: The Pothole Dome Cache and Other Obsidian Flaked-Stone Tool Caches in Yosemite National Park. California State University, Anthropology Department, Sacramento, California. Submitted to and on file in Yosemite Archaeology Office, Yosemite National Park. Moore, Jerry D.

1988 Marine Over-Exploitation on the Prehistoric California Coast: The Effects of Human Predation on Mytilus californianus. In The Testing and Evaluation of Fourtheen Archaeological Sites on South Vandenberg Air Force Base, Santa Barbara County, California, pp. B1-B16. Harmsworth Associates Research Report, Vol. 3. Harmsworth Associates, Laguna Hills, California.

Moratto, Michael J.

- 1969 Notes on Excavation at CA-MRN-192.
- 1971 Archaeological Investigations at 4-SMA-110: Contributions to the Archaeology of San Mateo County, California. *Treganza Anthropology Museum Papers* 8:56–70, edited by M. J. Moratto. San Francisco State College, San Francisco, California.
- 1974 An Assessment of the Cultural Resources within Point Reyes National Seashore. California State University, San Francisco. Prepared for the National Park Service, Tucson, Arizona. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1976 New Melones Archaeological Project Stanislaus River, Calaveras and Tuolumne Counties, California: Phase VI. Archaeological Research Laboratory, Department of Anthropology, San Francisco State University.
- 1984 California Archaeology. Academic Press, Orlando, Florida.
- 1995 Volume V Book 3: Technical Studies Appendices. Archaeological Investigations, PGT-PG&E Pipeline Expansion Project, Idaho, Washington, Oregon, and California 5. INFOTEC Research, Inc., Fresno, California. Submitted to Pacific Gas Transmission Company, San Francisco, California.
- 2002 Culture History of the New Melones Reservoir Area, Calaveras and Tuolumne Counties, California. In *Essays in California Archaeology: A Memorial to Franklin Fenenga*, edited by William J. Wallace and Francis A. Riddell, pp. 25–54. Contributions to the University of California Archaeological Research Facility 60. University of California Press, Berkeley.

Moratto, Michael J., Lynn M. Riley, and S. C. Wilson

1974 Shelter Hill: Archaeological investigations at 4-MRN-14, Mill Valley, California. Treganza Anthropology Papers 15 and Miwok Archaeological Preserve of Marin Papers 2:1–166. San Francisco, California.

Morgan, Christopher

- 2007 Reconstructing Prehistoric Hunter-Gatherer Foraging Radii: A Case Study from California's Southern Sierra Nevada. *Journal of Archaeological Science* 35:247–258.
- 2015 Is it Intensification Yet? Current Archaeological Perspectives on the Evolution of Hunter-Gatherer Economies. *Journal of Archaeological Research* 23(2):163–213.

Morgan, Sally Salzman

n.d. *Data Recovery Excavations at ALA-309 and ALA-310.* Preliminary draft report, in progress, provided by the author.

Morgan, Sally S., and Sean D. Dexter

2008 San Francisco-Oakland Bay Bridge East Span Seismic Safety Project – Archaeological Analysis of CA-SFR-4/H, Yerba Buena Island, San Francisco and Alameda Counties, California, edited by Patricia Mikkelsen, Brian F. Byrd, Jeffrey Rosenthal, and Sharon A. Waechter. Far Western Anthropological Research Group, Inc., Davis, California. URS Corporation, Oakland, California. Submitted by Parson Brinkerhoff, San Francisco, California and California Department of Transportation, District 4, Toll Bridge Program, Oakland, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Morley, Susan

2004 *The Classic Residence Project: Osteological Inventory and Analysis of Native American Burials from CA-SCL-623/H.* Ohlone Family Consulting Services, San Jose, California.

Mudie, P. J., and R. Bryne

1980 Pollen Evidence for Historic Sedimentation Rates in California Coastal Marshes. *Estuarine and Coastal Marine Science* 10:305–316.

Mundy, Joseph

1993 Elevation-Related Variables and Obsidian Hydration: A Diffusion Cell Study in Yosemite.

Munz, P. A.

1968 A California Flora. University of California Press, Berkeley.

National Park Service

- 2000 *Guidelines for Evaluating and Registering Archeological Properties*. National Register Bulletin 36. National Park Service. https://www.nps.gov/nr/publications/bulletins/pdfs/nrb36.pdf, accessed June 2016.
- 2016 *Curation of Federally Owned and Administered Archeological Collections (36 CFR 79).* http://www.nps.gov/archeology/tools/laws/36cfr79.htm, accessed June 2016.

Nelson, J. S.

1997 Interpersonal Violence in Prehistoric Northern California: A Bioarchaeological Approach. Master's thesis, Department of Anthropology, California State University, Chico.

Nelson, M. C.

1991 The Study of Technological Organization. In *Archaeological Method and Theory, Volume 3,* Michael B. Schiffer, pp. 57-100. University of Arizona Press, Tucson.

Nelson, M. C. and H. Lippermeir

1993 Grinding-tool Design as Conditioned by Land-Use Pattern. American Antiquity 58(2):286-305.

Nelson, Nels

1906 Excavation of the Emeryville Shellmound, 1906: Nels C. Nelson's Final Report, transcribed and prefaced by Jack M. Broughton. Archaeological Research Facility, University of California, Berkeley. Contributions of the University of California Archaeological Research Facility No. 54. Nelson, Nels continued

- 1909 Shellmounds of the San Francisco Bay Region. *University of California Publications in American Archaeology and Ethnology* 7(4):310–356.
- 1910a The Ellis Landing Shellmound. *University of California Publications in American Archaeology and Ethnology* 8. University of California Press, Berkeley.
- 1910b *San Rafael Mound #86c, MRN-315.* Phoebe A. Hearst Museum of Anthropology Manuscript 354. University of California, Berkley.
- 1910c *Sausalito Mound #3*. Phoebe A. Hearst Museum of Anthropology Manuscript 353. University of California, Berkley.
- 1910d *Bay Shore Mound #387*. Phoebe A. Hearst Museum of Anthropology Manuscript 355. University of California, Berkley.
- 1911a *San Mateo Mound #372, SMA-33*. Phoebe A. Hearst Museum of Anthropology Manuscript 359. University of California, Berkley.
- 1911b *Greenbrae Mound #76, MRN-76.* Phoebe A. Hearst Museum of Anthropology Manuscript 358. University of California, Berkley.

Netting, R. M.

1990 Links and Boundaries: Reconsidering the Alpine Village as Ecosystem. In *The Ecosystem Approach in Anthropology: From Concept to Practice,* pp. 229–246.

Newland, Michael

2013 A Subsurface Archaeological Study of CA-MRN-35, 44 San Rafael Avenue, City of Belvedere, Marin County, California. Prepared by the Anthropological Studies Center, Sonoma State University Project QC206 32/13.

Norton, William

2007 Diachronic Shifts in Shellfish Exploitation on the Marin Peninsula. Paper presented at the Society of California Annual Meetings, San Jose, California.

Novato Senior High Archaeology Club

1967 *Report on the Excavation of Marin-374.* Novato Senior High School, Novato, California.

O'Brien, Michael J., and R. Lee Lyman

2000 *Applying Evolutionary Archaeology: A Systematic Approach.* Plenum Press, New York.

Office of Historic Preservation (OHP)

1995 Instruction for Recording Historic Resources. http://www.nps.gov/hps/pad/PlngStds/index.htm, accessed June 2013.

Oliphant, R. L.

- 1971 The Archaeology of 4-SMA-101. Treganza Anthropology Museum Papers 8:37–48, edited by M.
 J. Moratto. San Francisco State College, San Francisco, California.
- n.d. *The Archaeological Salvage of 4-SMA-101.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Onken, J.

1991 *The Effect of Microenvironmental Temperature Variation on the Hydration of Late Holocene Mono Craters Volcanic Ashes from East-Central California.* Master's thesis, Department of Geosciences, University of Arizona, Tucson.

Origer, Thomas M.

- 1982 *Temporal Control in the Southern North Coast Ranges of California: The Application of Obsidian Hydration Analysis.* Master's thesis, Department of Anthropology, California State University, San Francisco.
- 1989 Hydration Analysis of Obsidian Flakes Produced by Ishi during the Historic Period. In *Current Directions in California Obsidian Studies,* edited by R. E. Hughes.
- 1992 Investigations at CA-MRN-601: An Archaeological Site on the West Flank of Burdell Mtn., Marin County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1993 *The Archaeology of CA-SON-2098: A Buried Archaeological Site in Santa Rosa, Sonoma County, California.* Thomas M. Origer, Consulting Archaeologist, Cotati, California. On file, Memorial Hospital, Santa Rosa, California.

Origer, Thomas, and Vicki Beard

- 1998 Archaeological Investigations at CA-SON-227 and CA-SON-2226, Sears Point Raceway, Sonoma County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Origer, Thomas M., and Brian P. Wickstrom
 - 1982 *The Use of Hydration Measurements to Date Obsidian Materials from Sonoma County.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Origer, Thomas M., Lauren Del Bondio, and Janine Loyd
 - 2013 Archaeological Investigations at CA-MRN-12, Mill Valley, Marin County, California. Tom Origer & Associates, Rohnert Park, California. Prepared for the Marin Municipal Water District, Pacific Gas & Electric Company, and the Mill Valley School District (Edna Maguire Elementary School).

Otterbein, Keith F.

2000 A History of Research on Warfare in Anthropology. *American Anthropology* 101:794–805.

Pahl, Gary

2003 *The Archaeology of de Silva Island, CA-MRN-17*. Treganza Museum Publication 17, San Francisco State University, San Francisco, California.

Palóu, Francisco

1926 *Historical Memoirs of New California*, edited by Herbert E. Bolton. University of California Press, Berkeley.

Panich, Lee M.

2014 Native American Consumption of Shell and Glass Beads at Mission Santa Clara de Asís. *American Antiquity* 79(4):730–748.
Panich, Lee M. continued

- 2015 "Sometimes they bury the deceased's clothes and trinkets:" indigenous mortuary practices at Mission Santa Clara de Asís. *Historical Archaeology* 49(4):110-129.
- 2016 Beyond the colonial curtain: Investigating indigenous use of obsidian in Spanish California through the pXRF analysis of artifacts from Mission Santa Clara. *Journal of Archaeological Science: Reports* 5:521–530.

Panich, Lee M., and Tsim D. Schneider

2015 Expanding Mission Archaeology: A Landscape Approach to Indigenous Autonomy in Colonial California. *Journal of Anthropological Archaeology* 40:48–58.

Pappas, Christopher

2013 TOP 10 Free Timeline Creation Tools For Teachers. https://elearningindustry.com/top-10-freetimeline-creation-tools-for-teachers, accessed April 2017.

Parkman, E. Breck

1994 The Bedrock Milling Station. In *The Ohlone Past and Present: Native Americans of the San Francisco Bay Region,* edited by Lowell J. Bean, pp. 43–63. Ballena Press, Menlo Park, California.

Parsons, Gary Alan

- 1990 Sourcing Monterey Banded Chert, a Cryptocrystalline Hydrosilicate: With Emphasis on its Physical and Thermal Traits as Applied to Archaeology. Master's thesis, Department of Anthropology, California State University, San Jose.
- Pastron, A. G.
 - 2002 1166–1188 Howard Street Affordable Housing Project, City and County of San Francisco, California: Archaeological Monitoring/Data Recovery Program. Prepared for Tenderloin Neighborhood Development Corporation. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Pastron, A. G., and R. D. Ambro
 - 2005 The Prehistoric Archaeology of the 835 Market Street (Bloomingdale's) Project, San Francisco, California, and Incidentally, an Expansion of the Boundaries of Site CA-SFR-113. Submitted to the San Francisco Planning Department, San Francisco, California.

Pastron, A. G., and V. Bellifemine

- 2007 Archaeological Investigations at CA-SCL-674, the Rubino Site, San Jose, Santa Clara County, California. Coyote Press Archives of California Prehistory 54. Coyote Press, Salinas, California.
- 2009 Archaeological Investigations at CA-CCO-235, City of Lafayette, Contra Costa County, California, Volume I. Coyote Press, Salinas, California.

Pastron, Allen G., and Andrew Gottsfield

2003 *Final Archaeological Report: East Block of the Mandela Gateway Project, City of Oakland, Alameda County, California.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California, report no. S-27364.

Pastron, A. G., and M. R. Walsh

- 1988a Archaeological Excavations at CA-SFR-112, the Market Street Shell Midden, San Francisco, California. Coyote Press Archives of California Prehistory 21.
- 1988b Archaeological Excavations at CA-SFR-113, the Market Street Shell Midden, San Francisco, California. Coyote Press Archives of California Prehistory 25.
- Pastron, A. G., A. Gottsfield, and A. Vanderslice
 - 2004 *Final Archaeological Report for the Jessie Square Garage Project, San Francisco, California*. Archeo-Tec, Inc., Oakland, California. Submitted to Jessie Square Garage Partners, San Francisco, California.

Patterson, Brandon, and Alex DeGeorgey

2014 The Influence of Trade on the Organization of Lithic Technology. *Proceedings of the Society for California Archaeology* 28:247–281.

Peak, Ann S., and Harvey L. Crew

1990 Parts I and II: An Archaeological Data Recovery Project at CA-CAL-S342, Clarks Flat, Calaveras County, California. In *Cultural Resource Studies, North Fork Stanislaus River, Hydroelectric Development Project, Volume II.* Peak & Associates, Sacramento. Report prepared for Northern California Power Agency, Roseville.

Peak, Ann S., and T. F. Weber

1978 Archaeological Investigations at the Wolfsen Mound, CA-MER-215, Merced County, California. Ann S. Peak and Associates, Sacramento, California. Prepared for the City of Newman, Stanislaus County, California. On file, Central California Information Center, California Historical Resources Information System, California State University, Stanislaus, California.

Pearsall, Deborah

2015 Paleoethnobotany: A Handbook of Procedures, 3rd Edition. Orlando: Academic Press.

Perry, David W., Scott M. Patterson, and Susan L. McMurray

1985 *The Makahmo Pomo: An Ethnographic Survey of the Cloverdale (Makahmo) Pomo.* Prepared for the US Army Corps of Engineers by Sonoma State University.

Pesnichak, Lisa M., Cassandra Chattan, Sally R. Evans, Amy Schilling, and Kristel Daunell

2004 The Results of Monitoring and Burial Recovery at the College Park Housing Development at the Union Pacific Railroad Site, CA-SCL-846/H, San Jose, Santa Clara County, California. Archaeological Resource Service. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Phebus, George Jr.

- 1973 *Contributions to Costanoan Archaeology: Archaeological Investigations at 4-ALA-330 and 4-SMA-*22. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1990 *Archaeological Investigations in the San Pablo-Suisun Region of Central California*. Printed privately, Astoria, Oregon.

Pilgram, Tom

1987 Predicting Archaeological Sites from Environmental Variables: A Mathematical Model for the Sierra Nevada Foothills, California. B.A.R International Series 320, Oxford, United Kingdom.

Pilling, A. R.

1950 The Archaeological Implications of an Annual Coastal Visit for Certain Yokuts Groups. *American Anthropologist* 52:438–440.

Piperno, Dolores R.

2006 Phytoliths: A Comprehensive Guide for Archaeologists and Paleoecologists. Rowman Altamira.

Plog, S.

Agriculture, Sedentism, and Environment in the Evolution of Political Systems. In *The Evolution of Political Systems: Sociopolitics in Small-Scale Sedentary Societies*, pp. 177–199.
 Cambridge University Press, Cambridge, United Kingdom.

Pohl, Gary

2003 *The Archaeology of de Silva Island, CA-MRN-17*. Treganza Museum Publication 17, Tiburon Archaeological Research Group Publication 2.

Popper, Virginia S., and Steve L. Martin

2002 Analysis of Plant Remains from Emeryville Shellmound (CA-ALA-309 and CA-ALA-310), Alameda County, California. Submitted to URS Corporation, Oakland, California.

Porinchu, David F., Glen M. MacDonald, Amy M. Bloom, and Katrina A. Moser

2003 Late Pleistocene and early Holocene climate and limnological changes in the Sierra Nevada, California, USA inferred from midges (Insecta: Diptera: Chironamidae). *Palaeogeography, Palaeoclimatology, Palaeoecology* 3166:1–20.

Potbury, S.

1932 A Pleistocene Flora from San Bruno, San Mateo County, California. *Carnegie Institution of Washington Publication* 415:25–44.

Powers, Stephen

1877 *Tribes of California, Contributions to North American Ethnology* Vol. 3. US Department of the Interior, Geographical and Geological Survey of the Rocky Mountain Region, Washington, DC. (Reprinted in 1976, University of California Press, Berkeley).

Praetzellis, Mary

- 2015a Archaeological Data Recovery Report for CA-SFR-175, Utilities 1, Revision 0c. Central Subway Technical Memorandum, January 22, 2015. Draft report on file, City of San Francisco Planning Department, San Francisco, California.
- 2015b Archaeological Data Recovery Plan for CA-SFR-175, YBM Station. Central Subway Technical Memorandum, January 26, 2015. Draft report on file, City of San Francisco Planning Department, San Francisco, California.

- Price, Barry A., Richard M. Pettigrew, Michael Ostrogorsky, Susan K. Goldberg, Judith A. Willig, Lou Ann Speulda, Pat Mikkelsen, and Melinda C. Romano
 - Volume IID: California Descriptive Reports and Data Compendia. Archaeological Testing and Evaluation Report, 1991–1992 Field Season, and Historic Properties Treatment Plan for 1992 Field Season, PGT-PG&E Pipeline Expansion Project, Idaho, Washington, Oregon, and California 2.
 INFOTEC Research, Inc., Fresno, California. Submitted to Bechtel Corporation, San Francisco, California.

Price, Carol A.

- 1981 *Maps and Descriptions of Radiocarbon-Dated Samples from Central and Northern California.* Miscellaneous Field Studies Map MF-1321. US Geological Survey.
- Price, Heather, Eric Strother, Kyle Brown, Allen Estes, Nancy Summerlin, Martin Wells, Marin Pilloud, James Allan, and William Self
 - 2002 Pleasanton Gateway Project: Report on Archaeological Data Recovery at CA-ALA-554, Pleasanton, Alameda County, California - Volume 1: Data Recovery. William Self Associates, Inc., Orinda, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Price, Heather, Aimee Arrigoni, and Jenni Price

2005 Data Recovery, Burial Removal and Construction Monitoring at the Canyon Oaks Site, CA-ALA-613/H, Pleasanton, Alameda County, California - Volume 3: Appendices. William Self Associates, Inc., Orinda, California. Submitted to KB Homes South Bay, Inc., Pleasanton, California.

Price, Heather, Aimee Arrigoni, Jenni Price, Eric Strother, and Jim Allan

2006 Archaeological Investigations at CA-CCO-309, Rossmoor Basin, Contra Costa County, California. William Self Associates, Inc., Orinda, California. Submitted to County of Contra Costa, Department of Public Works, Martinez, California.

Price, T. Douglas, and J. A. Brown

1985 *Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity*. Academic Press, San Diego, California.

Price, T. Douglas, and Gary M. Feinman

1995 Foundations of Social Inequality. Fundamental Issues in Archaeology. Plenum Press, New York.

Psota, Sunshine

1997 Results of Trench Monitoring and Site Boundary Definition from CA-SOL-391 in Green Valley, California. *Proceedings of the Society for California Archaeology* 10:4–13.

Psota, Sunshine, and M. R. Clark

1994 Site Perimeter Identification and Monitoring of Geotechnical Test Trenching at CA-SOL-391, Green Valley, in the City of Fairfield, Solano County, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Puseman, Kathryn, and Linda Scott Cummings

2005 Macrofloral Analysis of Samples from Site CA-SMA-151, Central Coastal California. http://core.tdar.org/document/379253, accessed 11/10/15.

Rackerby, F.

1967 The Archaeological Salvage of Two San Francisco Bay Shellmounds. In *Contributions to the Archaeology of Southern San Francisco Bay.* San Francisco State College, Department of Anthropology Occasional Papers in Anthropology No. 3. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Rafferty, Kevin A.

1985 The Archaeological Record on Sedentariness: Recognition, Development, and Implications. In *Advances in Archaeological Method and Theory*, edited by M. B. Schiffer, pp. 113–156. Academic Press, New York.

Ragir, S. R.

1972 *The Early Horizon in Central California Prehistory*. Contributions to the University of California Archaeological Research Facility 15. University of California, Berkeley.

Reddy, Seetha N.

- 1999 Plant Usage and Prehistoric Diet: Paleoethnobotanical Investigations on Camp Pendleton, Southern California. *Pacific Coast Archaeological Society Quarterly* 35(4):25–44.
- 2015 Feeding Family and Ancestors: Persistence of Traditional Native American Lifeways during the Mission Period in Coastal Southern California. *Journal of Anthropological Archaeology* 37:48–66.
- Reese, Elena, Alan Leventhal, Viviana Bellifemine, Susan Morley, Rosemary Cambra, and Norma Sanchez
 - 1998 *San Mateo Archaeological Testing and Burial Recovery for CA-SMA-84: The Lego Site.* On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Rehor, Jay

- 2013 Archaeological, Biological, and Native American Monitoring Peninsula Watershed Geotechnical Investigations, Upper Crystal Springs Reservoir. Technical Memorandum prepared for San Francisco Public Utility Commission.
- n.d. Excavation Report for CA-ALA-312, Horton Street Landing Project. Manuscript in Preparation.

Reidy, Liam Michael

- 2001 *Evidence of Environmental Change over the Last 2,000 Years at Mountain Lake, in the Northern San Francisco Peninsula, California.* Master's thesis, University of California, Berkeley.
- Reimer, Paula J., M. G. L. Baillie, E. Bard, A. Bayliss, J. W. Beck, C. J. H. Bertrand, P. G. Blackwell,
 C. E. Buck, G. S. Burr, K. B. Cutler, P. E. Damon, R. L. Edwards, R. G. Fairbanks, M. Friedrich,
 T. P. Guilderson, A. G. Hogg, K. A. Hughen, B. Kromer, G. McCormac, S. Manning,
 C. B. Ramsey, R. W. Reimer, S. Remmele, J. R. Southon, M. Stuiver, S. Talamo, F. W. Taylor,
 J. van der Plicht, and C. E. Weyhenmeyer
 - 2004 IntCal04 Terrestrial Radiocarbon Age Calibration, 0-26 cal kyr BP. Radiocarbon 46(3):1029-1059.

Reynolds, A. L.

2000 Mammalian and Avian Faunal Remains from CA-SFR-129.

Richards, Gary D.

1988 Human Osteological Remains from CA-SCL-294, a Late Period and Protohistoric Site, San Jose, Santa Clara County, California. Coyote Press Archives of California No. 24. Coyote Press, Salinas, California.

Rick, John W., and Thomas L. Jackson

1985 Description and Analysis of the "Great Blades Cache" (CA-GLE-138), Mendocino National Forest, California. Submitted to USDA, US Forest Service, Mendocino National Forest.

Rick, Torben C., Jon M. Erlandson, Nicholas P. Jew, and Leslie A. Reeder-Myers

2013 Archaeological Survey, Paleogeography, and the Search for Late Pleistocene Paleocoastal Peoples of Santa Rosa Island, California. *Journal of Field Archaeology* 38(4):324–331.

Ricketts, Edward Flanders, Jack Calvin, Joel Walker Hedgpeth, and David W. Phillips

1985 Between Pacific Tides. Stanford University Press: Palo Alto, California.

Riley, Lynn M.

1979 Shelter Hill: An Analysis of Faunal Remains and Artifacts from a Marin County Shellmond (4-Mrn-14). Master's thesis, Anthropology Department, San Francisco State, San Francisco.

Rocek, Thomas R., and Ofer Bar-Yosef

1998 Seasonality and Sedentism: Archaeological Perspectives from Old and New World Sites. Peabody Museum Bulletin 6. Peabody Museum of Archaeology and Ethnology. Harvard University, Cambridge, Massachusetts.

Rogers, Alexander K.

- 2007a Effective Hydration Temperature of Obsidian: A Diffusion Theory Analysis of Time-Dependent Hydration Rates. *Journal of Archaeological Science* 34:656–665.
- 2007b A Tale of Two Gophers: Depth Correction for Obsidian Effective Hydration Temperature in the Presence of Site Turbation Effects. *Bulletin on the International Association for Obsidian Studies* 38:7–12.
- 2008 A Reassessment of Obsidian Hydration Ages of Projectile Point Types from the Coso Volcanic Field. *Pacific Coast Archaeological Society Quarterly* 39(4).
- 2010 Accuracy of Obsidian Hydration Dating based on Obsidian–Radiocarbon Association and Optical Microscopy. *Journal of Archaeological Science* 37(12):3239–3246.

Rondeau, Michael F., Jim Cassidy, and Terry L. Jones

2007 Colonization Technologies: Fluted Projectile Points and the San Clemente Island Woodworking/Microblade Complex. In *California Prehistory: Colonization, Culture, and Complexity,* edited by Terry L. Jones and Kathryn Klar, pp. 63–70. Altamira Press, Walnut Creek, California.

Roop, William, and Katherine Flynn

1981 Unpublished field notes obtained by Randall Milliken on Excavations at MRN-175.

Roop, William, Christian Gerike, and Katherine Flynn

1981 Request for Determination of Eligibility to the National Register of Historic Places for Fourteen Prehistoric Cultural Resources within the Guadalupe Corridor, Northern Santa Clara Valley, California. Northwest Information Center, report no. S-005344. Archaeological Resource Service.

Rosen, Arlen M.

1985 *Cities of Clay: The Geoarchaeology of Tells.* University of Chicago Press, Chicago, Illinois.

Rosenthal, Jeffrey

- 1996 *A Cultural Chronology for Solano County, California*. Masters Thesis, Cultural Resources Management, Sonoma State University.
- 2001 Archaeological Survey and Extended Phase I/Phase II Excavations at CA-ALA-485 and -486 in the Baumberg Ecological Mitigation Tract, Alameda County, California. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for Army Corps of Engineers, San Francisco, California.
- 2005 Chronology: Worsaae's Law and Obsidian Hydration Dating An Evaluation of the Method. In *Lithic Production and Craft Specialization in the Middle Period: Data Recovery Excavations at CA-NAP-172*, edited by Kimberley Carpenter and Patricia Mikkelsen, pp. 66–75. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the City of Calistoga, California.
- 2006 Extended Phase 1 Test Investigation of the Southern Boundary of CA-ALA-576 for the Ala-680 Drainage Improvement Project, Alameda County, California, 04-ALA-680 PM 2.4, EA 2S4601. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for California Department of Transportaiton, District 4, Oakland, California.
- 2008 Chronostratigraphy and Component Definition. In Archaeological Analysis of CA-SFR-4/H, Yerba Buena Island, San Francisco & Alameda Counties, California, Sally S. Morgan and Sean D. Dexter, pp. 82–86. San Francisco-Oakland Bay Bridge East Span Seismic Safety Project. URS Corporation, Oakland, California. Prepared for California Department of Transportation, District 4, Oakland, California.
- 2010 Archaeological Investigations at CA-CCO-18/548 along Marsh Creek, Brentwood, California, 1946– 2008. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California State Parks, Archaeology, History, and Museum Division, West Sacramento, California.
- 2011a The Function of Shell Bead Exchange in Central California. In *Perspectives on Prehistoric Trade and Exchange in California and the Great Basin*, edited by Richard E. Hughes, pp. 83–113. University of Utah Press, Salt Lake City.

Rosenthal, Jeffrey S. (Editor)

- 2011b *A New Frame of Reference: Cultural Chronology and Ecology in the North-Central Sierra Nevada.* Center for Archaeological Research at Davis, Publication Number 16.
- 2012 Prehistoric Land Use and Settlement Systems in Yosemite National Park: A View from Crane Flat. Yosemite National Park Publications in Anthropology No. 38. Far Western Anthropological Research Group, Inc., Davis, California.

Rosenthal, Jeffrey S. (Editor) continued

2015 Archaeological Evaluation and Burial Recovery at CA-SCL-677 within the PG&E Gas Pipeline Terminal, Milpitas, California. Far Western Anthropological Research Group, Inc., Davis, California.

Rosenthal, Jeffrey S., and Brian F. Byrd

- 2005 Archaeological Survey Report for the I-580 Eastbound High Occupancy Vehicle Lane Project, Livermore Valley, Alameda County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the California Department of Transportation, District 4, Oakland, California.
- 2006 Archaeological Survey Report for the I–580 Eastbound High Occupancy Vehicle Lane Project, East of Greenville Road to Hacienda Drive, Livermore Valley, Alameda County, California. 4-Ala-580, K.P. R12.6/30.7 (P.M. R7.8/19.1), EA 04258–290810. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for State of California Department of Transportation, District 4, Oakland, California.

Rosenthal, Jeffrey S., and Richard T. Fitzgerald

- 2012 The Paleo-Archaic Transition in Western California. In *From the Pleistocene to the Holocene: Human Organization and Cultural Transformations in Prehistoric North America*, edited by C. Britt Bousman and Bradley J. Vierra, pp. 67–103. Texas A&M University Press, College Station.
- Rosenthal, Jeffrey S., and Philip Kaijankoski
 - 2014 Appendix C: Trans-Holocene Delta R Calculations on California Mussel (*Mytilus califorianus*) from the Bodega Bay Region, California. In *Extended Phase I/Phase II Archaeological Investigations for the Gleason Beach State Route 1 Realignment Project, Sonoma County, California,* by Philip Kaijankoski. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 4, Oakland, California.

Rosenthal, Jeffrey S., and Kelly R. McGuire

2004 *Middle Holocene Adaptations in the Central Sierra Nevada Foothills: Data Recovery Excavations at the Black Creek Site, CA-CAL-789.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 6, Fresno, California. On file, Central California Information Center, California State University, Stanislaus, California.

Rosenthal, Jeffrey S., and Jack Meyer

- 2004a Cultural Resources Inventory of Caltrans District 10 Rural Conventional Highways. Volume III: Geoarchaeological Study; Landscape Evolution and the Archaeological Record of Central California.
 Far Western Anthropological Research Group, Inc., Davis, California. Submitted to California Department of Transportation, District 10, Stockton. On file, Central California Information Center, California State University, Stanislaus, California.
- 2004b Landscape Evolution and the Archaeological Record: A Geoarchaeological Study of the Southern Santa Clara Valley and Surrounding Region. Center for Archaeological Research at Davis Publication 14. University of California, Davis.

Rosenthal, Jeffrey S., and Sharon A. Waechter

- 2002 *Results of Phase-II Test Excavations at CA-ELD-616/H, near Cool, Western El Dorado County.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the California Department of Transportation, District 3, Marysville, California.
- Rosenthal, Jeffrey S., and Adrian Whitaker
 - 2016 Methods, Components, and Assemblage from Data Recovery Excavations at CA-SOL-468, Alamo Detention Basin, Solano County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the City of Vacaville, California.
- Rosenthal, Jeffrey S., Jack Meyer, Jim Nelson, Denise Furlong, Tim Carpenter, and Eric Wohlgemuth
 - 2006 *Results of Limited Geoarchaeological and Archaeological Study of CACCO-18/548, John Marsh Historic Park, Brentwood, California.* Far Western Anthropological Research Group, Inc., Davis, California. Prepared for California Department of Parks and Recreation, Sacramento, California.
- Rosenthal, Jeffrey S., Gregory G. White, and Mark Q. Sutton
 - 2007 The Central Valley: A View from the Catbird's Seat. In *California Prehistory: Colonization, Culture, and Complexity,* edited by Terry L. Jones and Kathryn Klar, pp. 147–164. Altamira Press, Walnut Creek, California.

Rosenthal, Jeffrey S., Kimberley L. Carpenter, and Adrian R. Whitaker

2009 Boundaries, Bead Blanks, and Backwater: The Archaeology of CA-SOL-320/H and CA-SOL-425/H. Far Western Anthropological Research Group, Inc., Davis, California.

Rosenthal, Jeffrey, Eric Wohlgemuth, Kim Carpenter, and Paul Brandy

2011 Land Use and Subsistence in the West-Central Sierra Nevada during the Archaic and Recent Prehistoric Periods. In *A New Frame of Reference: Prehistoric Cultural Chronology and Ecology in the North-Central Sierra Nevada,* edited by J. Rosenthal, pp. 117–158. Center for Archaeological Research at Davis 16. Davis, California.

Rossa, Steven J., and David G. Brittin

1992 Osteological Report on Native American Skeletal Remains from CA-MRN-3 Recovered During Monitoring. Basin Research Associates, Inc. NWIC report no. S-015390.

Rudo, M. O.

- 1982 *The Prehistory of San Francisco;* A thesis submitted to the faculty of San Francisco State University in partial fulfillment of the requirements for the degree.
- Rudolf, J. L.
 - 1985 Changing Shellfish Exploitation in San Luis Obispo County, California. *Journal of California and Great Basin Anthropology* 7(1):126–132.

Russell, Emily W. B.

1983 Pollen Analysis of Past Vegetation at Point Reyes National Seashore, California. *Madroño* 30(1):1–11.

Russell, Matthew A.

2011 Encounters at tamál-húye: An Archaeology of Intercultural Engagement in Sixteenth-Century Northern California. UC Berkeley

Salmon, M. H.

1993 Philosophy of Archaeology: Current Issues. Journal of Archaeological Research 1(4):323–343.

Salzman, Sally

1984 SMA-147: Archaeological Research in San Mateo County, California. Unpublished Master's thesis, Department of Anthropology, San Francisco State University, California.

Sample, L. L.

1950 Trade and Trails in Aboriginal California. University of California Survey Reports 8.

Samuelson, Ann E., and William Self

1995 Archaeological Testing Report, Site CA-SCL-12 Tasman Corridor Light Rail Project, Santa Clara County, California. William Self Associates, Oakland, California. Submitted to Woodward-Clyde Consultants, Oakland, California.

San Francisco Estuary Institute

2012 *Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process.* Selfpublished, available at www.sfei.org, accessed October 2015.

Schenck, W. E.

1926 The Emeryville Shellmound: Final Report. *University of California Publications in American Archaeology and Ethnology* 23(3):147–282.

Scher, Naomi, and Jack Meyer

2014 *Extended Phase I Investigation for Sub-Phase CP-01 of Candlestick Point Redevelopment Project, San Francisco, California.* Far Western Anthropological Research Group, Inc., Davis, California. Prepared for Randall Dean, San Francisco Planning Department, San Francisco, California.

Schermer, Shirley J., Eve A. Hargrave, Kristin M. Hedman, Robin M. Lillie

2015 Transforming the Dead. In *Transforming the Dead*, edited by Eve A. Hargrave, Shirley J. Schermer, Kristin M. Hedman, and Robin M. Lillie, pp. 1–14. University of Alabama Press, Tuscaloosa.

Schiffer, Michael B.

- 1986 Formation Processes of the Archaeological Record. University of New Mexico Press, Albuquerque.
- 1999 Behavioral Archaeology: Some Clarifications. *American Antiquity* 64:166–168.

Schlocker, Julius

1974 *Geology of the San Francisco North Quadrangle, California*. US Geological Survey Professional Paper 782. Washington, DC.

Schneider, Joan S., and Richard H. Osborne

1996 A Model for the Production of Stone Mortars and Bowls. *Pacific Coast Archaeological Society Quarterly* 32(4):27-40. Schneider, Tsim D.

- 2009 Shell Mounds of China Camp and Tomales Bay State Parks, Marin County. *Proceedings of the Society for California Archaeology* 21:63–68.
- 2010 *Placing Refuge: Shell Mounds and the Archaeology of Colonial Encounters in the San Francisco Bay Area, California.* Ph.D. dissertation, Department of Anthropology, University of California, Berkeley.
- 2015a Envisioning colonial landscapes using Mission registers, radiocarbon, and stable isotopes: an experimental approach from San Francisco Bay. *American Antiquity* 80:511–529.
- 2015b Placing Refuge and the Archaeology of Indigenous Hinterlands in Colonial California. *American Antiquity* 80:695–713.

Schneider, T. D., L. D. Hager, S. S. Schell, L. N. Schrader III, and J. Holson

2013 Final Report: Archaeological Data Recovery at CA-NAP-399. CA-NAP-406, CA-NAP-413, and CA-NAP-863 for the St. Helena Flood Protection Project, City of St. Helena, Napa County, California. Pacific Legacy, Inc., Berkeley. California.

Schulz, P. D.

- 1981 Osteoarchaeology and Subsistence Change in Prehistoric Central California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Davis.
- Schwaderer, R.
 - 1992 Archaeological Test Excavation at the Duncans Point Cave, CA-SON-348/H. In *Essays on the Prehistory of Maritime California*, edited by Terry L. Jones, pp. 55-71. Center for Archaeological Research at Davis Publication 10, University of California, Davis.
- Schweikhardt, P., B. L. Ingram, K. Lightfoot, and E. Luby
 - 2011 Geochemical methods for inferring seasonal occupation of an estuarine shellmound: a case study from San Francisco Bay. *Journal of Archaeological Science* 38:2301–2312.
- Schwitalla, Al W., and Christopher Powell
 - 2014 Archaeological Data Recovery at CA-MRN-67 Larkspur, Marin County, California. Holman & Associates, San Francisco, California. Submitted to Larkspur Land & Owner, LLC, Walnut Creek, California.
- Schwitalla, A. W., T. L. Jones, M. A. Pilloud, B. F. Codding, and R. S. Wiberg
 - 2014 Violence among Foragers: The Bioarchaeological Record from Central California. *Journal of Anthropological Archaeology* 33:66–83.
- Scott, Sara A., Carl M. Davis, and Jeffrey Flenniken
 - 1986 The Pahoehoe Site: Lanceolate Biface Cache in Central Oregon. *Journal of California and Great Basin Anthropology* 8(1):7–23.

Serena, J.

Analysis of Shellfish Remains. In Archaeological Investigations on the San Antonio Terrace,
 Vandenberg Air Force Base, California in Connection with M-X facilities Construction, pp. 9-99–9 130. Chambers Consultants and Planners, Stanton, California.

Shipley, William F.

1978 Native Languages of California. In *California*, edited by Robert F. Heizer, pp. 80–90.
 Handbook of North American Indians Vol. 8, William G. Sturtevant general editor.
 Smithsonian Institution, Washington, DC.

Shlemon, R. J., and E. L. Begg

1975 Late Quaternary Evolution of the Sacramento-San Joaquin Delta, California. In *Quaternary Studies*, edited by R. P. Suggate and M. M. Cresswell, pp. 259–265. The Royal Society of New Zealand Bulletin 13.

Silliman, Stephen W.

- 2004 *Lost Laborers in Colonial California: Native Americans and the Archaeology of Rancho Petaluma.* University of Arizona Press, Tucson.
- 2010 Indigenous traces in colonial spaces: Archaeologies of ambiguity, origin, and practice. Journal of Social Archaeology 10:28–58.

Simms, Steven R.

1987 *Behavioral Ecology and Hunter-Gatherer Foraging: An Example from the Great Basin.* International Series 381. British Archaeological Reports, Oxford.

Simons, Dwight D.

- 1981 Avian and Mammalian Remains from Prehistoric Sites in the Richmond Harbor Area. In Investigation of Cultural Resources within the Richmond Harbor Redevelopment Project 11-A, Richmond, Contra Costs, California, edited by Peter M. Banks and Robert I. Orlins, pp 12.1-12.73. Prepared for the City of Richmond.
- 1992 Prehistoric Mammal Exploitation in the San Francisco Bay Area. In *Essays on the Prehistory of Maritime California,* edited by Terry L. Jones, pp. 73–104. Center for Archaeological Research at Davis Publication 10. University of California, Davis.
- 2004 Vertebrate Faunal Remains. In *Santa Clara Valley Prehistory: Archaeological Investigations at CA-SCL-690, the Tamien Station Site, San Jose, California,* edited by Mark G. Hylkema. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 2008 Appendix E: Faunal and Floral Remains. In San Francisco-Oakland Bay Bridge East Span Seismic Safety Project – Archaeological Analysis of CA-SFR-4/H, Yerba Buena Island, San Francisco and Alameda Counties, California, by Sally Morgan and Sean Dexter. URS Corporation, Oakland, California. Edited and Produced by Patricia Mikkelsen, Brian F. Byrd, Jeffrey Rosenthal, and Sharon A. Waechter, Far Western Anthropological Research Group, Inc., Davis, California. Submitted by Parson Brinkerhoff, San Francisco, California. Submitted to California Department of Transportation, District 4, Toll Bridge Program, Oakland, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.

Simons, Dwight D., and Tim Carpenter

2007 Vertebrate Remains. In *Final Report on Archaeological Investigations at CA-MRN-44/H Angel Island State Park, Marin County, California,* edited by Alex DeGregory, pp. 137–175. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California. Simons, Dwight D., Kenneth Gobalet, and Cynthia Desgrandchamp

2000 Subsistence. In *Data Recovery Excavations for the Wildcat and San Pablo Creeks Flood Control and Water Resources Project at CA-CCO-169, -270, -600, and -601, Contra Costa County, California,* edited by John Holson, Vol. 1, pp.251-449. Prepared for US Army Engineering District, Sacramento Corps of Engineers.

Simons, Dwight D., Kenneth Gobalet, J. Gaeta, R. Hasting, K. Hardin, and V. Popper

2008 Appendix E: Faunal and Floral Remains. In *Archaeological Analysis of CA-SFR-4/H, Yerba Buena Island*, edited by S. Morgan and S. Dexter. URS Corporation, Oakland, California. Submitted to California Department of Transportation, District 4, Oakland, California.

Simons, Dwight D., Kenneth Gobalet, Terry Joslin, Jeremy Foin, Grace Cesario, and Susan Lagle

2014 Vertebrate Faunal Remains In *Archaeological Data Recovery at CA-MRN-67*, edited by Al W. Scwitalla and Christopher Powell. On file with the Northwest Information Center, Rohnert Park, California.

Simoons, Frederick J.

1994 *Eat Not This Flesh: Food Avoidances from Prehistoric to the Present.* University of Wisconsin Press, Madison.

Simpson, G. D., Thompson, S. C., Noller, J. S., & Lettis, W. R.

1997 The northern San Gregorio fault zone: Evidence for the timing of late Holocene earthquakes near Seal Cove, California. *Bulletin of the Seismological Society of America* 87(5):1158–1170.

Sinats, Kevin

- 2007 *Conservation vs Intensification: 1000 years of mussel at a Bay Area Shellmound*. Senior Honor Thesis, Anthropology Department, University of California, Berkeley.
- Singh, G. G., and I. McKechnie
 - 2015 Making the Most of Fragments: A Method for Estimating Shell Length from Fragmentary Mussels (*Mytilus californianus* and *Mytilus trossulus*) on the Pacific Coast of North America. *Journal of Archaeological Science* 58:175–183.

Skinner, J. E.

1962 *An historical review of the fish and wildlife resources of the San Francisco bay Area.* California Fish and Game, Water Project Branch Report No. 1. 226 pp.

Skowronek, Russell K.

1998 *Radiocarbon Dates and Shell Artifact Analysis for Prehistoric Cemetery Site CA-SCL-755.* BETA Analytic, Inc. Manuscript on file, Santa Clara University, Department of Anthropology, Santa Clara, California.

Skowronek, Russell K., and Margaret A. Graham, eds.

2004 Discovering Santa Clara University's Prehistoric Past: CA-SCI-755. Santa Clara University, California.

Slaymaker, Charles Monroe

- 1972 *Cry for Olompali*—*An Initial Report on the Archaeological and Historical Features of Olompali*. Report on file, Northwest Information Center, Sonoma State University, California.
- 1974 *Fidemo, the Twilight and Before: A Study of Coast Miwok Political Organization,* Anthropology Department, San Francisco State University, San Francisco.
- 1982 *A Model for the Study of Coast Miwok Ethnogeography.* Ph.D. dissertation, Anthropology Department, University of California, Davis.

Smith, Kathleen Rose

2014 *Enough for All: Foods of My Dry Creek Pomo and Bodega Miwuk People*. Heyday Books, Berkeley, California.

Smith, Erin M., and Mikael Fauvelle

2015 Regional Interactions between California and the Southwest: The Western Edge of the North American Continental System. *American Anthropologist* 117:710–721.

Smol, John P., and Eugene F. Stoermer

2010 The Diatoms. In *Applications for the Environmental and Earth Sciences*. 2nd edition. Cambridge University Press.

Snoke, J. M.

1967 The Archaeology of Solano 11: A Middle Horizon Site in Green Valley, California.Unpublished Master's thesis, Department of Anthropology, University of California, Davis.

Snyder, L. M.

Barking Mutton: Ethnohistoric, Ethnographic, Archaeological, and Nutritional Evidence Pertaining to the Dog as a Native American Food Resource on the Plains. In *Beamers, Bobwhites, and Blue-Points: Tributes to the Career of Paul W. Parmalee,* edited by J. R. Purdue, W. E. Klippel, and B. W. Styles, pp. 359–378. Illinois State Museum, Springfield, Illinois and Department of Anthropology, University of Tennessee, Knoxville.

Spennemann, D. H. R.

- 1987 Availability of Shellfish Resources on Prehistoric Tongatapu, Tonga: Effects of Human Predation and Changing Environment. *Archaeology in Oceania* 22(3):81–96.
- Stanley, Daniel Jean, and Andrew G. Warne
 - 1994 Worldwide Initiation of Holocene Marine Deltas by Deceleration of Sea-Level Rise. *Science* 265:228–229.
- Steele, T. E., and R. G. Klein
 - 2006 Mollusk and Tortoise Size as Proxies for Stone Age Population Density in South Africa. *Munibe Antropologia-Arkeologia* 57(1):221–237.

Stein, J. K., J. N. Deo, and L. S. Phillips

2003 Big sites - Short time: Accumulation rates in archaeological sites. *Journal of Archaeological Science*, 30(3):297–316.

Stevens, Nathan E.

- 2005 Changes in Prehistoric Land Use in the Alpine Sierra Nevada: A Regional Exploration Using Temperature-Adjusted Obsidian Hydration Rates. *Journal of California and Great Basin Anthropology* 25(2):187–206.
- 2012 Appendix C. Explanation of Revised Casa Diablo Obsidian Hydration Rate. In *Prehistoric Land Use and Settlement Systems in Yosemite National Park: A View from Crane Flat,* edited by Jeffery S. Rosenthal, pp. C1-C10. Far Western Anthropological Research Group, Inc., Davis, California. Prepared for US Department of the Interior, National Park Service.

Stevens, Nathan E., and Richard McElreath

- 2015 When are Two Tools Better than One? Mortars, Millingslabs, and the California Acorn Economy. *Journal of Anthropological Archaeology* 37:100–111.
- Stevens, Nathan E., Jelmer W. Eerkens, Richard Fitzgerald, Jeffrey S. Rosenthal, Joanne E. Goodsell, and Jamie Dotey
 - 2009 Workaday Windmiller: Another Look at Early Horizon Lifeways in Central California. *Proceedings of the Society for California Archaeology* 23.

Stevenson, Christopher M., James J. Mazer, and Barry E. Scheetz

1998 Laboratory Obsidian Hydration Rates: Theory, Method, and Application. In *Archaeological Obsidian Studies: Method and Theory*, edited by M. Steven Shackley, pp. 181–204. Plenum Press, New York.

Steward, Julian

- 1936 The Economic and Social Basis of Primitive Bands. In *Essays in Anthropology Presented to A. L. Kroeber*, edited by R. H. Lowie, pp. 331–350. University of California Press, Berkeley.
- 1938 *Basin-Plateau Aboriginal Sociopolitical Groups*. Bureau of American Ethnology Bulletin 120. Washington, DC.

Stewart, Omer C.

1943 Notes on Pomo Ethnogeography. *University of California Publications in American Archaeology and Ethnology* 40(2):29–62.

Stewart, Suzanne, B.

 Archaeological Test Excavations at CA-MRN-644/H, San Rafael, Marin County, California. Hetherton Park and Ride Replacement Parking Project, Highway 101 KP 18.1 (PM 11.2).
 Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Submitted to California Department of Transportation, District 4, Oakland, California.

Stewart, Suzanne, Jack Meyer, and Mike Newland

2002 Phase One Investigations for the Fort Baker Archaeological Survey, Golden Gate National Recreation Area, Marin County, California. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Prepared for Golden Gate National Recreation Area, National Park Service, San Francisco, California. On file, Golden Gate National Recreation Area, National Park Service, San Francisco, California. Stine, S.

- 1990 Late Holocene Fluctuations of Mono Lake, Eastern California. *Palaeogeography, Palaeoclimatology, Palaeoecology* 78:333–381.
- 1994 Extreme and Persistent Drought in California and Patagonis during Mediaeval Times. *Nature* 369:546–49.
- 1998 A Medieval Climatic Anomaly in the Americas," in *Water, environment, and society in times of climatic change.* Edited by A. Issar and N. Brown. Dordrecht and Boston: Kluwer Academic.
- Stiner, M. C., N. D. Munro, and T. A. Surovell
 - 2000 The Tortoise and the Hare: Small Game Uses, the Broad Spectrum Revolution, and Paleolithic Demography. *Current Anthropology* 41:39–73.

Stoffle, Richard W., David B. Halmo, Michael J. Evans, and John E. Olmsted

- 1990 Calculating the Cultural Significance of American Indian Plants: Paiute and Shoshone Ethnobotany at Yucca Mountain, Nevada. *American Anthropologist* 92(2):416–432.
- Story, James A., Vincent E. Wessels, and John A. Wolfe
 - 1966 Radiocarbon Dating of Recent Sediments in San Francisco Bay. *Mineral Information Service* (now *California Geology*) 19:47–50.
- Stradford, Richard A., and Rae Schwaderer
 - 1982 Remembrance of Things Bypassed: Archaeological Investigations at CA-NAP-15/H, Napa County, California. Anthropological Studies Center, Sonoma State University, Rohnert Park, California. Submitted to California Department of Transportation, District 4, San Francisco, California.
- Stuiver, M., and P. J. Reimer
 - 1993 Extended 14C Data Base and Revised CALIB 3.0 14C Age Calibration Program. *Radiocarbon* 35:215–230.
- Stuiver, M., Reimer, P. J., and Reimer, R. W.
 - 2014 CALIB 7.4. [WWW program and documentation].
- Stuiver, Minze, Paula J. Reimer, E. Bard, J. W. Beck, G. S. Burr, K. A. Hughen, B. Kromer, G. McCormac, J. van der Plicht, and M. Spurk
 - 1998 IntCal98 Radiocarbon Age Calibration. *Radiocarbon* 40(3):1041–1083.
- Sullivan, M. E.
 - 1987 The Recent Prehistoric Exploitation of Edible Mussel in Aboriginal Shell Middens in Southern New South Wales. *Archaeology in Oceania* 22(1):97–106.
- Surovell, Todd A., and P. Jeffrey Brantingham
 - 2007 A Note on the Use of Temporal Frequency Distributions in Studies of Prehistoric Demography. *Journal of Archaeological Science* 34:1868–1877.

Surovell, Todd A., Judson Byrd Finley, Geoffrey M. Smith, P. Jeffrey Brantingham, and Robert Kelly

- 2009 Correcting Temporal Frequency Distributions for Taphonomic Bias. *Journal of Archaeological Science* 36:1715–1724.
- Swadling, P.
 - 1976 Changes Induced by Exploitation in Prehistoric Shellfish Populations. *Mankind* 10(3):156–162.
 - 1977 The Implications of Shellfish Exploitation for New Zealand Prehistory. *Mankind* 11:11–18.

Swetnam, T. W., and C. H. Baisan

2003 Tree-ring reconstructions of fire and climate history in the Sierra Nevada and southwestern United States. In *Fire and climatic change in temperate ecosystems of the western Americas,* pp. 158–195. Springer, New York.

Talaley, L., and D. R. Keller

- 1984 Hickory Nuts, Walnuts, Butternuts, and Hazelnuts: Observations and Experiments Relevant to their Aboriginal Exploitation in Eastern North America. In *Experiments and observations on aboriginal wild food utilization in eastern North America*. Edited by P. J. Munson, Indiana Historical Society Prehistory Research Series VI(2)Z:338-359.
- Tannam, Melody E., Michael R. Fong, Sondra A. Jarvis, Colin I. Busby, James C. Bard, Donna M. Garaventa, Steven J. Rossa, Robert M. Harmon, and Angela M. Banet
 - 1991 Analysis of Native American Skeletal Remains Recovered During Emergency Disinterment at CA-SCL-128, the Holiday Inn Site, City of San Jose, Santa Clara County, California. Basin Research Associates, Inc. On file, Northwest Information Center, report S-012535.

Taylor, Alexander Smith

1860 The Indianology of California. *California Farmer and Journal of Useful Sciences* 13–20.

Teixeira, Lauren

1997 *The Costanoan/Ohlone Indians of the San Francisco and Monterey Bay Area, A Research Guide.* Ballena Press Publication, Menlo Park, California.

Telford, R. J., E. Heegaard, and H. J. B. Birks

2004 The Intercept is a Poor Estimate of a Calibrated Radiocarbon Age. *The Holocene* 14(2):296–298.

Testart, A.

1982 The Significance of Food Storage Among Hunter-Gatherers: Residence Patterns, Population Densities, and Social Inequalities. *Current Anthropology* 23:523-538.

Thomas, David H.

- 1969 Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. *American Antiquity* 34:392–401.
- 1981 How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3(1):7-43.

Thompson, Richard E., Jr.

2002 Emergency Burial Excavation at Central Chevrolet, 4949 Thornton Avenue, City of Fremont, Alameda County, California. Archaeor Archaeological Consultants, Fremont. California. Submitted to Richard Brunelli, President, Central Chevrolet, 4949 Thornton Avenue, Fremont, California 94536. On file, Northwest Information Center, report S-025636.

Thompson, Richard E., Christopher Canzonieri, Phillip Reid, and Andrew A. Galvan

2003 *Emergency Burial Recovery at CA-CCO-538, Big Break Regional Shoreline, East Bay Regional Park District, City of Oakley, Contra Costa County, California.* Archaeor Archaeological Consultants, Fremont. Prepared for East Bay Regional Park District, Oakland. S-026856.

Thoms, Alston V.

2008 The fire stones carry: ethnographic records and archaeological expectations for hot-rock cookery in western North America. *Journal of Anthropological Archaeology* 27(4):443-460.

Thoms, Alston V., A. R. Laurence, L. Short and M. Kamiya

2015 Baking geophytes and tracking microfossils: taphonomic implications for earth-oven and paleodietary research. *Journal of Archaeological Method and Theory* 22(4):1038-1070.

Tiley, Shelly

- 2001 *Extended Phase I Assessment of Prehistoric Archaeological Site, CA-ALA-586, for the Highway 238 Widening Project.* Archaeological Research Center, California State University, Sacramento. Submitted to California Department of Transportation, District 4, Oakland, California.
- Treasher, Ray C.
 - 1963 Geology of the Sedimentary Deposits in San Francisco Bay, California. In *Short Contributions* of *California Geology*, pp. 11–24. Special Report 82. California Division of Mines and Geology, San Francisco, California.

Treganza, Adan E.

- 1957 *The Examination of Indian Shellmounds within San Francisco Bay with Reference to the Possible* 1579 *Landfall of Sir Francis Drake.* Manuscript S-12,945 on file Northwest Information Center, Sonoma State University.
- 1958 The Examination of Indian Shellmounds within San Francisco Bay with Reference to the Possible 1579 Landfall of Sir Francis Drake, Second Season. NWIC report no. S-13069. On file, Northwest Information Center.
- 1966 *Archaeological Observations at Angel Island State Park*. NWIC report no. S-12943. On file, Northwest Information Center.

Treganza, A. E., and S. F. Cook

1948 The Quantitative Investigation of Aboriginal Sites: Complete Excavation with Physical and Archaeological Analysis of a Single Mound. *American Antiquity* 13(4):287–297.

Tremaine, Kim J.

1993 Temporal Ordering of Artifact Obsidians: Relative Dating Enhanced Through the Use of Accelerated Hydration Experiments. In *There Grows a Green Tree*, edited by Pat Mikkelsen Greg White, William R. Hildebrandt, and Mark E. Basgall, pp. 265–275. Center for Archaeological Research at Davis Publication 11. University of California, Davis.

Tuohy, D. R.

1970 Notes on a Collection of Californian Shell Beads from the Humboldt Sink, Nevada. *Nevada Archeological Survey Reporter* 4(1):4–9.

Turner, N. J.

1988 The Importance of a Rose: Evaluating the Cultural Significance of Plants in Thompson and Lillooet Interior Salish. *American Anthropologist* 272–290.

Ubelacker, Douglas H.

2006 Skeletal Biology and Population Size: Introduction. In *Handbook of North American Indians, Volume 3: Environment, Origins, and Population,* edited by D. H. Ubelaker and W. C. Sturtevant. Smithsonian Institute, Washington, DC.

Ugan, Andrew, J. Bright, and A. Rogers

2003 When is Technology worth the Trouble? *Journal of Archaeological Science* 30:1315-1329.

Uhle, M

- 1907 The Emeryville Shellmound. *University of California Publications in American Archaeology and Ethnology* 7(1):1–107.
- Valeggia, C. R., and P. T. Ellison
 - 2003 Impact of Breastfeeding on Anthropometric Changes in Peri-Urban Toba Women (Argentina). *American Journal of Human Biology* 15(5):717–724.
- Van Bueren, Thad M., and Michael W. Love
 - 2008 *Archaeological Investigations at CA-SFR-17/H in San Francisco, California.* California Department of Transportation, District 4.

Van Bueren, Thad M., and Randy S. Wiberg

- 2011 Putting Central California Charmstones in Context: A View from CA-CCO-548. *California Archaeology* 3(2):199–248.
- Van Dyke, S.
 - 1971 The archaeology of 4-SMa-100. *Treganza Anthropology Museum Papers* 8:21–36, edited by M. J. Moratto. San Francisco State College, San Francisco, California.
- Van Ginkel, R.
 - 1990 Farming the Edge of the Sea: The Sustainable Development of Dutch Mussel Factory. *MAST* 3(2):49–67.

Velásquez de la Cadena, Mariano

1974 New Revised Velásquez Spanish and English Dictionary. Follett Publishing Company, Chicago.

Veldhuizen, H. D. V.

1981 Analysis of molluscan remains from CA-CCO-297 and CACCO-298. In *Investigation of the Cultural Resources Within the Richmond Harbor Redevelopment Project 11-A, Richmond, Contra Costa County, California* edited by P. M. Banks and R. I. Orlins, pp. 15.1–15.58. Manuscript on File, City of Richmond, California.

Vellanoweth, Rene L.

2001 AMS Radiocarbon Dating and Shell Bead Chronologies: Middle Holocene Trade and Interaction in Western North America. *Journal of Archaeological Science* 28:941–950.

Vellanoweth, R. L., B. G. Bartelle, A. F. Ainis, A. C. Cannon, and S. J. Schwartz

2008 A double dog burial from San Nicolas Island, California, USA: osteology, context, and significance. *Journal of Archaeological Science* 35(12):3111–3123.

Vellanoweth, Rene L., Amira F. Ainis, Jon Erlandson, and L. D. Thomas-Barnett

2014 An Olivella Grooved Rectangle Bead Cluster from San Nicolas Island, California. Journal of California and Great Basin Anthropology 34(2):229–246.

Villagran, Ximena S.

2014 A redefinition of waste: Deconstructing shell and fish mound formation among coastal groups of southern Brazil. *Journal of Anthropological Archaeology* 36:211–227.

Villagran, X. S., Balbo, A. L., Madella, M., Vila, A., Estevez, J.

2011 Stratigraphic and spatial variability in shell middens: microfacies identification at the ethnohistoric site Tunel VII (Tierra del Fuego, Argentina). *Archaeological and Anthropological Sciences* 3:357–378.

Von der Porten, Peter, and Alex Degeorgey

2015 Historical Insights Into Abandonment Of A San Francisco Bay Area Shell Mound (CA-CCO-297). *Proceeding of the Society of California Archaeology* 29:99-114.

Von der Porten, Peter, Katherine Dixon, and Alex DeGeorgey

2014 Seriation of Clam Shell Disk Beads in Central California. *Proceedings of the Society for California Archaeology* 28:267–281.

Voss, Barbara L.

- 2003 Culture contact and colonial practices: archaeological traces of daily life in early San Francisco. Boletín: *The Journal of the California Mission Studies Association* 20(1):63–77.
- 2005 From Casta to Californio: social identity and the archaeology of culture contact. *American Anthropologist* 107(3):461–474.
- 2008 *The Archaeology of Ethnogenesis: Race and Sexuality in Colonial San Francisco.* University of California Press, Berkeley.

Waechter, Sharon A.

1993 Report on the First Phase of Archaeological Survey for the Proposed SMUD Gas Pipeline between Winters and Sacramento Yolo and Sacramento Counties, California. Far Western Anthropological Research Group, Inc., Davis, California. Waechter, Sharon A. continued

2013 *Excavations at CA-SCL-628 on Matadero Creek, Palo Alto, California*. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Pacific Gas and Electric, San Ramon, California.

Waechter, Sharon A., and John E. Berg

- 2015 *Emergency Data Recovery Excavation at Site CA-MRN-12 in Mill Valley, Marin County, California.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Pacific Gas & Electric Company, San Francisco, California.
- Waechter, Sharon A., Kenneth R. Bethard, Amy Gilreath, Tammara Ekness-Hoyle, J. P. Mundwiller, K. Taite, and Eric Wohlegmuth
 - 1992 *Report on the 1992 Test Excavations at CA-CCO-474/H near Hercules; Contra Costa County, California.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Woodward-Clyde Consultants, Oakland, California.

Wake, Thomas A.

- 2012 Mammal Remains from the Emeryville Shellmound (CA-ALA-309) and CA-ALA-310. Cotsen Institute of Archaeology, University of California, Los Angeles. Prepared for URS Corporation.
- Walker, William H.
 - 1995 Ceremonial Trash? In *Expanding Archaeology*, edited by James M. Skibo, W. H. Walker, A. E. Nielsen, pp. 67–79. University of Utah Press, Salt Lake City.
- Walker, M. J. C., M. Berkelhammer, S. Bjorck, L. C. Cwynar, D. A. Fisher, A. J. Long, J. J. Lowe, R. M. Newnham, S. O. Rasmussen, and H. Weiss
 - 2012 Formal Subdivision of the Holocene Series/Epoch: a Discussion Paper by a Working Group of INTIMATE (Integration of ice-core, marine and terrestrial records) and the Subcommission on Quaternary Stratigraphy (International Commission on Stratigraphy). *Journal of Quaternary Science* 27(7):649–659.

Walker, P. L.

- 1989 Cranial injuries as evidence of violence in prehistoric southern California. *American Journal of Physical Anthropology* 80:313–323.
- 2000 Bioarchaeological Ethics: A Historical Perspective on the value of Human Remains. In Biological Anthropology of the Human Skeleton, edited by M. A. Katzenberg and S. R. Saunders, p. 3–39. Willey-Liss, New York.

Wallace, William J.

1978 Northern Valley Yokuts. In *California*, edited by Robert F. Heizer, pp. 462–470. Handbook of North American Indians Vol. 8, William C. Sturtevant, general editor. Smithsonian Institution, Washington, DC.

Wallace, William J., and D. W. Lathrap

1975 West Berkeley (CA-ALA-307): A Culturally Stratified Shellmound on the East Shore of San Francisco Bay. Contributions of the University of California Archaeological Research Facility 29. University of California Press, Berkeley.

Waters, Michael R.

1992 Principles of Geoarchaeology: A North American Perspective. University of Arizona Press, Tucson.

Watson, Patty Jo

1990 Ozymandias, Kings of Kings: Postprocessual Radical Archaeology as Critique. *American Antiquity* 55:673–689.

Weiss, E.

2007 Muscle markers revisited: activity pattern reconstruction with controls in a central California Amerind population. *American Journal of Physical Anthropology* 133(3):931–940.

Wells, Lisa E., and Michelle Goman

 Late Holocene Environmental Variability in the Upper San Francisco Estuary as Reconstructed from Tidal Marsh Sediments. In *Proceedings of the Eleventh Annual Pacific Climate (PACLIM) Workshop—April 19–22, 1994,* pp. 185–198. Interagency Ecological Program, Technical Report 40. California Department of Water Resources, Sacramento.

West, G. James

- 1977 *Late Holocene Vegetation History of the Sacramento San Joaquin Delta, California.* Cultural Heritage Section, Department of Parks and Recreation. California Department of Water Resources.
- 1989 Early Historic Vegetation Change in Alta California: The Fossil Evidence. In *Columbian Consequences, Volume 1: Archaeological and Historical Perspectives on the Spanish Borderlands West*, edited by David Hurst Thomas, pp. 333–348. Smithsonian Institution, Washington, DC.
- 1993 The Late Pleistocene-Holocene Pollen Record and Prehistory of California's North Coast Ranges. In *There Grows a Green Tree: Papers in Honor of David A. Fredrickson,* edited by G. White, P. Mikkelsen, W. R. Hildebrandt, and M. E. Basgall, pp. 219–236. Center for Archaeological Research at Davis Publication 11. University of California, Davis.
- 2000 Pleistocene-Holocene Transition and Holocene. In *The Redwood Forest, History, Ecology, and Conservation of the Coast Redwoods,* edited by R. F. Noss, pp. 7–38. Save-the-Redwoods League. Island Press, Covelo.
- 2001 Pollen Analysis of Late Pleistocene-Holocene Sediments from Core Cl-73-5, Clear Lake, Lake County, California: A Terrestrial Record of California's Cismountane Vegetation and Climate Change Inclusive of the Younger Dryas Event. In *Proceedings of the Seventeenth Annual Pacific Climate (PACLIM) Workshop*, edited by G. J. West and L. D. Buffaloe, pp. 91–109. May 22–25, 2000. Interagency Ecological Program, Technical Report 67. California Department of Water Resources.
- 2002 Pollen Analysis of Two Late Pleistocene-Holocene Cores from Clear Lake. In *Cultural Diversity and Cultural Change in Prehistoric Clear Lake Basin: Final Report of the Anderson Flat Project*, by G. G. White, D. A. Fredrickson, L. D. Hager, J. Meyer, J. S. Rosenthal, M. R. Waters, G. J. West, E. Wohlgemuth, pp. 99–113. Center for Archaeological Research at Davis Publication 13. University of California, Davis.

Whalen, M. E.

1983 Reconstructing Early Formative Village Organization in Oaxaca, Mexico. *American Antiquity* 17–43.

Whelan, James P.

- 1967 Partial Faunal Analysis of ALA-12 and 13, Two San Francisco Bay Shellmounds. In Contributions to the Archaeology of Southern San Francisco Bay. Department of Anthropology, San Francisco State College, Occasional Papers in Anthropology No.3. On File at the Northwest Information Center, S-9131.
- 1969 *The Comparative Analysis of the Mammal Remains from Three Prehistoric Indian Sites in Alameda County, California.* A thesis submitted to the faculty of San Francisco State College in partial fulfillment of the requirements for the degree. NWIC: S-016679.

Whitaker, Adrian R.

- 2008a *The Role of Human Predation in the Structuring of Prehistoric Prey Populations in Northwestern California.* Ph.D. dissertation, Department of Anthropology, University of California, Davis.
- 2008b Incipient Aquaculture in Prehistoric California?: Long Term Sustainability vs. Immediate Returns for the Harvest of Marine Invertebrates. *Journal of Archaeological Science* 35(4):1114– 1123.
- Whitaker, Adrian R., and Brian Byrd
 - 2012 Boat-Based Foraging and Discontinuous Prehistoric Red Abalone Exploitation along the California Coast. *Journal of Anthropological Archaeology* 31(2):196–214.
 - 2014 Social Circumscription, Territoriality, and the Late Holocene Intensification of Small-Bodied Shellfish along the California Coast. *Journal of Island & Coastal Archaeology* 9:150–168.
- Whitaker, Adrian R., and Kimberley Carpenter
 - 2010 *Data Recovery Excavations at CA-SOL-451, Vacaville, Solano County, California.* Submitted to the City of Vacaville, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Whitaker, Adrian R., and William R. Hildebrandt
 - 2011 Why Were Northern Fur Seals Spared in Northern California?: A Cultural and Archaeological Explanation. In *The Archaeology and Historical Ecology of Seals, Sea Lions, and Sea Otters of the North Pacific,* edited by Torben Rick and Todd Braje, pp. 197–219. University of California Press, Berkeley.
- Whitaker, Adrian, and Jeffrey S. Rosenthal
 - 2010 9,000 Years of Prehistory at the Poppy Hills Site: Data Recovery Excavations at CA-TUO-2797/H for the Poppy Hills Curve Realignment Project, Tuolumne County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Caltrans District 10, Stockton, California. On file, Central California Information Center, Stanislaus State University, Turlock.

Whitaker, Adrian R., and Nathan Stevens

- 2012 Data Recovery Excavations at CA-SOL-61 for the Suisun Valley Road, Bridge 23C-077 Replacement Project, Solano County, California. Far Western Anthropological Research Group, Inc., Davis, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Whitaker, Adrian R., John Berg, and Kimberley Carpenter
 - 2009 *Phase II Evaluation of the Ulatis Creek Site (P-48-000816) Vacaville, Solano County, California.* Far Western Anthropological Research Group, Inc., Davis, California. Submitted to the City of Vacaville, California. On file, Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Whitaker, Adrian R., Jelmer E. Eerkens, Amy M. Spurling, Eddie D. Smith, and Michelle A. Degras
 - 2008 Linguistic Boundaries as Barriers to Exchange in Northwestern California. *Journal of Archaeological Science* 35(4):1104–1113.

White, Gregory

- 1989 A Report of Archaeological Investigations at Eleven Native American Coastal Sites, MacKerricher State Park, Mendocino County, California. On file at California Archaeological Inventory, Northwest Information Center, Sonoma State University, Rohnert Park.
- 2002 *Cultural Diversity and Culture Change in Prehistoric Clear Lake Basin: Final Report of the Anderson Flat Project.* Center for Anthropological Research at Davis Publication 13. University of California, Davis.
- 2003 Population Ecology of the Prehistoric Colusa Reach. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Davis.

White, Greg, and R. King

Rethinking the Mostin Site. In *There Grows a Green Tree: Essays in Honor of David A. Fredrickson,* Greg White, Pat Mikkelsen, William R. Hildebrandt, and Mark E. Basgall, pp.
 121-140. Center for Archaeological Research at Davis Publication 10, University of California, Davis.

White, Greg, and Denise Thomas

- 1999 Phase 1.5 Prehistoric Archaeology Results, Routh 87 Guadalupe Corridor Freeway Project, San Jose, Santa Clara County, California. California State University, Chico. Prepared for California Department of Transportation, District 4.
- White, Gregory G., David A. Fredrickson, Lori D. Hager, Jack Meyer, Jeffrey S. Rosenthal, M. R. Waters, G. James West, and Eric Wohlgemuth
 - 2002 *Cultural Diversity and Culture Change in Prehistoric Clear Lake Basin: Final Report of the Anderson Flat Project.* Center for Archaeological Research at Davis 13.

Wiberg, R. S.

0,	
1986	<i>Summary of Subsurface Auger Testing of the Group Picnic Area/Twin Pines Park, Belmont, California.</i> Holman and Associates. Prepared for Parks and Leisure Department. On File at the Northwest Information Center, S-8039.
1988	The Santa Rita Village Mortuary Complex (CA-ALA-413): Evidence and Implications of a Meganos Intrusion. Vol. 18, Archives of California Prehistory. Coyote Press, Salinas, California.
1992	Archaeological Data Recovery at Sites CA-SOL-69, and CA-SOL-315, Green Valley, Solano County, California. Holman and Associates, San Francisco, California. Submitted to Duffel Financial and Construction Company, Concord, California.
1993	<i>Archaeological Data Recovery at Prehistoric Site CA-SOL-355/H, Green Valley, Solano County, California</i> . Holman and Associates, San Francisco, California. Submitted to Citation Northern Inc., Martinez, California.
1996	Archaeological Excavations and Burial Removal at Sites CA-ALA-483, CA-ALA-483Extension, and CA-ALA-555, Pleasanton, Alameda County, California.
1997	Archaeological Investigations at Site CA-ALA-42, Alameda County, California. Holman and Associates, San Francisco, California.
1999	Cultural Resources Evaluation and Impact Mitigation Program for the Wetern Drive Pipeline Replacement Project near Point Molate, Contra Costa County, California. Homan and Associates, San Francisco, California. Submitted to East Bay Municipal Utility District, Oakland, California.
2002	Archaeological Investigations: Skyport Plaza Phase I (CA-SCL-478), San Jose, Santa Clara County, California.

- 2010 *Archaeological Investigations at CA-CCO-18/548: Final Report for the Vineyards at Marsh Creek Project, Contra Costa County, California.* Holman & Associates, San Francisco, California. Submitted to Shea Homes, Brentwood, California.
- 2012 Final Archaeological Data Recovery Report, Limited Archaeological Investigations at CA-SMA-78, Crystal Springs Pipeline No. 2 Replacement Project Site 9, Town of Hillsborough, (EP Case No.
 2005.0963/ACOE File No. 08-00423S). On File at the Northwest Information Center, S-038900.

Wiberg, Randy and David Bieling

2002 Archaeological Data Recovery and Construction Monitoring: Green Valley Lake Park (CA-SOL-69), Fairfield, Solano County, California. Holman & Associates, San Francisco, California. Submitted to California Federal Bank, San Francisco, California.

Wiberg, Randy S., and Matthew R. Clark

- 2000 Evaluation and Impact Mitigation at CA-CCO-124, on the Circle E Ranch Project Area, in the City of San Ramon, Contra Costa County, California. NWIC report no. S-022498
- 2004 Report of Phase II Section 106 Evaluative Test Excavations at CA-CCO-548, Vineyards at Marsh Creek Project Area, Brentwood, Contra Costa County, California. Holman & Associates Archaeological Consultants, San Francisco, California. Submitted to RBF Consulting, Walnut Creek, California.

Wiberg, Randy S., and Matthew R. Clark continued

2007 Report of Phase II Section 106 Evaluative Test Excavations at CA-CCO-128, CA-CCO-129/138 and CA-CCO-767, East Cypress Corridor Specific Plan Area.

Wiberg, Randy S., and Ellen Moore

1998 *Results of Archaeological Monitoring and Burial Removal at the Buchanan Project Area (Site CA-SCL-806) in Los Altos Hills, Santa Clara County, California.* Homan & Associates, San Francisco, California. Submitted to Susan Buchanan, Los Altos Hills, California.

Wiberg, Randy S., Alisa Reynolds, and Ellen Moore

1998 Archaeological Monitoring and Burial Removal at Green Valley Lake Units Nos. 2 and 3 (Sites CA-SOL-69 and CA-SOL-315), Fairfield, Solano County, California. Holman & Associates, San Francisco, California. Submitted to California Federal Bank, San Francisco, California.

Wildesen, Leslie E.

1968 Report of Preliminary Investigations at ALA-343, Fremont. NWIC report no. S-009405.

Wilk, Richard R., and Robert M. Netting

1984 Households: Changing Form and Function. In *Household*, edited by Robert M. Netting, Richard R. Wilk, and Eric J. Arnould. University of California Press, Berkeley.

Willoughby, N. C.

1963 Division of Labor among the Indians of California: Face and Body Painting Practices among California Indians [by] Janet Sherwin. Aboriginal California Burial and Cremation Practices [by] Richard A. Gould. University of California Archaeological Research Facility, Department of Anthropology, Berkeley.

Wilson, D. J.

1988 Prehispanic Settlement Patterns in the Lower Santa Valley, Peru: A Regional Perspective on the Origins and Development of Complex North Coast Society. Smithsonian Institute Press, Washington, DC.

Wilson, G. B.

- 1993 *The Archaeological Collection from CA-ALA-329, the Ryan Mound, Alameda County, California.* Coyote Press Archives of California Prehistory 39.
- 1999 *The Coyote Hills Area, Alameda County, California: A Settlement Pattern and Artifact Distribution Study.* Coyote Press Archives of California Prehistory 46.
- 2004 Obsidian Hydration Values; A Listing of the Obsidian Hydration Determinations Made at the San Jose State University Hydration Laboratory. Coyote Press Archives of California Prehistory 52.

Winter, Joseph C

1978 *Archaeological Investigations at CA-SCL-128, The Holiday Inn Site. Rohnert Park, California.* NWIC report no. S-005281. On file at the Northwest Information Center, Sonoma State University.

Winterhalder, B.

1990 Open Field, Common Pot: Harvest Variability and Risk Avoidance in agricultural and Foraging Societies. *Risk and Uncertainty in Tribal and Peasant Economies* 67–87.

Winterhalder, Bruce, and Eric A. Smith

- 1981 *Hunter-Gatherer Foraging Strategies: Archaeological and Ethnographic Analyses.* University of Chicago Press, Chicago, Illinois.
- 2000 Analyzing Adaptive Strategies: Human Behavioral Ecology at Twenty-Five. *Evolutionary Anthropology* 9:51–72.

Winterhalder, Bruce, Douglas J. Kennett, Mark N. Grote, and Jacob Bartruff

2010 Ideal Free Settlement of California's Northern Channel Islands. *Journal of Anthropological Archaeology* 29(4):469–490.

Wisely, Justin

- 2015 Starch Grain Analysis of Bedrock Mortars in the Sierra Nevada Mountains; Feasibility, Methodology, and Implications to our Current Understanding of Bedrock Mortar Function. Unpublished Master's thesis, Department of Anthropology, California State University, Chico.
- Witt, Kelsey E., Kathleen Judd, Andrew Kitchen, Colin Grier, Timothy A. Kohler, Scott G. Ortman, Brian M. Kemp, and Ripan S. Malhi
 - 2015 DNA analysis of ancient dogs of the Americas: Identifying possible founding haplotypes and reconstructing population histories. *Journal of Human Evolution* 79:105-118.

Wohlgemuth, Eric

- 1994 Appendix C: Ethnobotanical Assessment. In *Investigations at CA-NAP-863: A Prehistoric Archaeological Site on the West Bank of the Napa River in the City of St. Helena, Napa Valley, California,* edited by T. M. Origer.
- 1996 Resource Intensification in Prehistoric Central California: Evidence from Archaeobotanical Data. *Journal of California and Great Basin Anthropology* 18:81–103.
- 1997 Plant Remains. In Archaeological and Geoarchaeological Investigations at Eight Prehistoric Sites in the Los Vaqueros Reservoir Area, Contra Costa County, California, by Jack Meyer and Jeffrey S. Rosenthal. Los Vaqueros Project Final Report Number 7, Anthropological Studies Center, Sonoma State University.
- 2002 Late Prehistoric Plant Resource Intensification in the Eastern San Francisco Bay Area: Plant Remains from ALA-42 and ALA-555, Pleasanton, California. In *Hunter-Gatherer Archaeobotany: Perspectives from the Northern Temperate Zone*, S. L. R. Mason and J. G. Hather, eds., pp. 28–43. London: The Institute of Archaeology, University College London.
- 2004 The Course of Plant Food Intensification in Native Central California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Davis.
- 2006 *Charred Plant Remains from CA-CCO-309*. Submitted to William Self and Associates, Orinda, California.
- 2010a Plant Remains. Chapter 15 of Archaeological Investigations at CA-CCO-18/548: Final Report for the Vineyards at Marsh Creek Project, Contra Costa County, California, by Randy Wiberg, pp. 275– 285. Prepared for Shea Homes, Brentwood, California.
- 2010b Plant Resource Structure and the Prehistory of Plant Use in Central Alta California. *California Archaeology* 2(1):57–76.

Wohlgemuth, Eric continued

- 2013 Archaeological Excavations at CA-MRN-150 for the Pacific Gas and Electric Company Alameda Del Prado Phase II Pipe Removal Project, Marin County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Pacific Gas & Electric, San Ramon, California.
- 2014a Charred Plant Remains from CA-MRN-67. Submitted to Holman and Associates, San Francisco.
- 2014b Variability in Late Period Plant Use Around San Francisco Bay. Paper presented at the Annual Meeting of the Society for California Archaeology, Visalia, California.
- n.d. Field Notes and Radiocarbon dates from Excavations at CA-YOL-187.

Wohlgemuth, Eric, and Naomi Scher

2015 Data Recovery Excavation at CA-CCO-755 for the PG&E Walnut Boulevard Crossover Redesign Project, Contra Costa County, California. Far Western Anthropological Research Group, Inc., Davis, California. Submitted to Pacific Gas and Electric, San Ramon, California.

Wohlgemuth, Eric, and Angela Tingey

2012 Charred Plant Remains from CA-ALA-312. Submitted to URS, Oakland, California.

Woodburn, J.

- 1980 Hunters and gatherers today and reconstruction of the past. *Soviet and Western Anthropology*:95-117.
- 1982 Egalitarian societies. Man 17(3):431-451.

William Self and Associates (WSA)

2011 Draft Results of Archaeological Testing, Data Recovery and Monitoring for Phase II Activities, Visitacion Valley Redevelopment Program, Schlage Lock Property, City and County of San Francisco, California. Prepared for: MACTEC Development Corp. 1819 Denver West Drive, Suite 100 Golden, CO 80401. May 2011.

Wrigley, E. A.

1966 *An Introduction to English Historical Demography: From the Sixteenth to the Nineteenth Century.* Weidenfeld and Nicolson, London.

Wylie, A.

2002 Thinking from things: Essays in the philosophy of archaeology. Univ of California Press.

Yamada, S. B., and E. E. Peters

1988 Harvest management and the growth and condition of submarket-size sea mussels, Mytilus californianus. *Aquaculture* 74(3):293–299.

Yee, Mary, and Ernestine Ygnacio-De Soto

2005 *The Sugar Bear Story*. Sunbelt Publications, San Diego, California.

- Yokoyama, Yusuke, Kurt Lambeck, Patrick De Deckker, Paul Johnston, and L. Keith Fifield
 - 2000 Timing of the Last Glacial Maximum from Observed Sea-level Minima. *Nature* 406:713–716.

York, Andrew L.

2000 *Archaeological Investigations at Site CA-SCL-829, San Jose, California*. KEA Environmental, Inc. NWIC: S-023573.

Zeanah, David W., ed

2000 *Transport Costs, Central-Place Foraging, and Hunter-Gatherer Alpine Land-Use Strategies.* Edited by D. B. Madsen and M. D. Metcalf. University of Utah Anthropological Papers 122. University of Utah Press, Salt Lake City.

Zimmer, Paul D.

2013 Conflicting Chronometric Data from Three Prehistoric Sites in Contra Costa County, California. *Proceedings of the Society for California Archaeology* 27:273–280.

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SECTION 5 – SUPPLEMENTARY DATA

APPENDICES

Appendix A.	List and Map showing Distribution of 7.5-Minute USGS Quadrangles within the Study Area.
Appendix B.	Detailed Discussion of the Community Distribution Model (with Randall Milliken).
Appendix C.	Prehistoric Archaeological Attribute Codes from Department of Parks and Recreation Site Form 523.
Appendix D.	List of Substantive Archaeological Sites in Study Area.
Appendix E.	Radiocarbon Dates by Site and Scheme D Period within the Study Area.
Appendix F.	Approach Used for Radiocarbon Calibration to Correct for the Percentage of Marine Influence on Human Bone.
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Appendix H.	Example of Field Forms for Documentation of Study Area Excavations.
Appendix I.	Detailed Analytical Methods for Flaked and Ground Stone.

APPENDIX A

LIST AND MAP SHOWING DISTRIBUTION OF 7.5-MINUTE USGS QUADRANGLES WITHIN THE STUDY AREA.

Antioch North	Mindego Hill
Antioch South	Montara Mtn
Benicia	Mountain View
Birds Landing	Mt George
Bolinas	Napa
Bouldin Island	Newark
Brentwood	Niles
Briones Valley	Novato
Byron Hot Springs	Oakland East
Calaveras Reservoir	Oakland West
Castle Rock Ridge	Palo Alto
Clayton	Petaluma
Cordelia	Petaluma Point
Cupertino	Petaluma River
Cuttings Wharf	Point Bonita
Denverton	Redwood Point
Diablo	Richmond
Dublin	Rio Vista
Elmira	San Francisco North
Fairfield North	San Francisco South
Fairfield South	San Geronimo
Glen Ellen	San Jose East
Half Moon Bay	San Jose West
Hayward	San Leandro
Honker Bay	San Mateo
Hunters Point	San Quentin
Isleton	San Rafael
Jersey Island	Santa Teresa Hills
La Costa Valley	Sears Point
La Honda	Sonoma
Las Trampas Ridge	Tassajara
Livermore	Vine Hill
Los Gatos	Walnut Creek
Mare Island	Woodside
Milpitas	Woodward Island

List of 7.5-minute USGS Quadrangles within the Study Area.


USGS 7.5-minute Quadrangles within San Francisco Bay-Delta Study Area.

APPENDIX B

DETAILED DISCUSSION OF THE COMMUNITY DISTRIBUTION MODEL (WITH RANDALL MILLIKEN)

THE CONTACT-PERIOD NATIVE CALIFORNIA COMMUNITY DISTRIBUTION MODEL

Prior to the Community Distribution Model (CDM), no statewide tribelet map had been constructed for contact-period ethnographic California. Robert Heizer commented on this fact in his 1966 mapping project entitled *Languages, Territories, and Names of California Indian Tribes*, a study that introduced the only composite statewide map of local groups based upon C. Hart Merriam's many field notes, and compared against A. L. Kroeber's 1925 map of the language groups of California. At the time, Heizer (1966:9) wrote:

Kroeber estimates that California held between 500 and 600 ... 'independent and separate definable groups.' It may be anticipated that future scholars, undaunted by the huge mass of available published and manuscript data on California Indians, will work over the information on a tribe-by-tribe basis and prepare maps showing the domains of the identifiable or inferable tribelets. Such a task is far too complex and time-consuming to be attempted here.

The CDM accomplishes the tribe-by-tribe study mentioned by Heizer, and the most indepth analysis to date has been for the Bay Area (Milliken 1995, 2006, 2010), which includes the study area tribes—San Francisco Bay Costanoan/Ohlone, Ohlone Karkin, Bay Miwok, Coast Miwok, Plains Miwok, Patwin, and Yokuts. The CDM is a digital atlas and encyclopedia that models the socio-political landscape of these native Californians at the time of first contact with the Spanish, a rolling moment from the 1770s through the 1830s. The CDM atlas portrays a model distribution of community *regions* (inferred or known village communities or tribelets) across California on a GIS digital map layer, divided into *analytical zones* that combine regions on the basis of mutual histories, shared language, and similar land-use patterns. After factoring in landholding community types, Franciscan mission registers of baptism and death, rancheria delineation, domino effects of missionization, marriage patterns, family reconstitution, mortality rates, inferred population densities, classical ethnographies, and seasonal-use areas, Milliken (2010) was able to delineate 663 year-round local group regions in California. The project study area is entirely within the Bay Area analytical zone, incorporating 52 complete or partial regions.

To make these important studies available to scholars, Milliken donated his database to the Bancroft Library where it is currently accessible by laptop in the reading room. Plans in 2016 are to make the data downloadable in *DASH (https://dash.berkeley.edu/xtf/search)*, through the Bancroft's digital library, where information can be expanded, modified, and annotated. The ultimate goal is to connect studies by major ethnographers (e.g., Merriam, Barrett, Kroeber, Harrington) to specific CDM regions in an interconnected database.

FRANCISCAN MISSION REGISTER DATA

At baptism, each individual's native name, newly bestowed Spanish name, and inferred age was transcribed in a dated entry next to a unique sequential baptismal identification number. Confirmations, marriages, and deaths were also recorded, each in their own dedicated books. Beyond this, individual missionaries varied in what they wrote about individuals.

The missionaries did write down the names of thousands of communities that they called "rancherias," but they seldom clarified whether they were referring to a specific village, on the one hand, or a regional multi-village group on the other. Nor did they often provide explicit clues regarding the locations of the communities they listed. Alternate spellings of rancheria names by different priests are also a major problem, as they can be quite extreme. This issue is partially

resolved by bringing together the mission register information for nuclear and extended families so that names spelled out by different priests over many years can be seen at one time. A problem in understanding the socio-political meaning of the many rancheria names is that of synonymy. Some missionaries labeled groups by the name of the group's headman, others labeled them by the name of their largest village, and still others named them by some directional or regional term. One missionary might label a group by a word used by its neighbors of a different language, while another might name the same group by a label that it called itself; this was common among groups that sent people to more than one mission. Through study of extended family groups, some synonymous rancheria names become apparent.

Another problem in interpreting the socio-political landscape from mission register information is that of scale. It has been mentioned that the word "rancheria" means "community." From the earliest days of exploration in California, Spanish diarists used the term in describing specific villages, or clusters of grass houses, inhabited by the tribal people they encountered. That usage corresponds to the modern Spanish-English dictionary definition of rancheria as "a collection of huts, like a hamlet" (Velásquez 1974:551). But the English term "community" can also mean a group of people who share a number of villages within a fixed territory, and the Spanish term "rancheria" came to be used that way in California as well (Milliken 1987:59, 1995:21, 233). In military diaries and mission records, the term "rancheria" may signify either a specific village or the community of shared identity that uses one or more specific village. This conflation of two meanings partially explains why some rancheria names appear only five or six times in all the mission registers, while others appear hundreds of times.

The backbone technique for identification and resolution of such problems is the family reconstitution method. Family reconstitution, first introduced for social geography studies in Europe (Henry 1976; Wrigley 1966), is the process of amalgamating dispersed bits of information about individuals, married couples, and extended families into composite information sets. In mission register studies, family kinship charts are reconstituted from various register entries, resulting in composite data sets that illuminate: (1) synonymous terms for rancherias; (2) relationships of rancherias that are villages to rancherias that are regional names; (3) patterns of intermarriage among communities; (4) timing of family and community movements to missions; and (5) numerous demographic processes that do not emerge from aggregative mission register studies.

Milliken (2006:39) offers an excellent explanation of the fairly exhaustive process of assigning individuals to regions, using the Marin Peninsula as an example:

The term "Tamal" is critical to the reconstruction of Marin Peninsula ethnogeography. The term is used in some early cases at Mission Dolores as part of the name of a specific tribelet, the Tamal-Aguasto (alias Habasto), of the San Rafael area. However, between 1802 and 1810 more than 170 neophytes were baptized at Mission Dolores from "the rancheria Tamal," "the Tamales," "the Olema Tamals," as well as the "the Tamal Aguastos." Later, another 108 people at Mission San Rafael were said to be from one or another of 50 tiny villages associated with the Tamales. For instance, on August 17, 1819, a group of 53 people were baptized at Mission San Rafael from a number of villages, including Caltipa, Calupetamal, Copoloyomi, Echacolom, Echajutti, Geluayomi, Guolea, Guatta, Hutchi, Mottucocha, Ocolom, Pattai, Segloqui, Xotomcohui, Yoittica, and Yuipa (SRA-B 244-295B [SRA – Mission San Rafael, B – baptismal record, # - individual identifier]). Father Amoros, the scribe of record, wrote in the last of the entries, "These 53 neophytes, although nearly all are identified to their distinct communities, are all from the

same direction called 'The Tamales,' some on one side and some on the other" (SRA-B 295). This clue and other clues suggest that the missionaries applied the term Tamales to a large swath of the Marin Peninsula from the San Rafael area on the bay shore westward and northward to the Olema and Tomales Bay areas, and still farther northward on the Pacific coast facing lands to Bodega Bay.

The people from specific "Tamal" villages and from undifferentiated "Tamal" areas have been tentatively assigned either to the San Rafael region (homeland of the Tamal Aguastos) or to one of four arbitrarily created Pacific coast regions of the Marin Peninsula north of Bolinas Bay. They were assigned by an iterative process. First, all adults associated with Tamal were pooled together with other people known to have come from one of the five Tamal regions, mainly the "Costa" and "Olema" people at Mission Dolores. This created a pool of 797 adults who were then assigned provisionally among the five Tamal regions, one fifth of them to each region, in order of their time of baptism. This created an artificial distribution, but a powerful artificial distribution nevertheless. As a result of that artificial process, the preponderance of people in each of 50 different small village groups ended up in one specific region. Then the second iteration took place, in which all adults of a given rancheria were re-assigned to the region to which his or her rancheria seemed to belong under the first iteration. When the redistribution was finished, children were assigned to the regions of their parents. A third and final iteration involved the assignment of the remaining Coast Miwok individuals, who had not been identified at baptism (or by family ties) to a specific rancheria, to the region of the largest number of individuals with whom they were baptized.

THE CDM DATABASE

The basis for the present CDM for all of California, including the Bay Area, is computerized mission record data that augment family reconstitution and contain fields that assign individuals and married couples to groups with standardized group names. The current Mission Database, organized with Microsoft ACCESS, consists of records up through the year 1840 for all Bay Area missions.

The database has two key tables—the "Individual" table, which tracks baptismal/death record information, and the "Marriage" table. Baptism data in the Individual table include date and location of baptism, sex, age, Spanish name, Native name, home group (original spelling), parents, godfather, and priest who signed the entry. Reconstructed data include standardized spelling of the home name, reliability of the data, region, and language. Death statistics include a link to the baptismal record, date, location, cause, home group, and age. Additional demographic research information includes year of baptism and death, age at death, and any additional information such as siblings or runaway. The Marriage table incorporates the names of two individuals, including marriage date, age, home origin, prior spouses, surname, Spanish name, baptismal numbers, marital status (renewing, widower), baptism number, witnesses, and priest.

The CDM also contains tables on confirmations, regions, rancherias, and padrons. The "Regions" table focuses on the hundreds of identified tribelet-sized geographical regions. It includes type of region (e.g., year-round), analysis zone, region name, prominent rancherias, language, political cohesion (e.g., tribelet, small local groups), land use, known names, and references. Additional information includes "research investment," which describes the amount of consideration given to the entries, and confidence level. Historical regional data include percentage

of individuals who moved to the missions, which missions took which individuals from which region, and treaties signed. Demographic information includes number of adults baptized, average year of baptism, baptizable population from 1770 on, contact-period adult population and full population by region, and GIS area. Geographic data include geography (e.g., coast, central valley), elevation, and county. The Region data are cross-linked to the GIS-mapped California habitation regions and also cross-linked internally to baptismal records in the Individuals table through a "Regions" field. The "Padron" tables are also cross-linked to the Individuals table.

CDM REGION MAPPING LAYERS

The CDM mapping layer provides a reasonable placement on the landscape for every San Francisco Bay Area landholding group mentioned in Franciscan mission registers. It was generated using the Microsoft Access CDM database and ESRI ArcView GIS software. Initial region boundaries were produced as lines digitized by hand in GIS, with the 1:500,000 USGS California base map as an underlying reference. Region polygons were generated based on the dividing lines as well as environmental data such as coastline, water bodies, specific elevation contours, and point feature class containing the region name. The region polygon feature class can be linked to the CDM database based on the region names to facilitate analysis and cartographic representation on various attributes, including population density or language.

ASSESSING THE REGIONAL MODEL

The specific regions draw attention to the local nature of everyday life in pre-European times and allow us a comparative perspective on the level of ethnographic knowledge. Many of the regions do approximate the year-round use-areas of tribelets or loose regional communities. In other cases, a model region may inadvertently split the territory of some "real" past groups, or present the areas of separate groups as though they were one. There is no doubt, however, that pre-European California people lived out most of their lives within regions of the size presented by the CDM model, and that they interacted with neighbors in contiguous regions and knew much less about more distant groups.

It is a down side of this "cubby hole" approach that some readers will fail to read caveats presented here and believe that the regional boundaries are all precisely documented local group borders. But that problem is less serious than the tyranny of "language group as tribe" that informs the understanding of the public and some scholars. The upside of the model presented here lies in its exposure of the variation in quality of ethnographic information from one region to the next and in its flexibility for adding new information about regions and their possible boundaries through indepth local studies.

It is impossible to know how close the CDM model approaches ethnographic reality in the absence of a completely accurate survey in the year 1770. Thus the model can be criticized, even rejected, by perfectionists. But one of its main points is to illuminate assumptions about group locations and stimulate careful review of the evidence behind each of those assumptions.

SUMMARY

The CDM is a unique tool available to California scholars. The exhaustive dataset and mapping layers are now available at the Bancroft Library and will soon be available for downloading, updating, and revising; it will always be a work in progress, similar to the *Wikipedia* concept. As shown in this study, this flexible package of tools that makes up the CDM has great

potential for generating detailed, expansive, and thought-provoking research. One example is presented here, documenting the effects of mission outreach across the study area based on baptismal data and population density analysis. This research can also be applied to archaeological studies in relation to Late and Mission Period village locations and the behavior of neophytes outside the mission and of those attempting to return to their home lands and Native cultures.

The CDM can also serve as a bibliographic source—a place to check for references when conducting studies in any local region. It can also be used as a model for historic demography studies—separate data columns can be used to build and map regional population densities under alternative assumptions. Geographical social interaction studies can be created using evidence on endogamous and exogamous marriage patterns translated to a map model and tied to studies of genetic and cultural flow over time.

APPENDIX C

PREHISTORIC ARCHAEOLOGICAL ATTRIBUTE CODES FROM DEPARTMENT OF PARKS AND RECREATION SITE FORM 523

PREHISTORIC ARCHAEOLOGICAL SITE AND ETHNOGRAPHIC SITE RESOURCE ATTRIBUTE CODES AND ATTRIBUTE DEFINITIONS (OFFICE OF HISTORIC PRESERVATION 1995)

- AP1 Unknown: no characteristics listed on the site record.
- AP2 Lithic scatter: a major characteristic of the site is a scatter of chipped or flaked stone resulting from human manipulation (e.g., obsidian flakes and few or no other artifacts).
- AP3 Ceramic scatter: a major characteristic of the site is a scatter of pot sherds. If the site contains both lithics and ceramics, check both.
- AP4 BRM/milling feature: site contains one or more bedrock mortars, milling surfaces or cupules which indicate material processing activity.
- AP5 Petroglyphs: site contains a stone surface which has been scored by humans in a patterned manner for a purpose other than material processing. This category includes intaglios.
- AP6 Pictographs: site includes any design painted on a rock surface.
- AP7 Architectural feature: site contains any feature which indicates the presence of human construction activity (e.g., post holes, house pits, dance house, sweat lodge, hunting blinds, fish traps).
- AP8 Stone feature: site contains a patterned arrangement of rocks purposefully constructed or modified (e.g., rock alignments, cairns, rock rings of unknown function, etc.).
- AP9 Burial: the site contains human bone.
- AP10 Cache: the site contains an natural or constructed feature used for storing food or goods.
- AP11 Hearths/pits: site contains any feature which indicated cooking activity, such as roasting pits, association of cracked or burnt rock, discolored soil, ash and carbonized wood or plants.
- AP12 Quarry: site contains a source of lithic material with evidence of human usage.
- AP13 Lineal feature: site contains natural or constructed features indicating human use such as trails, earth works, windrows or stone fences.
- AP14 Rock shelter/cave: a concavity within a rock surface evidencing human use.
- AP15 Habitation debris: site contains a deposit characterized by a wide range of artifacts, materials or features which represent a variety of human activities.
- AP16 Other: check here if there is no other category in which the site description can be placed.

APPENDIX D

LIST OF SUBSTANTIVE ARCHAEOLOGICAL SITES IN STUDY AREA

Site Number	Site Name	Study Area Region	Radiocarbon dates	Obsidian Sourcing	Obsidian Hyrdation	Burials	Bird, Mammal, Reptile Remains	Fish Remains	Shellfish	Plants	Referencesª					
ALA-001/H	-	South Bay	N	Ν	N	N	N	Ν	Ν	Ν	Thompson et al. 2003					
ALA-012	-	East Bay	N	Y	Y	Y (10)	Y	N	N	N	Banks 1985; Bickel 1981; Rackerby 1967; Whelan 1967, 1969; Wilson 1993 (artifacts); Wilson 1999 (obsidian)					
ALA-013	-	East Bay	Y (2)	Y	Y	Y (108)	Y	N	N	N	Banks 1985; Bickel 1981; Rackerby 1967; Whelan 1967,1969; Wilson 1993 (artifacts), 1999 (obsidian)					
ALA-017	-	East Bay	Y (25)	Y	Y	Y (3)	Y	Y	Y	N	Jones and Darcangelo 2007					
ALA-042	-	East Bay	Y (14)	Y	Y	Y (343)	Y	Y	Y	Y	Fong and Brittin 1994 (skeletal analysis); Wiberg 1997					
ALA-046	-	East Bay	Y (2)	Ν	N	Y (18)	Ν	N	Ν	Ν	Ambro 1993; Fong et al. 1991a, 1991b					
ALA-060	-	East Bay	Y (8)	Y	Y	N	Y	Y	Ν	Ν	Bard et al. 1985, 1989; Miller 1982					
ALA-307	West Berkley	East Bay	Y (42)	N	N	Y (330)	Y	N	N	N	Dore et al. 2004 (geoarch coring); Gifford 1916 (shellfish); Ingram 1998 (dating); Wallace and Lathrap 1975					
ALA-309	Emeryville Shellmound	East Bay	Y (76)	N	N	Y (706+ 120)	Y	N	Y	Y	 Wallace and Lathrap 1975 Y Breschini and Haversat 1986; Broughton 1999 (fauna); Gifford 1916 (shellfish constituents); Morgan n.d.; Nelson 1906; Popper and Martin 2002 (plants); Sc 1926; Uhle 1907; Wake 2002 Y Morgan n.d.; Popper and Martin 2002 (plants); Wake 2002 (fauna) X Behor n.d. 					
ALA-310	-	East Bay	Y (19)	Ν	N	Y	Y	N	Ν	Y Morgan n.d.; Popper and Martin 2002 (plants); Wake 2002 (fauna)						
ALA-312	-	East Bay	Y (10)	Ν	N	Y (2)	Ν	N	Ν	Y Morgan n.d.; Popper and Martin 2002 (plants); Wake 2002 (fauna) Y Rehor n.d.						
ALA-328	Patterson Mound	East Bay	Y (7)	Y	Y	Y (~600)	Y	N	Y	N	Bickel 1976, 1981 (shell); Davis and Treganza 1959; Luby 1992 (burials), 2004; Whelan 1969 (fauna)					
ALA-329	Ryan Mound	East Bay	Y (53)	Y	Y	Y (283)	Y	N	Ν	Ν	Coberly 1973; Leventhal 1993; Wilson 1993, 1999 (obsidian)					
ALA-330	Haley Road Site	South Bay	N	Y	Y	Y (19)	Y	N	Ν	Ν	Phebus 1973; Wilson 1993 (artifacts), 1999 (obsidian)					
ALA-331	-	South Bay	N	Y	Y	?	Ν	Ν	Ν	Ν	Bickel 1976; Holman 1981; Wilson 1999 (obsidian)					
ALA-342	-	South Bay	N	Y	Y	?	N	N	Ν	Ν	Jurmain 1983; Wilson 1999 (obsidian)					
ALA-343	M.H. Podell Presidio Apartments	South Bay	Y (9)	Y	Y	Y (16)	Y	N	Y	N	Desmond 1998; Hall 1985; Hall et al. 1988 (cemetary); Wildesen 1968; Wilson 1993 (artifacts), 1999 (obsidian)					
ALA-413	Santa Rita Village	East Bay	Y (22)	Ν	N	Y (68)	Ν	N	Ν	Ν	Wiberg 1988					
ALA-424	-	South Bay	Y (1)	Y	Y	Y (9)	Ν	Ν	Ν	Ν	Bard and Brock 1986; Bard and Busby 1988					
ALA-428/H	-	East Bay	Y (4)	Y	Y	N	N	N	Ν	Ν	Leventhal et al. 1989					
ALA-453	-	East Bay	Ν	Y	Y	Y (1)	N	Ν	Ν	Ν	Dietz 1985; Wilson 1993 (artifacts), 1999 (obsidian)					
ALA-466	Olympia 1	East Bay	Ν	Ν	Ν	Ν	Y	Ν	Y	Ν	Bard et al. 1987					
ALA-479	-	East Bay	Y (1)	Y	Y	Y (41)	Ν	Ν	Y	Ν	Leventhal et al. 1987; Wilson 1993 (artifacts), 1999 (obsidian)					
ALA-483	-	East Bay	Y (6)	Y	Y	Y (63)	Y	Ν	Ν	Ν	N Bard et al. 1992; Wiberg 1996					
ALA-485	-	East Bay	Y (1)	Ν	N	N	Y	Ν	Y	Y	Y Rosenthal 2001					
ALA-486	-	East Bay	Y (1)	Ν	N	N	Y	N	Y	Y	Y Rosenthal 2001					
ALA-514/H	The Hidden Valley Ranch Site	South Bay	Y (1)	Ν	N	Y (3)	N	N	Ν	Ν	N Fong et al. 1990					
ALA-554	Pleasanton Gateway Project	East Bay	Y (18)	Y	Y	Y (+169)	Y	Y	N	Y	Price et al. 2002; Eerkens et al. 2012 (tobaco residue); Estes et al. 2012; Lentz 2009 (ground stone)					
ALA-555	-	East Bay	Y (12)	Y	Y	Y (203)	Y	Y	Y	Y	Wiberg 1996					

Site Number	Site Name	Study Area Region	Radiocarbon dates	Obsidian Sourcing	Obsidian Hyrdation	Burials	Bird, Mammal, Reptile Remains	Fish Remains	Shellfish	Plants	Referencesª				
ALA-565/H	-	East Bay	N	N	N	N	N	Ν	Ν	Ν	Luby 1995				
ALA-566	-	East Bay	Y (3)	Y	Y	N	N	Ν	Ν	Y	Gmoser 1994				
ALA-574	-	East Bay	Y (2)	Y	Y	N	Y	Y	Y	Y	Gmoser et al. 1999				
ALA-576	-	South Bay	Y (5)	Y	Y	Y(42?)	Y	Y	Y	Ν	Gmoser et al. 1999; Jurmain 1983; King 1968; Rosenthal 2006				
ALA-586	-	East Bay	Y (3)	Y	Y	Y (2)	N	Ν	Ν	Y	Tiley 2001				
ALA-604	-	East Bay	Y (11)	Ν	N	N	N	Ν	Y	Y	Pastron and Gottsfield 2003				
ALA-613/H	Canyon Oak	East Bay	Y (10)	Y	Y	Y (473)	Y	Ν	Ν	Y	Price et al. 2005				
ALA-621	Central Chevrolet	South Bay	Y (2)	Ν	N	Y (21)	N	Ν	Ν	Ν	Thompson 2002				
ALA, P-01-0011556	Freemont site	South Bay	Y (6)	Ν	N	N	Y	Y	Ν	Y	Meyer 2015				
CCO-001	-	South Delta	N	Ν	N	Y (26)	N	Ν	Ν	Ν	Anderson 2008; Cook and Elsasser 1956				
CCO-009	-	South Delta	Y (4)	Y	Y	?	N	Ν	Ν	Y	Zimmer 2013				
CCO-014	-	East Bay	Y (2)	Ν	N	?	N	Ν	Ν	Ν	Groza 2002 (C14)				
CCO-018/H	Marsh Creek	South Delta	Y (208)	Y	Y	Y (+480)	Y	Y	N	Y	Eerkens et al. 2009 (<i>Olivella</i> sourcing), 2013a (mortuary); Griffin 2014 (health); Jorgenson et al. 2009 (strontium); Rosenthal 2010; Rosenthal et al. 2006; Stevens et al. 2009; Van Bueren and Wiberg 2011 (charmstone); Wiberg 2010; Wiberg and Clark 2004				
CCO-030	-	South Delta	Y (4)	Ν	N	?	N	Ν	Ν	N	Ericson 1977 (C14); Fredrickson 1968				
CCO-124	-	East Bay	Y (3)	Y	Y	Y (8)	Y	Ν	Ν	N	Wiberg and Clark 2000				
CCO-128	Dal Porto	South Delta	N	Y	N	N	Y	Ν	Ν	N	Wiberg and Clark 2007				
CCO-137/H	-	South Delta	N	N	N	Y (1+)	N	N	N	N	Anderson 2008; Cook and Elsasser 1956; Heizer 1950; Jackson and Fredrickson 1979				
CCO-138	Hotchkiss Site	South Delta	Y (5)	Y	Y	Y (662)	Y	Y	Y	Y	Atchley 1994; Beardsley 1954; Chard et al. n.d.; Jackson 1974 (obsidian); Price et al. 1993; Wiberg and Clark 2007				
CCO-147	-	South Delta	N	Y	Y	Y (2)	N	Ν	Y	Y	Holson et al. 1993				
CCO-151	-	East Bay	Y (6)	Ν	N	?	N	Ν	Ν	N	Erickson 1977 (radiocarbon); Groza 2002				
CCO-156	El Sobrante	South Delta	Y (1)	Y	Y	N	Y	Y	Y	Y	Baker 1992				
CCO-222	-	South Delta	Y (2)	Y	N	N	Y	Ν	Ν	N	Holman et al. 1982				
CCO-235	-	South Delta	Y (10)	Y	Y	Y (64)	Y	N	Y	Y	Andrushko et al. 2009 (burials); Groza 2002 (C14); Pastron and Bellifemine 2009				
CCO-236	Buchan	South Delta	N	Y	Y	Y (2)	Y	Y	Ν	N	Baker 1994				
CCO-259	-	East Bay	Y (1)	Ν	N	?	N	Ν	Ν	Ν	Fergusson and Libby 1964 (C14); Fredrickson 1974				
CCO-268	-	East Bay	Y (1)	Y	N	Y (1)	Y	Y	Y	Ν	Banks and Orlins 1979				
CCO-269	-	East Bay	Y (14)	Y	Y	Y (57)	Y	Y	Y	Ν	N Banks and Orlins 1979; Holson et al. 2000				
CCO-270	-	East Bay	Y (4)	Y	N	N	Y	Y	Y	Ν	N Banks and Orlins 1979; Holson et al. 2000				
CCO-271	-	East Bay	Y (6)	Y	N	N	Y	Y	Y	Ν	Banks and Orlins 1979				
CCO-275	-	East Bay	N	Y	Y	Y (3)	Y	Y	Ν	Ν	Banks and Orlins 1980				
CCO-284	-	East Bay	Ν	Y	Y	N	Y	Y	Y	Y	Wiberg 1999				

Site Number	Site Name	Study Area Region	Radiocarbon dates	Obsidian Sourcing	Obsidian Hyrdation	Burials	Bird, Mammal, Reptile Remains	Fish Remains	Shellfish	Plants	References ^a				
CCO-290	Brooks Island	East Bay	Y (19)	Ν	N	Ν	Ν	Ν	Ν	Ν	Finstad et al. 2013 (shell isotope C14); Sinats 2007 (shellfish)				
CCO-295	Ellis Landing	East Bay	Y (7)	N	N	Y (65)	N	N	N	N	Beasley 2008 (isotopes); Beasley et al. 2013; Finstad et al. 2013 (shell isotope C14); Gifford 1916 (shellfish & constituents); Nelson 1910a; Schweikhardt et al. 2011				
CCO-297	Stege Mound	East Bay	Y (24)	Y	Y	N	Y	Y	Y	Y	DeGeorgey 2013, 2016; Eerkens et al. 2014 (shellfish isotopes); Patterson and DeGeorgey 2014 (obsidian trade); Von der Porten et al. 2014 (clam disk bead dating)				
CCO-298	Stege Mound	East Bay	Y (5)	Y	Y	Y (1)	N	Y	Ν	N	Banks and Orlins 1979				
CCO-299	-	East Bay	N	Y	Y	Y	Y	Y	Y	Ν	Banks and Orlins 1985				
CCO-308	-	South Delta	Y (10)	Ν	N	Y (49)	N	Ν	Y	Ν	Fredrickson 1966				
CCO-309	-	South Delta	Y (8)	Y	Y	Y (27)	Y	Y	Ν	Y	Price et al. 2006				
CCO-320/H	-	South Delta	Y (3)	Y	Y	Y (1)	Y	Ν	Y		Meyer 2000				
CCO-368	-	South Delta	Y (2)	Y	Y	Y (4)	Y	Y	Y	Ν	Moratto et al. 1995; Price et al. 1993				
CCO-377	-	South Delta	N	Ν	N	Y (1+)	N	Ν	Ν	N Anderson 2008; Jackson and Fredrickson 1979; Jones et al. 1980 Y Zimmer 2013					
CCO-397	-	South Delta	Y (8)	Y	Y	?	N	Ν	Ν	Y	Zimmer 2013				
CCO-431	-	South Delta	Y (1)	Y	Y	Y (1)	Y	Ν	Ν	Ν	Banks et al. 1984				
CCO-447	-	South Delta	Y (1)	Y	Y	N	N	Ν	Ν	Ν	Meyer 2000				
CCO-450/H	-	South Delta	Y (8)	Y	Y	Y (2)	N	Ν	Ν	Y	Meyer and Meyer 2000; Zimmer 2013				
CCO-458/H	-	South Delta	Y (1)	Y	Y	Y (3)	N	Y	Y	Y	Meyer and Rosenthal 1997				
CCO-459	-	South Delta	Y (2)	Y	Y	Y (1)	N	Y	Y	Y	Meyer and Rosenthal 1997				
CCO-462/468	-	South Delta	Y (1)	Y	Y	N	N	Ν	Y	Ν	Meyer and Rosenthal 1997				
CCO-474/H	-	East Bay	Y (4)	Y	Y	Y (113)	Y	Y	Y	Y	Estes et al. 2002; Waechter et al.1992				
CCO-538	-	South Delta	Y (3)	Ν	N	Y (13)	N	Ν	Ν	Ν	Thompson et al. 2003				
CCO-593	-	South Delta	N	Ν	N	N	N	Ν	Y	Ν	Holson et al. 1993				
CCO-600	-	East Bay	Y (3)	Y	Y	Y (29)	N	Ν	Ν	Ν	Holson et al. 2000				
CCO-601	-	East Bay	Y (1)	Ν	N	Y (14)	N	Ν	Ν	Ν	Holson et al. 2000				
CCO-636	-	South Delta	Y (1)	Y	Y	N	N	Ν	Y	Ν	Meyer and Rosenthal 1997				
CCO-637	-	South Delta	Y (7)	Y	Y	Y (18)	N	Y	Y	Y	Meyer 1998; Meyer and Rosenthal 1997				
CCO-655	-	East Bay	Y (1)	Ν	N	?	N	Ν	Ν	Ν	Groza 2002 (C14)				
CCO-696	-	South Delta	Y (17)	Y	Y	Y (160)	N	Y	Y	Y	Meyer and Rosenthal 1997				
CCO-725	-	South Delta	Y (1)	Ν	N	N	N	Ν	Ν	Y	Meyer and Meyer 2000				
CCO-726/H	-	South Delta	Y (1)	Ν	N	N	N	Ν	Ν	Y	Meyer and Meyer 2000				
CCO-750	-	East Bay	Y (2)	Ν	N	N	N	Ν	Ν	Ν	N Kaijankoski et al. 2012				
CCO-755	-	South Delta	Y (5)	Y	Y	N	Y	Y	Y	Y	Y Wohlgemuth and Scher 2015				
CCO-767	Biggs	South Delta	Y (4)	Y	Y	N	Y	Y	Y	Y	Y Wiberg and Clark 2007				
CCO-832	PATB	South Delta	Y (1)	Ν	N	N	N	Ν	Ν	Y	Y Price, H. personal communication (C14)				
MRN-020	Strawberry Point	Northwest Bay	N	Ν	N	Y (19)	Y	Y	Y	Ν	Follett 1957 (fauna); McGeein and Mueller 1955				
MRN-026	-	Northwest Bay	Ν	Ν	Y	N	Ν	Ν	Ν	Ν	Jackson 1974b (obsidian sourcing); King 1970:5				

Site Number	Site Name	Study Area Region	Radiocarbon dates	Obsidian Sourcing	Obsidian Hyrdation	Burials	Bird, Mammal, Reptile Remains	Fish Remains	Shellfish	Plants	References ^a				
MRN-003	Sausalito Mound	Northwest Bay	N	N	N	Y (~7)	Y	N	N	N	Gifford 1916 (shellfish & constituents); Kroeber 1925 (artifacts); Nelson 1910c; Rossa and Brittin 1992 (1 burial)				
MRN-005/H	Fireside Inn	Northwest Bay	Y (4)	Y	Y	Y (8)	Y	Y	Ν	Ν	Byrd et al. 2013 (dog); Evans and Smith 2009				
MRN-012	Alto	Northwest Bay	N	Y	Y	Y (13)	Y	Y	Y	Ν	Goerke 2012; Origer et al. 2013; Waechter 2013; Waechter and Berg 2015				
MRN-014	Shelter Hill	Northwest Bay	Y (2)	Ν	N	Y (2)	Y	Y	Ν	Ν	Moratto et al. 1974; Riley 1979				
MRN-017	De Silva Island	Northwest Bay	Y (6)	Y	Y	Y (6)	Y	Y	Y	Ν	Pahl 2003				
MRN-027	Tiburon	Northwest Bay	Y (2)	Ν	Y	Y (49)	Y	Ν	Ν	Ν	Jackson 1974b (obsidian sourcing); King 1970				
MRN-035	Hillarita	Northwest Bay	N	Y	Y	Y (18)	N	Ν	Ν	Ν	Bennyhoff Notes; Bieling 2011; Miller 1977; Milliken DB*; Newland 2013				
MRN-039	Belvedere Mound	Northwest Bay	Y (9)	Ν	N	Y (~43)	N	Ν	Ν	Ν	Chattan et al. 2005				
MRN-042	-	Northwest Bay	Y (2)	Y	Y	Y	N	Ν	Y	Ν	Hines 1983				
MRN-044/H	Angel Island	Northwest Bay	Y (14)	Ν	Y	N	Y	Y	Y	Y	DeGeorgey 2007; Hines 1983				
MRN-045	-	Northwest Bay	N	Ν	N	Y (1)	N	Y	Ν	Ν	Hines 1982; Treganza 1966				
MRN-067	-	Northwest Bay	Y (38)	Y	Y	Y	Y	Y	Y	Y	Schwitalla and Powell 2014				
MRN-076	Greenbrae	Northwest Bay	N	N	N	Y (9)	N	N	Y	N	Beardsley 1954; Gifford 1916 (shellfish & constituents); Kroeber 1925 (artifacts); Nelson 1911a				
MRN-080	-	Northwest Bay	N	Ν	N	Y (8)	N	Ν	Ν	Ν	Treganza 1957				
MRN-114	-	Northwest Bay	Y (4)	Y	Y	N	Y	Y	Y	Y	Schneider 2010, 2015 (shellfish isotopes)				
MRN-115	Thomas site	Northwest Bay	Y (3)	Y	N	N	Y	Y	N	N	Baumhoff 1953 (basketry); Janzen and Schneider 2009 (fauna); Meighan 1953; Schneider 2009, 2010				
MRN-127	Marin Civic Center	Northwest Bay	Y (1)	Y	Y	Y (1)	Y	Y	Ν	Ν	Bieling and Psota 1989				
MRN-138	Miller Creek	Northwest Bay	Y (2)	Ν	N	Y (20)	N	Ν	Ν	Ν	Slaymaker 1974				
MRN-139	-	Northwest Bay	N	Ν	N	N	N	Ν	Ν	Ν	Slaymaker 1974				
MRN-140	-	Northwest Bay	N	Ν	N	N	N	Ν	Ν	Ν	Slaymaker 1974				
MRN-141	-	Northwest Bay	N	Ν	N	N	N	Ν	Ν	Ν	Slaymaker 1974				
MRN-142	-	Northwest Bay	N	Ν	N	N	N	Ν	Ν	Ν	Slaymaker 1974				
MRN-150	-	Northwest Bay	Y (5)	Y	Y	N	Y	Y	Y	Y	Wohlgemuth 2013				
MRN-152	Pacheco	Northwest Bay	Y (2)	Ν	N	Y (9)	Y	Y	Y	Ν	Clelow and Wells 1981 (C14); Goerke and Cowen 1983				
MRN-168	-	Northwest Bay	N	Ν	Y	Y (49)	N	Ν	Ν	Ν	Jackson 1974b (obsidian sourcing); Melander and Slaymaker 1969				
MRN-170	Ignacio	Northwest Bay	Y (2)	Ν	Y	Y (9)	N	Ν	Ν	Ν	Chavez 1976; Jackson 1974b (obsidian sourcing)				
MRN-171	Old Novato	Northwest Bay	N	Ν	N	Ν	N	Ν	Ν	Ν	Flynn K. notes 1986; Milliken DB*				
MRN-174	-	Northwest Bay	N	Ν	N	N	N	Ν	Y	Ν	Holman et al. 1987				
MRN-175	Deer Island	Northwest Bay	N	Ν	N	N	N	Ν	Ν	Ν	N Milliken DB*; Roop & Flynn notes				
MRN-192	-	Northwest Bay	N	Y	Y	Y (6)	Y	Y	Y	Y	Y Basgall et al. 2006; Hansen 1970; McBeath 1965 (burials); Moratto 1969 (notes),1974:49-50				
MRN-193	Olompali	Northwest Bay	Y (2)	Y	Y	Y (20)	N	Ν	Ν	N	N Hines et al. 1996; Slaymaker 1972; Treganza 1958				
MRN-194	-	Northwest Bay	Y (1)	Y	Y	N	Y	Y	Y	Y	Basgall et al. 2006				
MRN-195	-	Northwest Bay	Y (1)	Y	Y	Ν	Y	Y	Y	Y	Basgall et al. 2006				

Site Number	Site Name	Study Area Region	Radiocarbon dates	Obsidian Sourcing	Obsidian Hyrdation	Burials	Bird, Mammal, Reptile Remains	Fish Remains	Shellfish	Plants	References ^a					
MRN-196	-	Northwest Bay	Y (1)	Y	Y	N	Y	Y	Y	Y	Basgall et al. 2006					
MRN-197	-	Northwest Bay	Ν	Y	Y	N	Y	Ν	Y	Ν	Basgall et al. 2006					
MRN-254	-	Northwest Bay	Y (13)	Y	Y	Y (6)	Y	Y	Y	Y	Bieling 1998, 1999; Byrd et al. 2012 (plants); Treganza 1958					
MRN-255/H	-	Northwest Bay	Y (5)	Y	Y	Y (3)	Y	Y	Ν	Ν	Bieling 2000; Treganza 1957					
MRN-315	San Rafael Mound	Northwest Bay	N	N	N	Y (~40)	N	N	Y	N	Beardsley 1954; Gifford 1916 (shellfish & constituents); Kroeber 1925 (artifacts); Nelson 1910b					
MRN-327	-	Northwest Bay	Y (2)	Y	Y	N	Y	Y	Y	Y	Basgall et al. 2006					
MRN-328	-	Northwest Bay	Y (2)	Y	Y	N	Y	Y	Y	Ν	Schneider 2010					
MRN-352	-	Northwest Bay	N	Ν	N	N	N	Ν	Ν	Y	Bieling 2007 (no report)					
MRN-357	Perry Site	Northwest Bay	N	Ν	N	Y (9)	N	N	Y	Ν	King et al. 1966					
MRN-365	Novato	Northwest Bay	N	Ν	N	Y (12)	N	Ν	Ν	Ν	Milliken DB ^b ; unpublished notes San Francisco State University					
MRN-374	-	Northwest Bay	N	Ν	N	N	N	N	Ν	Ν	Novato Senior High Archaeology Club 1967					
MRN-403	Ripoff	Northwest Bay	N	Ν	N	N	N	N	Ν	N Slaymaker 1974						
MRN-406	Marin College	Northwest Bay	N	Ν	N	Y (14)	Ν	N	Y	N Goerke 1994						
MRN-43	-	Northwest Bay	N	Ν	N	Y	N	Ν	Y	N Goerke 1994 N Hines 1983; Treganza 1966						
MRN-471	San Jose village	Northwest Bay	Y (2)	Ν	N	Y (3)	N	N	Ν	N	Breschini et al. 1996 (C14); Jackson 1974b					
MRN-495	-	Northwest Bay	Y (2)	Y	Y	Y (1)	N	Ν	Ν	Ν	Chavez 1995					
MRN-507	-	Northwest Bay	N	Y	Y	N	Y	N	Y	Y	Basgall and Glover 2012; Basgall et al. 2006					
MRN-526	-	Northwest Bay	N	Ν	N	N	Y	Y	Y	Y	Basgall and Glover 2012; Basgall et al. 2006					
MRN-529	Lost Luggage	Northwest Bay	Y (3)	Y	Y	?	Y	Y	Y	Ν	Clark 1992					
MRN-530	Hobo's Rest	Northwest Bay	Y (4)	Y	Y	?	Y	Y	Y	Ν	Clark 1992; Clark et al. 1995					
MRN-601	-	Northwest Bay	N	Y	Y	N	N	N	Ν	Ν	Origer 1992					
MRN-611	East Marin Island	Northwest Bay	N	Ν	N	N	N	N	Ν	Ν	Luby 1994					
MRN-644/h	-	Northwest Bay	N	Y	Y	N	Y	N	Y	Ν	Stewart 1999					
MRN-678	-	Northwest Bay	N	Ν	N	N	N	N	Y	Y	Bieling 2007 (no report)					
NAP-015/H	Suscol mound	Northwest Bay	Y (8)	Y	Y	N	Y	N	Ν	Ν	Heizer 1953; Stradford and Schwaderer 1982					
NAP-016	-	Northwest Bay	N	Ν	N	N	N	N	Ν	Ν	Heizer 1953					
NAP-189/H	-	Northwest Bay	Y (26)	Y	Y	Y	Y	Y	Y	Y	Basgall et al. 2015					
NAP-190	-	Northwest Bay	N	Y	Y	N	N	N	Ν	Ν	Basgall et al. 2015					
NAP-265	-	Northwest Bay	N	Y	Y	N	Y	Y	Y	Ν	Origer 1993					
NAP-795	-	Northwest Bay	Y (1)	Y	Y	N	Y	Y	Y	Y	Basgall et al. 2015					
SCL-001	Castro/Ponce	South Bay	Y (4)	Ν	N	Y	N	N	Y	Ν	N Gifford 1916 (shellfish); Loud 1912					
SCL-004	-	South Bay	Y (1)	Ν	N	?	N	N	Ν	Ν	N Breschini et al. 1996 (C14)					
SCL-006E	Tasman Park Project	South Bay	Y (3)	Y	Y	N	Y	Y	Y	Ν	N Bard et al. 1984, 1986; Cartier et al. 2003; Roop et al. 1981					
SCL-006W	The Lick Mill Boulevard Site	South Bay	Y (12)	Y	Y	Y (140)	N	Ν	Y	Ν	N Cartier et al. 1990, 1993					
SCL-007	-	South Bay	Y (2)	Ν	N	N	N	Ν	Ν	Ν	Carrico et al. 1987					
SCL-012/H	Ynigo Mound	South Bay	Y (14)	Y	Y	Y (38)	Y	Y	Y	Y	Arrigoni et al. 2008; Byrd and Berg 2009					

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SCL-030/H	Santa Clara Mission	South Bay	Y (7)	Y	Y	N	N	N	N	N	Allen 1998 (shellfish and beads); Eerkens 2013 personal communication; Hylkema 1995; Hylkema and Allen 2009 (beads); Leventhal 2013 personal communication (C14); Leventhal et al. 2011			
SCL-038	Elmwood/Yikisma Mound	South Bay	Y (41)	Y	Y	Y (250)	Y	N	Y	N	Bellifemine 1997, 1998; Bellifemine and Leventhal 1998; Cartier et al. 1988a; Gardner 2013 (burials/isotopes); Leventhal 1998			
SCL-065	-	South Bay	Y (2)	Y	Y	?	N	Ν	Ν	Ν	Fitzgerald 1993			
SCL-068	-	South Bay	Y (2)	Y	Y	Y (10)	Y	Ν	Y	Ν	Bard et al. 1984; Cartier et al. 1993; Fong et al. 1988, 1989; Roop et al. 1981			
SCL-070	-	South Bay	Y (4)	Ν	N	N	N	Ν	Ν	N	Edwards 1973			
SCL-124	Hillsdale Site	South Bay	N	Ν	N	Y (77)	N	Ν	Ν	N	Ancient Enterprises, Inc. 1980			
SCL-128	Holiday Inn Site	South Bay	Y (6)	Y	Y	Y (29+)	Y	Y	Y	N	Breschini 1977; Cartier et al. 2003; James et al. 1988; Roop et al. 1981; Tannam et al. 1991; Winter 1978			
SCL-134	Mission College Site	South Bay	Y (12)	Y	Y	Y (15)	Y	Y	Y	Y	Cartier et al. 1994; Farnsworth et al. 2010; Lippel et al. 2012			
SCL-155	Alviso Adobe	South Bay	N	Y	Y	?	N	Ν	Ν	N	Wilson 2004 (obsidian)			
SCL-268	LamP Lighter	South Bay	Y (4)	Ν	N	N	Y	Y	Y	N	Bard et al. 1984			
SCL-276	-	South Bay	Y (2)	Ν	N	?	N	Ν	Ν	N	Breschini et al. 1996 (C14)			
SCL-287/H	-	South Bay	Y (26)	Y	Y	Y	Y	Y	Y	Y	Holson 2009; Leventhal et al. 2010; Wilson 2004 (obsidian)			
SCL-294	-	South Bay	N	Ν	N	Y (90)	N	Ν	Ν	N	Fong et al. 1988; Richards 1988; Roop et al. 1981			
SCL-300/302	-	South Bay	Y (10)	Y	Y	Y (21)	Y	N	Y	N	Anastasio 1988; Bard and Kobori 1981; Basin Research Associates, Inc. 1981; Busby et al. 1982; Cartier et al. 1993; Roop et al. 1981			
SCL-314	-	South Bay	Y (1)	Ν	N	?	N	Ν	Ν	N	Craft et al. 1978 (C14)			
SCL-317/H	-	South Bay	N	Ν	N	Y (4)	N	Ν	Ν	N	Brock 1986			
SCL-327	-	South Bay	Y (4)	Ν	N	?	N	Ν	Ν	N	Cartier 1988			
SCL-343	Ernst Mound	South Bay	Y (1)	Y	Y	Y (1)	N	Ν	Ν	N	Cambra et al. 1988; Wilson 2004 (obsidian)			
SCL-354	-	South Bay	Y (8)	Ν	N	?	N	Ν	Ν	N	Bocek 1988			
SCL-418	-	South Bay	Y (1)	Y	Y	Y (4)	N	Ν	Ν	Ν	Bocek 1988; Cartier et al. 1993; Kobori and Bard 1980; Roop et al. 1981			
SCL-464	Standford West	South Bay	Y (10)	Y	Y	?	Y	Y	Ν	Ν	Bocek 1992			
SCL-478	Skyport Plaza	South Bay	Y (15)	Y	Y	Y (90)	Y	Y	Y	Y	Wiberg 2002			
SCL-484	-	South Bay	Y (1)	Ν	N	?	N	Ν	Ν	Ν	Breschini et al. 1996 (C14)			
SCL-548	Parkside Glen Apartments Project	South Bay	Y (1)	Y	Y	Y (4)	N	Ν	Ν	Ν	Cartier 1999			
SCL-581	Lands of Oki	South Bay	Y (14)	Y	Y	Y (37)	Y	Ν	Y	N	Anastasio et al. 1988; James et al. 1987; Leventhal et al. 1988			
SCL-583	-	South Bay	Y (1)	Ν	N	?	N	Ν	Ν	N	Gerow 1981 (C14)			
SCL-584	Standford West	South Bay	N	Y	Y	?	Y	Ν	Ν	N	Holson 2009			
SCL-586	Golf Course	South Bay	Y (4)	Ν	N	?	N	Ν	Ν	N	N Bocek 1988; Holson 2009			
SCL-591/H	-	South Bay	Ν	Y	Y	?	Y	Ν	Y	Ν	N Holson 2009			
SCL-592/H	-	South Bay	Ν	Y	Y	?	Y	Ν	Y	Ν	I Holson 2009			
SCL-593	Berryessa Creek Site	South Bay	Y (2)	Ν	Ν	Y (1)	Ν	Ν	Y	Ν	Cartier et al. 1986			
SCL-600	Alma-Adobe Site	South Bay	Y (1)	Ν	N	N	Ν	Ν	Y	Ν	Cartier et al. 1988b			

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SCL-609	Ronald McDonald	South Bay	Y (1)	Ν	N	?	Ν	Ν	Ν	Ν	Bocek 1988				
SCL-613	Childrens Health Council Site	South Bay	Y (13)	Ν	N	?	Y	Y	Y	Y	Bocek 1988; Holson 2009; Jones et al. 1997				
SCL-619	The Elk Site	South Bay	Y (2)	Ν	N	N	N	Ν	Ν	Ν	Carrico and Cartier 1987				
SCL-623	Ochas	South Bay	Y (9)	Ν	N	?	N	Ν	Ν	Ν	Bocek 1988; Holson 2009				
SCL-628	-	South Bay	Y (2)	Y	Y	N	Y	Y	Y	Y	Waechter 2013				
SCL-674	Rubino Site	South Bay	Y (20)	Y	Y	Y (224)	Y	Y	Y	Y	Pastron and Bellifemine 2007				
SCL-677	-	South Bay	Y (5)	Ν	N	Y	Y	Y	Y	Y	Rosenthal 2015				
SCL-678	-	South Bay	N	Ν	N	Y (12)	Y	Y	Y	Ν	James et al. 1990				
SCL-690	Tamien Station	South Bay	Y (13)	Y	Y	Y (129)	Y	Y	Ν	Ν	Cartier et al. 1993; Hylkema 2007				
SCL-755	-	South Bay	Y (4)	Ν	N	Y (21)	N	Ν	Ν	Ν	L. Hylkema 2009; Skrownek 1998; Skrownek and Graham 2009				
SCL-806	-	South Bay	N	Y	Y	Y (17)	N	Ν	Ν	Ν	Wiberg and Moore 1998				
SCL-828	-	South Bay	Y (1)	Ν	N	N	N	Ν	Ν	Ν	White and Thomas 1999				
SCL-829	-	South Bay	Y (1)	Ν	N	N	Y	Ν	Ν	N	York 2000				
SCL-830	Evelyn and Fair Oaks Isolated Burial	South Bay	Y (1)	Ν	N	Y (1)	N	Ν	Ν	N Cartier 2000 N Cartier 2002					
SCL-832	Sunnydale Red burial	South Bay	Y (1)	Ν	N	Y	N	Ν	Ν	Ν	Cartier 2002				
SCL-846/H	Union Pacific Railroad	South Bay	Y (3)	Ν	Y	Y (65)	N	Ν	Ν	N Cartier 2002 N Pesnichak et al. 2004					
SCL-851	-	South Bay	Y (1)	N	N	Y	N	N	Ν	N	Leventhal 2013 personal communication				
SCL-861	Sanborn Avenus (SNI WA03: Alma Improvements Project)	South Bay	Y (3)	N	N	Y (3)	N	N	N	N	Cartier 2006				
SCL-867	Riipin Wareeptak Site	South Bay	Y (1)	Ν	N	Y (1)	N	Ν	Ν	Ν	Leventhal et al. 2007				
SCL-870	-	South Bay	Y (2)	Ν	N	N	N	Ν	Ν	Ν	Leventhal 2013 personal communication				
SCL-894	-	South Bay	Y (1)	Ν	N	Y	N	Ν	Ν	Ν	Leventhal et al. 2012				
SCL-919	Penitencia Creek	South Bay	Y (19)	Ν	N	Y	Y	Y	Y	Y	Kaijankoski et al. in prep				
SCL-928	Great Mall	South Bay	Y (3)	Ν	N	Y	N	Ν	Ν	N	Kaijankoski et al. in prep				
SCL, Sunnyvale Hearth	-	South Bay	Y (1)	Ν	N	N	N	Ν	Ν	Ν	LaJoie, Peterson and Gerow 1980 (C14)				
SCL, Sunnyvale Man	-	South Bay	Y (1)	Ν	N	N	N	Ν	Ν	Ν	LaJoie, Peterson and Gerow 1980 (C14)				
SFR-004/H	Yerba Buena	Southwest Bay	Y (28)	Ν	Y	Y (35)	Y	Y	Y	Y	Morgan and Dexter 2008				
SFR-006/026	Presidio Mound	Southwest Bay	Y (3)	Y	Y	Y (1)	Y	Y	Y	Y	Jones and Stokes 2002				
SFR-007	Crocker/Bay Shore mound	Southwest Bay	N	N	N	Y (28)	Y	N	Y	N	Banks 1981a, 1981b; Gifford 1916 (shellfish & constituents); McCrossin 1981; Nelson 1910d; Rudo 1982				
SFR-017/H	Islais Creek Shellmound	Southwest Bay	Y (3)	Y	Y	N	N	Y	Y	Ν	Fitzgerald and Gmoser 1987; Van Bueren and Love 2008				
SFR-021	Sutro Baths Site	Southwest Bay	N	Ν	N	N	N	Ν	Y	Ν	Holman et al. 1977				
SFR-022H	Notre Dame Plaza	Southwest Bay	N	Y	Y	N	Y	Y	Y	N	N Ambro 2003				
SFR-028	BART women	Southwest Bay	Y (1)	Ν	N	Y	N	Ν	Ν	N	N Henn and Schenk 1970				
SFR-029	Fort Mason	Southwest Bay	Y (1)	Y	Y	N	Y	Y	Y	N	N Baker 1978; Eschmeyer and Schonewald 1981				
SFR-030	Fort Mason	Southwest Bay	Y (1)	Ν	Y	N	Y	Y	Y	N	Baker 1978; Eschmeyer and Schonewald 1981				
SFR-031	Fort Mason	Southwest Bay	N	Ν	Y	N	Y	Y	Y	N	Baker 1978; Eschmeyer and Schonewald 1981				

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SFR-112	-	Southwest Bay	Y (5)	Y	Y	N	Y	Y	Y	Ν	Pastron and Walsh 1988a				
SFR-113	-	Southwest Bay	Y (16)	Y	Y	N	Y	Y	Y	Y	Pastron and Ambro 2005; Pastron and Walsh 1988b				
SFR-114	Yerba Buena	Southwest Bay	Y (15)	Ν	N	Y (11)	Y	Y	Y	Ν	Archeo-Tec 1990; Byrd et al. 2013; Hattori and Pastron n.d., 1993				
SFR-129	Crissy Field Restoration Project	Southwest Bay	Y (7)	Y	Y	N	Y	Y	Ν	Ν	Clark 1998, 2001; Reynolds 2000				
SFR-135/H	-	Southwest Bay	N	Ν	Y	N	Y	Y	Y	Ν	Estes et al. 2001				
SFR-136/H	-	Southwest Bay	Ν	Ν	N	N	N	Ν	Y	Ν	Pastron 2002				
SFR-147	-	Southwest Bay	Y (1)	Y	Y	N	Y	Y	Y	Y	Pastron et al. 2004				
SFR-148	-	Southwest Bay	Y (5)	Y	Y	N	Y	Y	Y	Ν	Crawford 2005				
SFR-151/H	-	Southwest Bay	Y (1)	Ν	N	N	N	Ν	Ν	Ν	Byrd et al. 2010				
SFR-154/H	-	Southwest Bay	Y (2)	Y	Y	N	Y	Y	Y	Ν	Martin 2006				
SFR-155	-	Southwest Bay	Y (3)	Y	Y	N	Y	Y	Y	Y	Pastron et al. 2004				
SFR-171	-	Southwest Bay	Y (2)	Y	Y	N	Y	Y	Y	Y	Byrd and Kaijankoski 2011; Eerkens et al. 2013b (shellfish isotopes)				
SFR-175	-	Southwest Bay	Y (6)	Y	Y	N	Y	Y	Y	Ν	Praetzellis 2015a, 2015b				
SFR-191/H	Ralston Mound	Southwest Bay	Y (2)	Ν	N	N	Y	Ν	Y	N	WSA 2011				
SFR, Transbay Man	Transbay Man	Southwest Bay	Y (1)	Ν	N	Y	N	Ν	Ν	Ν	Meyer 2015				
SMA-004	-	Southwest Bay	N	Ν	N	N	N	Ν	Ν	Ν	Salzman 1984				
SMA-006	-	Southwest Bay	Y (3)	Y	Y	N	Y	Y	Y	Y	Byrd et al. 2012; Eerkens et al. 2013b (shellfish isotopes)				
SMA-022	Princeton Mound	Southwest Bay	N	Ν	N	Y (3)	N	Ν	Ν	Ν	Hylkema 1991; Loud 1912, 1915; Phebus 1973				
SMA-023	San Bruno (Mills Estate)	Southwest Bay	N	Ν	N	Y (44)	N	Ν	Ν	Ν	Drake 1942, 1948; Salzman 1984				
SMA-033	San Mateo Mound	Southwest Bay	N	Ν	N	Y (16)	N	Ν	Y	Ν	Gifford 1916 (shellfish & constituents); Nelson 1911b				
SMA-040	San Bruno Mountain Mound Site	Southwest Bay	Y (16)	Y	Y	N	Y	Y	Y	Ν	Clark 1989				
SMA-072	Mussel Rock	Southwest Bay	Y (2)	Y	Y	N	Y	Ν	Y	Ν	Clark 1986				
SMA-077	University Village	South Bay	Y (17)	Ν	Y	Y	Y	Ν	Y	Ν	Gerow with Force 1968				
SMA-078	-	Southwest Bay	Y (1)	Ν	N	N	Y	Ν	Y	Y	Wiberg 2012				
SMA-083	-	Southwest Bay	Y (2)	Ν	N	N	N	Ν	Ν	Ν	Basin Research Associates, Inc. 2013				
SMA-084	-	South Bay	Y (1)	Y	Y	Y (12)	Y	Y	Y	Ν	Reese et al. 1998				
SMA-100	-	Southwest Bay	Y (1)	Y	Y	N	Y	Y	Y	Ν	Van Dyke 1971				
SMA-101	-	Southwest Bay	N	Ν	N	Y(4)	N	Ν	Ν	Ν	Oliphant n.d., 1971				
SMA-110	-	Southwest Bay	N	Ν	N	Y (3)	N	Ν	Y	Ν	Asturias 1971				
SMA-115	-	Southwest Bay	Y (3)	Ν	N	N	Y	Ν	Y	Ν	Hylkema 2002; Hylkema and Hall 1985				
SMA-125	Filoli	Southwest Bay	Y (6)	Ν	N	Y (46)	N	Ν	Ν	Ν	Galloway 1976; Griffin et al. 2006 (osteology)				
SMA-134	-	Southwest Bay	Y (7)	Y	Y	N	Y	Y	Y	Ν	Hylkema 1998; Simpson et al. 1997				
SMA-139	-	Southwest Bay	Y (3)	Ν	N	?	N	Ν	Ν	Ν	N Hylkema 1991 (CRD)				
SMA-140	-	Southwest Bay	N	Y	N	N	N	Ν	Y	N	N Moratto 1971, 1976				
SMA-147	Crystal Springs	Southwest Bay	N	Ν	N	Y (12)	N	Ν	Ν	N	Salzman 1984				
SMA-150	-	Southwest Bay	Y (11)	Ν	N	Y (9)	N	Ν	Y	Ν	Cartier 2004; Wiberg 1986, 1988				
SMA-151	-	Southwest Bay	Y (2)	Ν	N	Y (1)	Y	Y	Y	Y	Flint et al. 2004; Puseman and Cummings 2005 (plants)				

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SMA-160	Hillier Mound	Southwest Bay	Y (11)	Y	Y	Y (44)	Y	Y	Y	Ν	Bocek 1987, 1992; Cartier 1996
SMA-204	Jasper Ridge	South Bay	Y (3)	Y	Y	N	Y	Y	Y	Y	Bocek 1987, 1988, 1992
SMA-248	Tarlton Site	Southwest Bay	Y (2)	Ν	N	N	N	Ν	Y	Ν	Cartier and Carrico 1988
SMA-256	SLAC 2	South Bay	N	Ν	N	N	N	Ν	Y	Ν	Bocek 1987, 1992:281
SMA-263	Oak Knoll	South Bay	Y (8)	Ν	N	?	N	Ν	Ν	Ν	Bocek 1988; Holson 2009; Leventhal et al. 2010
SMA-266	-	Southwest Bay	Y (2)	Ν	N	N	N	Ν	Ν	Ν	Basin Research Associates, Inc. 2013
SMA-267	-	South Bay	Y (1)	Ν	N	Y (1)	N	Ν	Ν	Ν	Leventhal et al. 2014
SMA-269	-	South Bay	Y (1)	Ν	N	Y (1)	N	Ν	Ν	Ν	Heizer and McGown 1950
SMA-273	Coyote Point	Southwest Bay	Y (1)	Ν	N	Y (1)	N	Ν	Ν	Ν	Leventhal 1987
SMA-314	-	Southwest Bay	Y (2)	Ν	N	N	N	Ν	Y	Ν	Cartier 1999
SMA-335/H	-	Southwest Bay	Y (7)	Y	Y	N	N	Ν	Ν	Ν	Cartier 2000
SMA-368/H	-	Southwest Bay	Y (1)	Y	Y	N	Y	Y	Y	Ν	Fitzgerald 2005
SMA, SFPUC ISO-2	-	Southwest Bay	Y (4)	Ν	N	?	N	Ν	Ν	Ν	Rehor 2013
SOL-011	Jones site	North Delta	Y (10)	Ν	N	Y (48)	N	Ν	Ν	Ν	Snoke 1967; Rosenthal 1996
SOL-025/H	-	North Delta	N	Y	Y	N	N	Ν	Ν	Y	Mikkelsen et al. 1995
SOL-069	-	North Delta	Y (5)	Y	Y	Y (11)	Y	Y	Ν	Y	Wiberg 1992; Wiberg and Bieling 2002; Wiberg et al. 1998
SOL-236	-	North Delta	Y (2)	Ν	N	Y	N	Ν	Ν	Ν	Beardsley 1954:96
SOL-315	-	North Delta	Y (11)	Y	Y	Y (85)	Y	Ν	Ν	Y	Wiberg 1992; Wiberg et al. 1998
SOL-355/H	-	North Delta	Y (3)	Y	N	Y (62)	Y	Y	Y	Y	Wiberg 1993
SOL-356	-	North Delta	Y (5)	Y	Y	Y (2)	Y	Y	Ν	Y	Wiberg 1996
SOL-364	-	North Delta	Y (10)	Ν	N	Y (335)	Y	Y	Y	Y	Coleman et al. 2014
SOL-391	-	North Delta	Y (5)	Ν	N	Y (3)	N	Ν	Ν	Ν	Psota 1997; Psota and Clark 1994
SOL, P-48-00898	Hale site	North Delta	Y (1)	Y	Y	N	Y	Y	Ν	Y	Hildebrandt et al. 2012
SON-0227	-	Northwest Bay	N	Y	Y	Y	Y	Ν	Ν	Ν	Origer and Beard 1998
SON-1082	-	Northwest Bay	N	Y	Y	N	Y	Ν	Y	Ν	Hayes and Fredrickson 1981
SON-2226	-	Northwest Bay	N	Y	Y	N	N	Ν	Ν	Ν	Origer and Beard 1998
SON, Cardoza #2	-	Northwest Bay	N	Ν	Y	Y	N	Ν	Ν	Ν	Phebus 1990
SON, Cardoza #3	-	Northwest Bay	N	Ν	N	N	N	Ν	Ν	Ν	Phebus 1990
SON, Cardoza #4	-	Northwest Bay	N	Ν	Y	N	N	Ν	Ν	Ν	Phebus 1990
SON, Cardoza #5	-	Northwest Bay	N	Ν	N	N	N	Ν	Ν	Ν	Phebus 1990
SON, Cardoza #6	-	Northwest Bay	N	Ν	N	Y	N	Ν	Ν	Ν	Phebus 1990
SON, Cardoza #8	-	Northwest Bay	N	Ν	N	Y	N	Ν	Ν	Ν	Phebus 1990
Note: ^a References in Sec	ction 5. ^b Milliken DB: Randall Milliken's Access	Database of site a	ttributes fo	r centr	al Californi	a.	·	·	*		· · · · · · · · · · · · · · · · · · ·

APPENDIX E

RADIOCARBON DATES BY SITE AND SCHEME D PERIOD WITHIN THE STUDY AREA

		⊦Late Holocene 00-4050 cal BP)	·ly 1 (4050-3550 cal BP)	·ly 2 (3550-3050 cal BP)	·ly 3 (3050-2550 cal BP)	T (2550-2150 cal BP)	idle 1 (2150-1530 cal BP)	idle 2 (1530-1365 cal BP)	Idle 3 (1365-1200 cal BP)	tdle 4 (1200-930 cal BP)	T (930-685 cal BP)	e 1 (685-430 cal BP)	e 2 (430-180 cal BP)	ssion (180-115 cal BP)	toric (post 115 cal BP)	
	Region	Pre (90	Eai	Eai	Eai	Ш	2 Mic	Mic	Mic	Mic	¥	Lat	Lat	Mis	His	Total
ALA-013	East Bay	-	-	- 5	-	- 3	2	-	-	-	-	-	-	-	-	2 25
	East Bay	-	-	-	-	-	-	1		2	11		_	-	<u> </u>	14
AL A-046	East Bay	-	-	-				- '	-	1	1	-	-	-	<u> </u>	2
AL A-060	Fast Bay	-	1	-	1	2	1	1	-	-	2	-	-	-	-	8
ALA-307	East Bay	7	5	13	9	3	3	-	1	1	-	-	-	-	-	42
ALA-309	East Bay	-	-	-	13	23	27	-	2	7	3	1	-	-	-	76
ALA-310	East Bay	-	-	-	1	-	-	-	-	-	1	10	6	-	-	18
ALA-312	East Bay	1	7	1	-	1	-	-	-	-	-	-	-	-	-	10
ALA-328	East Bay	-	-	-	-	2	6	-	-	-	-	-	-	-	-	8
ALA-329	East Bay	-	-	-	-	-	6	3	3	13	5	18	5	-	-	53
ALA-343	South Bay	-	-	-	-	-	-	-	7	1	-	1	-	-	-	9
ALA-413	East Bay	-	-	-	-	-	6	16	-	-	-	-	-	-	-	22
ALA-424	South Bay	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
ALA-428/H	East Bay	-	-	-	-	-	-	-	-	-	1	2	1	-	-	4
ALA-479	East Bay	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
ALA-483	East Bay	-	1	1	1	-	-	1	-	-	1	1	-	-	-	6
ALA-485	East Bay	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
ALA-486	East Bay	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
ALA-514/H	South Bay	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
ALA-554	East Bay	-	-	-	-	-	-	-	-	8	3	7	-	-	-	18
ALA-555	East Bay	-	-	-	-	1	4	-	-	-	-	4	3	-	-	12
ALA-566	East Bay	1	-	-	-	-	-	-	-	-	1	1	-	-	-	3
ALA-574	East Bay	-	-	-	1	-	1	-	-	-	-	-	-	-	-	2
ALA-576	South Bay	-	-	-	-	-	1	-	1	-	-	2	1	-	-	5
ALA-586	East Bay	-	-	-	-	-	-	1	1	1	-	-	-	-	-	3
ALA-604	East Bay	-	-	-	-	-	-	-	-	-	3	8	-	-	-	11
ALA-613/H	East Bay	-	-	-	-	1	-	-	-	-	3	5	1	-	-	10
ALA-621	South Bay	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2
ALA, P-01-011556	South Bay	6	-	-	-	-	-	-	-	-	-	-	-	-	-	6
CCO-009	South Delta	-	-	-	-	-	2	-	-	-	-	-	2	-	-	4
CCO-014	East Bay	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2
CCO-018/H	South Delta	24	98	71	4	-	2	1	1	4	-	1	1	1	-	208
CCO-030	South Delta	-	-	-	-	-	-	-	-	-	-	3	1	-	-	4
CCO-124	East Bay	-	-	-	-	-	-	-	-	2	-	-	1	-	-	3
CCO-129/138	South Delta	-	-	-	-	-	-	-	-	1	1	1	1	1	-	5
000-151	East Bay	-	-	-	-	-	-	2	2	2	-	-	-	-	-	6
000-156	East Bay	-	-	-	-	-	-	-		-	-	-	-	-	-	1
000-222	South Dalta	-	-	-		-		-	-	-	-	-	-	-	-	2
000.050	South Delta	-	-	-	-	-	-	-	-	-	-	9		-	-	10
000-259	East Bay	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1

		ə-Late Holocene 100-4050 cal BP)	rly 1 (4050-3550 cal BP)	rly 2 (3550-3050 cal BP)	rly 3 (3050-2550 cal BP)	IT (2550-2150 cal BP)	ddle 1 (2150-1530 cal BP)	ddle 2 (1530-1365 cal BP)	ddle 3 (1365-1200 cal BP)	ddle 4 (1200-930 cal BP)	.T (930-685 cal BP)	te 1 (685-430 cal BP)	te 2 (430-180 cal BP)	ssion (180-115 cal BP)	storic (post 115 cal BP)	
Site	Region East Bay	- Ar	Еа	Ша	<u>в</u> 1		Ň	Ň	Ĕ	Ň	M	La	La	Μï	ΞÏ	1 otal
CCO-269	East Bay	-		-	2	3	2	3	1	3	-	-	-	-	<u> </u>	14
CCO-270	East Bay	-	-	-	-	1	2	-	-	-	-	1	-	-	-	4
CCO-271	East Bay	-	-	-	1	-	4	1	-	-	-	-	-	-	-	6
CCO-290	East Bay	-	-	-	-	-	-	-	-	4	4	7	4	-	-	19
CCO-295	East Bay	-	-	2	-	-	-	-	-	1	-	1	3	-	-	7
CCO-297	East Bay	-	-	-	1	-	-	-	-	-	3	3	17	-	-	24
CCO-298	East Bay	1	-	2	2	-	-	-	-	-	-	-	-	-	-	5
CCO-308	South Delta	1	-	1	2	-	-	-	-	2	3	1	-	-	-	10
CCO-309	South Delta	3	1	3	-	-	-	-	-	-	-	-	1	-	-	8
CCO-320/H	South Delta	-	-	-	-	-	1	-	-	-	-	-	2	-	-	3
CCO-368	South Delta	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2
CCO-397	South Delta	-	-	-	-	-	-	-	-	-	1	1	2	2	2	8
CCO-431	South Delta	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
CCO-447	South Delta	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
CCO-450	South Delta	2	3	-	-	-	2	-	-	-	-	-	1	-	-	8
CCO-459	South Delta	-	-	-	-	-	-	-	1	-	-	1	-	-	-	2
CCO-462/468	South Delta	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
CCO-474/H	East Bay	1	-	-	-	-	2	-	-	-	-	-	1	-	-	4
CCO-538	South Delta	-	-	-	-	-	-	-	-	1	2	-	-	-	-	3
CCO-600	East Bay	-	-	-	-	-	2	-	-	1	-	-	-	-	-	3
CCO-601	East Bay	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
CCO-636	South Delta	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
CCO-637	South Delta	6	-	-	1	-	-	-	-	-	-	-	-	-	-	7
CCO-655	East Bay	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
CCO-696	South Delta	3	-	1	3	3	2	1	2	-	2	-	-	-	-	17
CCO-725	South Delta	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
CCO-726/H	South Delta	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
CCO-750	East Bay	-	-	-	-	-	1	-	-	-	-	-	1	-	-	2
CCO-755	South Delta	-	-	-	-	-	1	-	-	-	-	-	4	-	-	5
CCO-767	South Delta	-	-	-	-	-	-	-	-	-	1	3	-	-	-	4
CCO-832	South Delta	1	-	-	2	-	1	-	3	-	-	-	3	1	-	11
MRN-005/H	Northwest Bay	-	-	-	-	-	-	-	-	-	1	-	3	-	-	4
MRN-014	Northwest Bay	-	-	-	-	-	-	-	1	1	-	-	-	-	-	2
MRN-017	Northwest Bay	3	-	-	-	2	1	-	-	-	-	-	-	-	-	6
MRN-027	Northwest Bay	-	-	-	-	1	1	-	-	-	-	-	-	-	-	2
MRN-039	Northwest Bay	-	-	-	-	-	4	1	-	-	4	-	-	-	-	9
MRN-042	Northwest Bay	-	-	-	-	-	-	-	-	-	-			-	-	2
MDN 007	Northwest Bay	-	-	-	-		2	-	4	4	-	2		-	-	14
	Northwest Bay	ïb		3	11	4	2	-	-		-	-	-	-	-	58
WIKIN-114	Northwest Bay	-	-	-	-	-	-	-	-	1	-	1	2	-	-	4

		te Holocene 1050 cal BP)	(4050-3550 cal BP)	(3550-3050 cal BP)	(3050-2550 cal BP)	:550-2150 cal BP)	1 (2150-1530 cal BP)	2 (1530-1365 cal BP)	3 (1365-1200 cal BP)	4 (1200-930 cal BP)	30-685 cal BP)	(685-430 cal BP)	(430-180 cal BP)	n (180-115 cal BP)	c (post 115 cal BP)	
Site	Perion	re-La 000-∠	arly 1	arly 2	arly 3	MT (2	iddle	iddle	iddle	iddle	LT (9	ate 1	ate 2	issio	istori	Total
MRN-115	Northwest Bay	- <u>-</u> -	<u>ш</u> -	<u>ш</u> -	<u>ш</u> -	· 🖂	<u>Σ</u> .	<u>Σ</u> .	<u>Σ</u> .	2	<u>≥</u>	ت -	2	<u>Σ</u> .	<u> </u>	3
MRN-127	Northwest Bay	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
MRN-138	Northwest Bay	-	-	-	1	-	1	-	-	-	-	-	-	-	-	2
MRN-150	Northwest Bay	-	-	-	-	-	-	-	-	-	-	5	-	-	-	5
MRN-152	Northwest Bay	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2
MRN-170	Northwest Bay	-	-	-	-	-	-	-	1	-	-	1	-	-	-	2
MRN-193	Northwest Bay	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2
MRN-194	Northwest Bay	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
MRN-195	Northwest Bay	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
MRN-196	Northwest Bay	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
MRN-254	Northwest Bay	-	-	-	-	-	3	-	1	6	-	2	1	-	-	13
MRN-255/H	Northwest Bay	-	-	-	-	4	1	-	-	-	-	-	-	-	-	5
MRN-327	Northwest Bay	-	-	-	-	-	-	-	-	-	-	1	-	1	-	2
MRN-328	Northwest Bay	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
MRN-471	Northwest Bay	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
MRN-495	Northwest Bay	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2
NAP-015/H	Northwest Bay	-	3	1	-	-	-	-	-	1	-	-	2	1	-	8
NAP-189/H	Northwest Bay	5	1	-	4	-	2	1	5	-	-	-	6	2	-	26
NAP-795	Northwest Bay	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
SCL-001	South Bay	-	-	1	-	-	2	-	-	1	-	-	-	-	-	4
SCL-004	South Bay	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
SCL-006E	South Bay	-	-	-	-	-	-	-	-	-	-	-	3	-	-	3
SCL-006W	South Bay	-	-	-	-	-	-	-	-	1	4	5	1	-	-	11
SCL-007	South Bay	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
SCL-012/H	South Bay	1	-	3	6	1	-	-	2	1	-	-	-	-	-	14
SCL-030/H	South Bay	-	-	-	-	1	-	-	-	-	-	1	4	1	-	7
SCL-038	South Bay	2	-	-	-	1	2	1	-	4	11	15	5	-	-	41
SCL-065	South Bay	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
SCL-068	South Bay	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2
SCL-070	South Bay	-	-	-	1	-	2	-	-	-	1	-	-	-	-	4
SGL-128	South Bay	-	-	-	-	-		-	2	-	-	2		-	-	0
SCL-134	South Day	-	-	2	2	2	-	3	-	3	-	-	-	-	-	12
SUL-208	South Bay	-	-	-	-	-	-	-	-	1		1	1	-	-	4
SCL-270	South Bay	-	-	-	-	-	-	1	-	-	-	2	-	-	-	2
SCL-300/302	South Bay	-	-	-	-	-	12 A	5	1	-	-	-	-	-	-	10
SCI -314	South Bay		-	_	-		-	-	1	_						1
SCI -327	South Bay		-	-	-	1	1	-		-	2	-		-	-	4
SCI -343	South Bay	-	-	-	-			-	-	-	1	-	-	-	-	1
SCI -354	South Bay	-	-	1	1	-	6			_	-	_	_	-	-	8
SCI -418	South Bay	_	_	-	1	-	-	-	-	_	-	_		_	-	1
	South Day	-		-	'	ΙĨ	ΙĨ	1	1	1 -	1	1 -		1 -	1	

		ene BP)	550 cal BP)	050 cal BP)	550 cal BP)) cal BP)	1530 cal BP)	1365 cal BP)	1200 cal BP)	930 cal BP)	al BP)	cal BP)	cal BP)	l5 cal BP)	15 cal BP)	
		loloc 0 cal l	50-3	50-3	50-2	-215(2150-	1530-	1365-	1200-	685 c	5-430	0-180	80-11	ost 1	
		_ate	1 (40	, 2 (35	3 (30	(2550	le 1 (;	le 2 (le 3 (le 4 ((930-	1 (68	2 (43	ion (1	oric (p	
Site	Region	Pre-L (900(Early	Early	Early	EMT	Midd	Midd	Midd	Midd	MLT	Late	Late	Miss	Histo	Total
SCL-464	South Bay	-	-	1	1	-	1	2	1	2	1	1	-	-	-	10
SCL-478	South Bay	-	-	-	1	9	4	-	-	-	-	-	1	-	-	15
SCL-484	South Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SCL-548	South Bay	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
SCL-581	South Bay	-	-	1	1	-	4	2	3	-	-	2	1	-	-	14
SCL-583	South Bay	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
SCL-586	South Bay	-	-	-	-	-	2	-	2	-	-	-	-	-	-	4
SCL-593	South Bay	-	-	-	-	-	-	-	-	1	1	-	-	-	-	2
SCL-600	South Bay	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
SCL-609	South Bay	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
SCL-613	South Bay	2	4	2	2	-	1	1	-	-	1	-	-	-	-	13
SCL-619	South Bay	-	-	-	-	-	-	-	1	-	-	-	1	-	-	2
SCL-623	South Bay	2	1	-	-	1	1	1	-	1	1	1	-	-	-	9
SCL-628	South Bay	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
SCL-674	South Bay	1	-	-	-	5	10	-	-	-	2	1	1	-	-	20
SCL-677	South Bay	-	-	-	-	-	3	-	-	-	-	1	1	-	-	5
SCL-690	South Bay	-	-	-	-	-	-	-	-	1	6	6	-	-	-	13
SGL-755	South Bay	-	-	1	-	1	4	3	9	5	-	-	-	-	-	23
SCL-020	South Bay	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
SCL-029	South Bay	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
SCL-030	South Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SCL-846/H	South Bay		-	-	-	-	-	-	-	-	-	- 3	-	-	-	1 3
SCL-040/11	South Bay	-	-	-	-	-	-	-	-	-	-	5	-	-	-	3 1
SCL-861	South Bay	-	-	-	-	-	-	-	-	1	2	-	-	-	-	3
SCL-867	South Bay	-	-	-	-	-	-	-	-	1	2	-	-	-	-	3 1
SCL-870	South Bay	-	-	-	-	-	-	_	2	_	_	_	_	_	_	2
SCI -894	South Bay	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
SCI -919	South Bay	-		-	-	-	-	-	-	-	1	8	10	-	-	19
SCI -928	South Bay	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3
SCL. Sunnyvale Hearth	South Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SCL. Sunnyvale Man	South Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SFR-004/H	Southwest Bay	-	7	-	-	1	3	5	4	-	4	3	-	1	-	28
SFR-006/026	Southwest Bay	-	-	-	-	-	-	-	-	2	1	-	-	-	-	3
SFR-017/H	Southwest Bay	-	-	-	-	1	-	-	-	-	2	-	-	-	-	3
SFR-028	Southwest Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SFR-029	Southwest Bay	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
SFR-030	Southwest Bay	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
SFR-112	Southwest Bay	-	-	-	-	-	1	2	1	1	-	-	-	-	-	5
SFR-113	Southwest Bay	-	-	-	-	1	15	-	-	-	-	-	-	-	-	16
SFR-114	Southwest Bay	-	1	-	-	-	1	7	3	2	1	-	-	-	-	15

		Late Holocene 0-4050 cal BP)	y 1 (4050-3550 cal BP)	y 2 (3550-3050 cal BP)	y 3 (3050-2550 cal BP)	⁻ (2550-2150 cal BP)	dle 1 (2150-1530 cal BP)	dle 2 (1530-1365 cal BP)	dle 3 (1365-1200 cal BP)	dle 4 (1200-930 cal BP)	. (930-685 cal BP)	i 1 (685-430 cal BP)	: 2 (430-180 cal BP)	sion (180-115 cal BP)	oric (post 115 cal BP)	
Site	Region	Pre- (900	Earl	Earl	Earl	EMJ	Mid	Mid	Mid	Mid	MLT	Late	Late	Mis	Hist	Total
SFR-129	Southwest Bay	-	-	-	-	-	-	-	-	-	-	3	3	1	-	7
SFR-147	Southwest Bay	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
SFR-148	Southwest Bay	-	-	-	-	1	3	-	-	-	-	-	-	1	-	5
SFR-151/H	Southwest Bay	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
SFR-154/H	Southwest Bay	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2
SFR-155	Southwest Bay	-	-	-	-	-	3	-	-	-	-	-	-	-	-	3
SFR-1/1	Southwest Bay	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
SFR-175	Southwest Bay	-	-	-	-	-	-	1	4	1	-	-	-	-	-	0
SFR-191/H	Southwest Bay	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	Southwest Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
SMA-000	Southwest Bay	-	-	-	-	-	-	-	-	-	-	1	2	-	-) 10
SMA-040	Southwest Bay	2		2	1	2	5	2	2	-	-	1 2	-	-	-	10
SMA-072	South Bay	-	- 2	-	- 5	2	-	-	-	-	-	2	-	-		2 10
SMA-078	Southwest Bay	-	2	9	5	2	1	-	-	-	-	-	-	-		15
SMA-083	Southwest Bay	_		_	_	_	'		1			1	_	_		2
SMA-083	South Bay	-		-	-	-	-	1					-	-		1
SMA-100	Southwest Bay	-		-	-	-	-	-	-	1	-	-	-	-	-	1
SMA-115	Southwest Bay	-	-	-	-	-	-	-	-	-	-	3	-	-	-	3
SMA-125	Southwest Bay	-	-	-	-	-	-	-	-	1	4	1	-	-	-	6
SMA-134	Southwest Bay	-	-	-	-	-	-	-	-	-	3	4	-	-	-	7
SMA-139	Southwest Bay	-	-	-	-	-	-	-	-	1	2	-	-	-	-	3
SMA-150	Southwest Bay	3	-	-	4	-	3	1	-	-	-	-	-	-	-	11
SMA-151	Southwest Bay	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2
SMA-160	Southwest Bay	-	-	-	-	-	-	1	-	3	3	4	-	-	-	11
SMA-204	South Bay	-	-	-	-	-	-	-	-	1	-	1	-	1	-	3
SMA-248	Southwest Bay	-	-	-	-	1	1	-	-	-	-	-	-	-	-	2
SMA-263	South Bay	1	-	1	-	1	1	1	1	-	1	1	-	-	-	8
SMA-266	Southwest Bay	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2
SMA-267	South Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SMA-269	South Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SMA-273	Southwest Bay	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
SMA-314	Southwest Bay	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
SMA-335/H	Southwest Bay	-	-	-	-	4	2	-	-	-	1	-	-	-	-	7
SMA-368/H	Southwest Bay	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
SMA, SFPUC ISO-2	Southwest Bay	-	-	-	-	-	-	-	1	2	1	-	-	-	-	4
SOL-011	North Delta	-	-	-	-	1	8	-	1	-	-	-	-	-	-	10
SOL-069	North Delta	2	1	2	-	-	-	-	-	-	-	-	-	-	-	5
SOL-236	North Delta	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2
SOL-315	North Delta	7	-	-	-	1	1	-	-	-	-	1	1	-	-	11
SOL-355/H	North Delta	-	1	-	1	-	-	-	1	-	-	-	-	-	-	3

Appendix E. Radiocarbon Dates (count) by Site and Scheme D2 Chronological Framework within the Study Area.

Site	Region	Pre-Late Holocene (9000-4050 cal BP)	Early 1 (4050-3550 cal BP)	Early 2 (3550-3050 cal BP)	Early 3 (3050-2550 cal BP)	EMT (2550-2150 cal BP)	Middle 1 (2150-1530 cal BP)	Middle 2 (1530-1365 cal BP)	Middle 3 (1365-1200 cal BP)	Middle 4 (1200-930 cal BP)	MLT (930-685 cal BP)	Late 1 (685-430 cal BP)	Late 2 (430-180 cal BP)	Mission (180-115 cal BP)	Historic (post 115 cal BP)	Total
SOL-356	North Delta	-	-	-	-	-	-	-	-	-	1	1	3	-	-	5
SOL-364	North Delta	-	-	-	-	-	7	1	2	-	-	-	-	-	-	10
SOL-391	North Delta	2	2	1	-	-	-	-	-	-	-	-	-	-	-	5
SOL, P-48-898	North Delta	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Total		124	149	136	94	97	236	78	90	113	123	197	130	18	2	1587

APPENDIX F

APPROACH USED FOR RADIOCARBON CALIBRATION TO CORRECT FOR PERCENTAGE OF MARINE INFLUENCE ON HUMAN BONE
If C12/13 Value is:	Then % of Marine=0	For Human Bone Dates
0.00	1.00	Assumes 100% Marine
-1.00	0.95	↑
-2.00	0.90	
-3.00	0.85	
-4.00	0.80	
-5.00	0.75	
-6.00	0.70	
-7.00	0.65	
-8.00	0.60	
-9.00	0.55	
-10.00	0.50	50% Marine
-11.00	0.45	
-12.50	0.38	
-13.00	0.35	
-14.00	0.30	
-15.00	0.25	
-16.00	0.20	
-17.00	0.15	
-18.00	0.10	
-19.00	0.05	₩
-20.00	0.00	Assumes 100% Terrestrial

Appendix F. Approach Used for Radiocarbon Calibration to Correct for the Percentage of Marine Influence on Human Bone.

APPENDIX G

CULTURAL SIGNIFICANCE SCORES FOR PLANTS AND ANIMALS USED FOR IDEAL FREE DISTRIBUTION STUDY

MAMMALS	Latin Name	ICS SCORE		Fo	od		Stor	red fo	or Fu	ture	Rav ir	v Mat nplei	erial nent	for s	Skir bed	n for cloth ding crac	blan ning, , qui Idle	ket, ver,	Chai Gar	rms f nblin	for L Ig, Lo	uck, ove		01	ther	
			u	i	е	Р	u	i	е	Р	u	i	е	Р	u	i	е	Р	u	i	е	Р	u	i	е	Р
	Max Utility for	r Category	5				5				4				4				2							
Deer	Odocoileus columbianus	138	5	5	2	50	5	4	1	20	4	3	2	24	4	4	1	16	-	-	-	-	2b/4d	3/2	3/2	12/16
Bears	Ursus spp.	27	5	2	0.5	5	5	2	1	10	-	-	-	•	4	2	1	8	2	2	1	4	-	-	-	-
Dog		42	5	2	1	10	-	-	-	-	-	-	-	•	-	-	-	-	-	-	-	-	4a	4	2	32
Raccoon	Proyon lotor	34	5	2	1	10	-	-	-	-	-	-	-	-	4	3	1	12	-	-	-	-	2a	3	2	12
Ring-tail cat		8	-	-	-	-	-	-	-	-	-	-	-	•	4	2	1	8	-	-	-	-	-	-	-	-
Fisher		8	-	-	-	-	-	-	-	-	-	-	-	•	4	2	1	8	-	-	-	-	-	-	-	-
Mink		8	-	-	-	-	-	-	-	-	-	-	-	•	4	2	1	8	-	-	-	-	-	-	-	-
Sea Otter		24	-	-	-	-	-	-	-	-	-	-	-	•	4	3	2	24	-	-	-	-	-	-	-	-
Skunk	Mephitis mephitis	37	5	1	1	5	-	-	-	-	-	-	-	•	4	3	1	12	2	2	1	4	2a/2c	2/2	2/2	8/8
Gray Fox	Urocyon cinereoargenteus	12	-	-	-	-	-	-	-	-	-	-	-	•	4	3	1	12	-	-	-	-	-	-	-	-
Coyote	Canis latrans	0	-	-	-	-	-	-	-	-	-	-	1	•	-	-	-	-	-	-	-	-	-	-	-	-
Mountain Lion	Felis concolor	27	5	2	0.5	5	5	2	1	10	-	-	-	•	4	3	1	12	-	-	-	-	-	-	-	-
Bobcat		18	5	2	1	10	-	-	-	-	-	-	-	•	4	2	1	8	-	-	-	-	-	-	-	-
Mole		8	-	-	-	-	-	-	-	-	-	-	-	•	4	2	1	8	-	-	-	-	-	-	-	-
Tree Squirrel		27	5	3	1	15	-	-	-	-	4	3	1	12	-	-	-	-	-	-	-	-	-	-	-	-
Ground Squirrel		15	5	3	1	15	-	-	-	-	-	-	-	•	-	-	-	-	-	-	-	-	-	-	-	-
Gopher		15	5	3	1	15	-	-	-	-	-	-	-	•	-	-	-	-	-	-	-	-	-	-	-	-
Field Mouse		15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Woodrat		15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rat		22	5	2	1	10	-	-	-	-	-	-	1	•	4	2	1	8	2	2	1	4	-	-	-	-
Jackrabbit		87	5	4	2	40	5	3	1	15	-	-	1	•	4	4	2	32	-	-	-	-	-	-	-	-
Brushrabbit		40	5	4	2	40	-	-	-	-	-	-		•	-	-	-	-	-	-	-	-	-	-	-	-
Whale		21	5	2	0.5	5	-	-	-	-	-	-		•	-	-	-	-	2	2	1	4	3f	2	2	12
Harbor Seal		15	5	3	1	15	-	-	-	-	-	-	-	•	-	-	-	-	-	-	-	-	-	-	-	-
Sea Lion		12	-	-	-	-	-	-	-	-	-	-	-	•	4	3	1	12	-	-	-	-	-	-	-	-
Notes: u – Utility; instruments, effigi	i – Intensity; e – Exclusivity; P=(u es.	*i*e).a-F	Pets;	b – E	Enter	tainm	ient; d	c – Pe	ersor	al ad	lornm	ient; (d – R	aw n	nateri	al for	con	struct	ion; f	– Cu	iring	imple	ements/	music	al	

Appendix G1. Ethnozoology Index of Cultural Significance Values for Mammals.

Appendix G2. Ethnozoology Index of Cultural Significance Values for Birds.

BIRDS	ICS SCORE		Fo	od			Eggs	Eaten		Raw M	aterial f	or imple	ements	Raw	Material	for Bas	ketry		Otl	ner	
Common Name	000nL	u	i	е	Р	u	i	е	Р	u	i	е	Р	u	i	е	Р	u	i	е	Р
Max Uti	lity for Category	5				5				4				3							
Band-Tailed Pidgeon	10	5	2	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
California Valley Quail	20	5	2	1	10	5	2	1	10	-	-	-	-	3	2	-	0	-	-	-	-
Quail	10	5	2	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sooty Grouse	10	5	2	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turkey Vulture/condor	8	-	-	-	-	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Osprey	8	-	-	-	-	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Red-tailed hawk	18	5	2	1	10	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Gulls	20	5	2	1	10	5	2	1	10	-	-	-	-	-	-	-	-	-	-	-	-
Screech Owl	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horned Owl	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brown Pelican	12	-	-	-	-	-	-	-	-	4	2	1	8	-	-	-	-	2c	2	1	4
Cormorant	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great Blue Heron	8	-	-	-	-	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Geese	46	5	3	2	30	-	-	-	-	-	-	-	-	-	-	-	-	4f	2	2	16
Various Ducks	54	5	4	2	40	-	-	-	-	-	-	-	-	3	2	1	6	2a	2	2	8
Coot	15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mudhen	30	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-	5d	3	1	15
California Woodpecker	22	-	-	-	•	-	-	-	-	-	-	-	-	3	2	1	6	4b	2	2	16
Flicker	13	5	2	0.5	5	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Crested Jay	5	5	2	0.5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Varied Thrush	5	5	2	0.5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Robin	5	5	2	0.5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Meadowlark	5	5	2	0.5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sandpiper	5	5	2	0.5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crow	8	-	-	-	-	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Goldfinch	8	-	-	-	-	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Red-winged blackbird	8	-	-	-	-	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Crane/Heron	8	-	-	-	-	-	-	-	-	4	2	1	8	-	-	-	-	-	-	-	-
Golden Eagle	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2c	2	1	4
Notes: u – Utility; i – Intens	ity; e – Exclusivity	; P=(u *	i*e).a-	- Enterta	inment;	b – Othe	er food; o	c – Char	ms for Li	uck, Gar	nbling, L	ove; d –	Stored f	or future	use; f-	Skin for	blanket	, clothing	, beddin	g, etc.	

		Fo	od			Eggs	Eaten		S	tored fo	or Futu	re	R	taw Ma imple	terial fo ments	or
JUOKE	u	i	е	Р	u	i	е	Р	u	i	е	Р	u	i	e	Р
ility for Category	5				5				5				4			
0	-	-	-	-	-	-	-	-	-	- 1	-	-	-	-	-	-
10	5	2	1	10	-	-	-	-	-	-	-	-	-	-	-	-
15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	5	3	1	15	-	-	-	-	5	3	1	15	-	-	-	-
15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-
15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-
27	5	3	1	15	-	-	-	-	_	-	-	-	3	2	2	12
70	5	4	1	20	5	2	1	10	5	4	2	40	-	-	-	-
25	5	2	1	10	-	-	-	-	5	3	1	15	-	-	-	-
20	5	4	1	20	-	-	-	-	-	-	-	-	-	-	-	-
25	5	3	1	15	5	2	1	10	_	-	-	-	-	-	-	-
15	5	3	1	15	-	-	-	-	_	-	-	-	-	-	-	-
45	5	3	1	15	5	2	1	10	5	4	1	20	-	-	-	-
15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-
15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	5	3	1	15	-	-	-	-	_	-	-	-	-	-	-	-
15	5	3	1	15	-	-	-	-	-	-	-	-	-	-	-	-
10	5	2	1	10	-	-	-	-	-	-	-	-	-	-	-	-
10	5	2	1	10	-		-	-		-	-	-	-	-	-	-
	ICS SCORE ility for Category 0 10 15 0 30 15 27 70 25 20 25 10 10	ICS SCORE u ility for Category 5 0 - 10 5 15 5 0 - 30 5 15 5 27 5 27 5 20 5 25 5 20 5 15 5	ICS SCORE Formation 0 - 0 - 10 5 15 5 30 5 15 5 30 5 15 5 27 5 20 5 21 5 30 5 31 5 27 5 30 5 27 5 30 5 31 5 32 70 5 3 15 5 31 5 32 5 33 3 15 5 33 3 15 5 31 5 32 5 33 3 15 5 31 5 32 5 33 3	ICS SCORE Food u i e ility for Category 5 - 0 - - 10 5 2 1 15 5 3 1 0 - - - 30 5 3 1 15 5 3 1 15 5 3 1 15 5 3 1 27 5 3 1 20 5 4 1 25 5 2 1 20 5 4 1 25 5 3 1 15 5 3 1 15 5 3 1 15 5 3 1 15 5 3 1 15 5 3 1 15 5 3 1	ICS SCORE Food u i e P ility for Category 5	ICS SCORE Food u i e P u ility for Category 5 5 5 0 - - - 5 10 5 2 1 10 - 10 5 2 1 10 - 10 5 3 1 15 - 0 - - - - - 30 5 3 1 15 - 30 5 3 1 15 - 15 5 3 1 15 - 70 5 4 1 20 5 25 5 2 1 10 - 20 5 4 1 20 - 215 5 3 1 15 - 225 5 3 1 15 -	ICS SCORE Food Eggs u i e P u i 10 5 10 5 2 1 10 10 5 2 1 10 10 5 2 1 10 10 5 2 1 10 10 5 3 1 15 0 30 5 3 1 15 15 5 3 1 15 27 5 3 1 15 20 5 4 1 20 25 5 3 1	ICS SCORE Food Eggs Eaten u i e P u i e ility for Category 5 <t< td=""><td>ICS SCORE Food Eggs Eaten u i e P u i e P ility for Category 5 5 0 10 5 10 5 10 10 15 15 15 15 </td><td>ICS SCORE Fool Eggs Eaten S ility for Category 5 5 5 5 5 0 - - - 5 5 5 0 -</td><td>ICS SCORE Food Eggs Eaten Stored for ility for Category 5 - - 5 - 5 5 5 0 - - - 5 - - 5 5 5 5 10 5 2 1 10 - <td< td=""><td>ICS SCORE Food Eggs Eaten Stored for Future ility for Category 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0</td><td>ICS SCORE Food Eggs Eaten Stored for Future u i e P u i e P u i e P iity for Category 5 </td><td>ICS SCORE Food Eggs Eaten Stored for Future R 11/14 for Category 5 5 5 5 5 6 4 4 0 - - 5 - 5 5 5 4 4 0 - - - - - - 5 5 4 4 0 -</td><td>LCS SCORE Foot Foot Eggs Eaten Stored for Future Raw Mainple 11/14 for Category 5 0 5 0 5 0 6 0 5 0</td><td>ICS SCORE I Fool I Eggs Eate Stored for Future Raw Material for implements 10 1 e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e A i</td></td<></td></t<>	ICS SCORE Food Eggs Eaten u i e P u i e P ility for Category 5 5 0 10 5 10 5 10 10 15 15 15 15	ICS SCORE Fool Eggs Eaten S ility for Category 5 5 5 5 5 0 - - - 5 5 5 0 -	ICS SCORE Food Eggs Eaten Stored for ility for Category 5 - - 5 - 5 5 5 0 - - - 5 - - 5 5 5 5 10 5 2 1 10 - <td< td=""><td>ICS SCORE Food Eggs Eaten Stored for Future ility for Category 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0</td><td>ICS SCORE Food Eggs Eaten Stored for Future u i e P u i e P u i e P iity for Category 5 </td><td>ICS SCORE Food Eggs Eaten Stored for Future R 11/14 for Category 5 5 5 5 5 6 4 4 0 - - 5 - 5 5 5 4 4 0 - - - - - - 5 5 4 4 0 -</td><td>LCS SCORE Foot Foot Eggs Eaten Stored for Future Raw Mainple 11/14 for Category 5 0 5 0 5 0 6 0 5 0</td><td>ICS SCORE I Fool I Eggs Eate Stored for Future Raw Material for implements 10 1 e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e A i</td></td<>	ICS SCORE Food Eggs Eaten Stored for Future ility for Category 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0 0 5 0	ICS SCORE Food Eggs Eaten Stored for Future u i e P u i e P u i e P iity for Category 5	ICS SCORE Food Eggs Eaten Stored for Future R 11/14 for Category 5 5 5 5 5 6 4 4 0 - - 5 - 5 5 5 4 4 0 - - - - - - 5 5 4 4 0 -	LCS SCORE Foot Foot Eggs Eaten Stored for Future Raw Mainple 11/14 for Category 5 0 5 0 5 0 6 0 5 0	ICS SCORE I Fool I Eggs Eate Stored for Future Raw Material for implements 10 1 e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e P u i e A i

Appendix G3. Ethnozoology Index of Cultural Significance Values for Reptiles, Fish, and Insects.

MARINE INVERTEBRATES	ICS SCORE		Fo	od		Ste	ored f	or Fut	ture	Ra	aw Mat implei	terial f ments	or	Cł G	arms ambli	for Lu ng, Lo	ve	R	aw Ma Bas	iterial ketry	for		Mor	ney	
	ooon12	u	i	е	Р	u	i	e	e P	u	i	e	Р	u	i	e	Р	u	I	i e	P	u	i	e	P
Max Uti	lity for Category	5				5				4				2				3				4			
Black Turban	15	5	3	1	15	-	-	-		-	-	-	-	-	-	-	-	-			-	-	-	-	-
Brown Turban	15	5	3	1	15	-	-	-	• •	-	-	-	-	-	-	-		-			-	-	-	-	
Goose barnacle	30	5	3	1	15	5	3	1	15	-	-	-	-	-	-	-	- 1	-			-	-	-	-	
Sea Urchin	10	5	2	1	10	-	-	-	· -	-	-	-	-	-	-	-	-	-	· -	· -	-	-	-	-	-
Purple Shell snal	5	5	1	1	5	-	-	-	· -	-	-	-	-	-	-	-	•	-			-	-	-	-	•
Limpets	10	5	2	1	10	-	-	-	• •	-	-	-	-	-	-	-	-	-				-	-	-	-
Sea Anenomes	10	5	2	1	10	-	-	-	• •	-	-	-	-	-	-	-	-	-				-	-	-	-
Large Crabs	10	5	2	1	10	-	-	-	· -	-	-	-	-	-	-	-	- 1	-			-	-	-	-	-
Octopus	10	5	2	1	10	-	-	-	• •	-	-	-	-	-	-	-	-	-			-	-	-	-	-
Clam (saxidomus)	60	5	4	1	20	-	-	-	• •	-	-	-	-	-	-	-	-	-				4	5	2	40
Red Abalone	35	5	1	1	5	-	-	-	• •	4	3	2	24	-	-	-	-	3	2	1	6	-	-	-	-
Black Abalone	5	5	1	1	5	-	-	-	• •	-	-	-	-	-	-	-	- 1	-			-	-	-	-	-
Mussel	59	5	4	1	20	5	3	1	15	4	3	2	24	-	-	-	-	-	· -	· -	-	-	-	-	•
purple olive snail	64	-	-	-	-	-	-	-	• •	4	3	2	24	-	-	-	-	-				4	5	2	40
Clam (Protothaca)	55	5	3	1	15	-	-	-	• •	-	-	-	-	-	-	-	-	-				4	5	2	40
giant chiton	30	5	3	1	15	5	3	1	15	-	-	-	-	-	-	-	- 1	-			-	-	-	-	-
katy chiton	15	5	3	1	15	-	-	-	• •	-	-	-	-	-	-	-	-	-			-	-	-	-	-
star fish	5	5	1	1	5	-	-	-	· •	-	-	-	-	-	-	-	•	-				-	-	-	•
Sand Dollar	4	-	-	-	-	-	-	-	• •	-	-	-	-	2	2	1	4	-				-	-	-	-
Oyster	20	5	4	1	20	-	-	-	· •	-	-	-	-	-	-	-	-	-				-	-	-	
Horn Snail	20	5	4	1	20	-	-	-	· -	-	-	-	-	-	-	-	-	-			-	-	-	-	-
Notes: u – Utility; i – In	tensity; e – Exclus	sivity; P	=(u * i	* e).	1	<u> </u>	1	1	1			<u> </u>	1	1	1	1	1	1	1	1	1	1	<u> </u>	I	1

Appendix G4. Ethnozoology Index of Cultural Significance Values for Shellfish.

Abbreviation	Vegetation Community
AG	Annual Grassland
BAR	Barren
BOW	Blue Oak Woodland
BOF	Blue Oak-Foothill Pine
CRC	Chamise-Redshank Chapparal
CCP	Closed-Cone Pine-Cypress
СМ	Coastal Marsh
COW	Coastal Oak Woodland
CS	Coastal Scrub
DBC	Deep Bay / Channel
DW	Desert Wash
DF	Douglas Fir
DUN	Dune
EST	Estuarine
FEW	Freshwater Emergent Wetland
JUN	Juniper
LAC	Lacustrine
LAG	Lagoon
MAR	Marine
МХС	Mixed Chaparral
мос	Montane Chaparral
МН	Montane Hardwood
МНС	Montane Hardwood-Conifer
MR	Montane Riparian
PAS	Pasture
PG	Perennial Grassland
RED	Redwood
RIV	Riverine
SEW	Saline Emergent Wetland
SP	Salt Pond
SB	Sandy Beach
SBC	Shallow Bay / Channel
SFL	Shellflat
SMD	Shellmound
TF	Tidal Flat
ТМ	Tidal Marsh
VFR	Valley Foothill Riparian
VOW	Valley Oak Woodland
WAT	Water
WM	Wet Meadow

Appendix G6. Habitat Suitability Scores for Birds within Each Habitat.

Common Name	Meadowlark	Robin	Sandpiper	blackbird	golden eagle	Red-tailed hawk	band-tailed pigeon	Crow	Varied Thrush	Crested Jay	Sooty Grouse	CA Woodpecker	Goldfinch	Turkey Vulture	Flicker	Mountain quail	CA Valley Quail	Various Ducks	Geese	Crane/Heron	mudhen	Gulls	Osprey	Brown Pelican
Latin Name	Stumella neglecta	Turdus migratorius	Scolopacidae	Agelaius phoeniceus	Aquila chrysaetos	Buteo jamaicensis	Columba fasciata	Corvus spp.	Ixoreus naevius	cyanocitta stelleri	Denragapus obscurus	Melanerpes sp.	Spinus tristis	Cathartes aura	Colaptes auratus	Calipepla	Lophortys califomia	Anatidae	Anserinae	Ardeaidae	Fulica americana	Laridae sp.	Pandion haliaetus	Pelecanus
Beach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	-	0.66
Tidal Flat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	-	0.50
Rocky Shore	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	-	-
Coastal Marsh	-	-	-	-	-	-	-	0.10	-	-	-	-	-	0.50	-	-	-	0.67	0.42	0.86	0.67	-	0.33	-
Estuary	-	-	0.67	-	-	-	-	0.11	-	-	-	-	-	0.37	-	-	-	0.67	0.42	0.54	0.38	0.62	0.17	0.31
FEW	-	-	0.83	0.50	0.26	0.42	-	0.22	-	-	-	-	-	-	-	-	-	1.00	1.00	0.86	0.92	0.64	0.33	-
LAC	-	-	0.78	-	-	-	-	0.33	-	-	-	-	-	0.37	-	-	-	0.67	0.38	0.67	0.49	0.71	0.33	0.12
SEW	-	-	0.67	0.50	-	0.42	-	0.11	-	-	-	-	-	-	-	-	-	0.76	0.44	0.86	0.67	0.65	0.33	-
AG	0.75	0.25	0.61	0.50	0.55	0.55	-	0.33	-	-	0.44	0.33	0.19	1.00	0.33	0.33	0.69	0.89	0.78	0.67	0.44	0.39	0.11	0.67
BAR	-	-	0.67	-	1.00	0.78	-	0.89	-	-	-	-	-	0.89	-	-	-	-	-	-	-	0.67	0.11	0.67
BOW	0.75	0.53	-	-	0.92	0.73	0.53	0.86	0.44	0.42	-	0.68	0.43	0.92	0.67	-	0.93	0.47	-	0.60	-	-	0.17	-
BOF	0.60	0.53	-	-	0.92	0.72	0.53	0.86	0.28	0.43	-	0.68	0.43	0.92	0.51	0.70	0.93	0.43	-	0.46	-	-	0.17	-
CRC	0.33	0.17	-	-	0.52	0.23	-	0.76	0.21	-	-	-	-	0.77	0.30	0.39	0.75	-	-	0.22	-	-	-	-
CCP	0.78	0.53	-	-	-	0.72	0.31	0.84	-	0.48	-	-	0.40	0.92	0.61	-	0.61	-	-	0.46	-	-	0.17	-
COW	0.75	0.53	-	-	0.92	0.72	0.53	0.84	0.44	0.42	-	0.68	0.43	0.92	0.67	0.70	0.93	0.47	-	0.54	-	-	0.17	-
CS	0.52	-	-	0.49	0.92	0.29	0.22	0.22	-	-	-	0.32	0.18	0.92	0.28	0.30	0.90	-	-	0.67	-	-	-	0.37
DW	-	0.16	-	-	0.24	0.41	-	0.22	-	-	-	0.58	-	0.90	0.28	0.36	0.31	-	-	-	-	-	0.11	-
DF	0.78	0.58	-	-	0.78	0.72	0.71	0.85	0.71	0.77	0.82	0.26	0.27	0.92	0.37	0.54	0.62	0.28	-	0.34	-	-	0.50	-
Eucalyptus	0.51	0.32	-	0.22	0.37	0.47	-	0.54	0.22	0.30	-	0.22	0.39	0.47	0.47	-	0.34	0.33	-	0.27	-	-	0.22	-
MC	0.33	0.17	-	-	0.52	0.27	0.22	0.76	0.21	0.22	-	0.21	0.18	0.77	0.31	0.52	0.75	-	-	0.22	-	-	0.11	-
MC	-	0.33	-	-	0.83	0.29	0.22	0.76	0.21	-	-	0.16	-	0.92	0.28	0.67	0.88	-	-	0.22	-	-	0.11	-
МН	0.32	0.68	-	-	0.92	0.72	0.64	0.84	0.29	0.62	0.22	0.63	0.21	0.87	0.67	0.88	0.63	0.39	-	0.33	-	-	0.36	-
МНС	0.31	0.60	-	-	0.93	0.73	0.66	0.85	0.31	0.79	0.55	0.67	0.21	0.86	0.69	0.87	0.62	0.42	-	0.34	-	-	0.48	-
MR	-	0.58	-	0.33	0.92	0.73	0.83	0.85	0.54	0.63	0.59	0.61	0.21	0.86	0.69	0.87	0.62	0.68	-	0.52	-	-	0.57	-
PAS	-	-	-	-	0.55	0.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PG	0.75	0.25	0.61	0.50	0.36	0.44	-	0.33	-	-	0.44	0.33	0.19	1.00	0.33	0.33	0.69	0.89	0.78	0.67	0.44	0.39	0.11	0.67
RED	0.78	0.58	-	-	0.78	0.73	0.30	0.83	0.78	0.77	0.33	0.27	0.34	0.92	0.38	0.54	0.62	0.33	-	0.34	-	-	0.60	-
RIV	-	-	0.78	-	-	-	-	0.33	-	-	-	-	-	0.37	-	-	-	0.67	0.36	0.67	0.49	0.62	0.33	-
VFR	0.33	0.63	0.66	0.45	0.44	0.66	0.40	0.73	0.47	0.36	-	0.56	0.77	0.92	0.64	0.63	0.93	0.72	-	1.00	-	-	1.00	-
VOW	0.75	0.53	-	-	0.92	0.72	0.53	0.84	0.44	0.42	-	0.68	0.43	0.92	0.67	-	0.93	0.47	-	0.54	-	-	0.17	-
WM	0.75	0.25	0.92	0.50	0.26	0.44	-	0.33	0.44	-	-	0.33	0.11	1.00	0.22	0.33	0.69	0.89	1.00	0.44	0.44	0.51	0.11	-

Appendix G7. Habitat Suitability Scores for Mammals within Each Habitat.

Common Name	Fisher	sea lion	harbor seal	Ring-tail cat	EIk	Mountain Lion	jackrabbit	Bobcat	Skunk	woodrat	Mink	Deer	field mouse	Raccoon	Rat	Mole	tree squirrels	ground squirrel	brushrabbit	gopher	Gray Fox	Turtles
Latin Name	Martes pennanti	Otaniidae	Phoca vitulina	bassariscus astutus	Cervus elaphus	Felis concolor	Lepus sp.	Lynx Rufus	Mephitis mephitis	Neotoma	Neovison vison	O. Hemionus	P. califomianus	Procyon lotor	Rattus	Scapanus spp.	Sciunidae	Spermophilus	Sylvilagus spp.	Thomomys	U. cinereoargenteus	Actinemys marmota
Beach	-	0.70	0.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tidal Flat	-	0.50	0.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rocky Shore	-	1.00	0.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coastal Marsh	-	0.60	0.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Estuary	-	0.22	0.55	-	-	-	-	-	-	-	0.18	-	-	0.11	-	-	-	-	-	-	-	-
FEW	-	-	-	-	0.77	-	-	0.44	0.53	-	1.00	0.22	-	0.32	-	-	-	-	-	-	0.41	0.83
LAC	-	-	-	-	-	-	-	-	-	-	0.18	-	-	0.15	-	-	-	-	-	-	-	0.70
SEW	-	-	0.11	-	-	-	-	0.44	0.53	-	1.00	-	-	0.32	-	-	-	-	-	-	0.22	-
AG	-	-	-	0.11	0.22	0.33	0.44	0.44	0.53	0.44	-	0.26	-	0.15	-	1.00	-	1.00	0.66	1.00	0.30	0.66
BAR	-	0.44	0.55	0.22	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33	-	0.33	-	-
BOW	-	-	-	0.74	0.43	0.52	0.58	0.68	0.58	0.49	-	0.68	0.73	0.59	0.55	0.40	0.55	0.60	0.62	0.44	0.68	0.88
BOF	-	-	-	0.74	0.43	0.69	0.58	0.68	0.58	0.66	-	0.67	0.73	0.59	0.55	0.40	0.58	0.62	0.70	0.44	0.68	0.88
CRC	-	-	-	0.72	-	0.63	0.68	0.77	0.71	0.72	-	0.53	0.82	0.42	-	-	-	0.60	0.79	0.47	0.68	0.33
CCP	-	-	-	0.43	-	0.50	0.45	0.54	0.58	0.58	-	0.64	0.52	0.56	-	-	0.42	0.54	-	0.37	0.32	0.33
COW	-	-	-	0.74	0.43	0.52	0.58	0.68	0.58	0.49	-	0.68	0.73	0.59	0.55	0.40	0.55	0.60	0.62	0.44	0.68	0.88
CS	-	-	-	0.69	0.48	0.58	0.66	0.77	0.71	0.72	-	0.66	0.72	0.42	-	0.33	-	0.63	0.79	0.60	0.68	0.53
DW	-	-	-	0.26	0.36	0.36	0.64	0.52	-	0.72	-	0.22	-	-	-	-	-	0.78	0.80	0.38	0.30	-
DF	0.48	-	-	0.69	0.57	0.64	0.77	0.68	0.53	0.77	-	0.66	-	0.59	0.33	0.50	0.32	0.68	0.61	0.46	0.53	-
Eucalyptus	-	-	-	0.33	0.39	0.33	0.50	0.33	0.45	0.33	-	0.39	0.33	0.60	0.33	0.33	0.44	0.50	0.50	0.56	0.50	0.33
MC	-	-	-	0.72	0.62	0.69	0.66	0.77	0.71	0.82	-	0.65	0.82	0.42	-	-	0.11	0.67	0.81	0.43	0.68	0.33
MC	-	-	-	0.72	-	0.64	0.51	0.77	0.71	0.72	-	0.66	1.00	0.42	-	-	0.11	0.70	0.77	0.47	0.68	0.66
MH	-	-	-	0.43	0.39	0.66	0.60	0.68	0.58	0.72	-	0.66	0.69	0.58	-	0.40	0.56	0.73	0.46	0.55	0.64	0.47
MHC	0.48	-	-	0.71	0.59	0.73	0.54	0.68	0.56	0.57	-	0.65	0.64	0.61	-	0.50	0.58	0.73	0.61	0.46	0.62	0.49
MR	0.48	-	-	0.71	0.48	0.74	0.81	0.68	0.71	0.66	1.00	0.66	0.56	0.61	0.66	0.77	0.27	0.55	0.60	0.66	0.33	0.66
PAS	-	-	-	0.11	0.33	0.11	0.77	0.11	0.55	-	-	0.44	-	0.22	0.66	1.00	-	1.00	0.77	1.00	0.55	0.11
PG	-	-	-	0.22	0.64	0.33	0.41	0.44	0.53	0.33	-	0.26	-	0.18	-	1.00	-	1.00	0.66	1.00	0.43	0.33
RED	0.48	-	-	0.49	0.59	0.48	0.42	0.70	0.41	0.60	-	0.66	-	0.59	0.44	0.50	0.29	0.35	0.60	0.40	0.54	0.33
RIV	-	0.22	0.28	-	-	-	-	-	-	-	0.18	-	-	0.14	-	-	-	-	-	-	-	0.61
VFR	-	-	-	0.74	0.63	0.64	0.45	0.64	0.71	0.60	1.00	0.66	0.33	0.62	0.66	0.90	0.56	0.50	0.58	0.66	0.43	0.90
VOW	-	-	-	0.74	0.43	0.52	0.58	0.68	0.58	0.49	-	0.68	0.73	0.59	0.55	0.40	0.55	0.60	0.62	0.44	0.68	0.88
WM	-	-	-	0.22	0.77	0.44	0.33	0.44	0.53	0.55	-	0.28	-	0.32	-	1.00	-	1.00	0.52	1.00	0.41	0.66

Common Name	Latin Name	Beaches	Tidal Flats	Rocky Shores	Coastal Marsh	Estuarine	Fresh Emergent Wetland	Lacustrine	Saline Emergent Wetland	Riverine
purple olive snail	Olivella biplicata	1.00	-	,]	-	-	-	_	-	-
clam	Saxidomus nuttallii	-	-		1.00	-	-	-	-	-
mussel	Mytilus californianus	-	-	1.00	-	-	-		-	-
Pacific Littleneck Clam	Protothaca staminea	-	-	,	1.00	-	-	-	-	-
red ab	Haliotis rufenscens	-	-	1.00	-	-	-	-	-	-
Goose barnacle	Metella polymerus	-	-	1.00	-	-	-		-	-
giant chiton	Cryptochiton stelleri	-	- 1	1.00	-	-	-	-	-	-
Oyster	Ostrea	-	1.00		1.00	-	-	-	-	-
Horn Snail	Cerithidea	-	1.00	,	-	-	-	-	-	-
Black Turban	C. funebralis	-	-	1.00	-	-	-		-	-
katy chiton	Katarina tunicata	-	-	1.00	-	-	-	-	-	-
Sea Urchin	S. purplatus	-	-	1.00	-	-	-	-	-	-
Limpets	Lottidae	-	- 1	1.00	-	-	-	-	-	-
Sea Anenomes	Actiniaria	-	-	1.00	-	-	-	-	-	-
large crabs	Cancer	-	-	1.00	0.70	-	-	-	-	-
Purple Shell snal	Thais canaliculata	-	-		-	-	-	-	-	-
black ab	Haliotis cracherodii	-	-	0.10	-	-	-	-	-	-
star fish		-	-	1.00	-	-	-	-	-	-
Sand Dollar		1.00	- 1		-	-	-	,	-	-
Smelt/surf fish	Osmeridae	1.00	0.00	0.00	0.00	-	-	-	-	-
Salmon	Oncorhynchus spp	-	-		-	0.30	-	-	-	0.77
common greenling	H. decagrammus	-	0.70		0.70	0.70	-	-	-	-
Eels	Anguilliformes	-	-	0.70		-	-		-	-
Bullheads	Ameiurus melas	-	-		-	-	-		-	1.00
Flounder	Platichthys stellatus	-	-	0.50	0.50	0.70			0.70	-
Herring	Clupeaidae	-	-		1.00	1.00	-		1.00	-
Perch	Percidae	-	-			-	1.00	1.00	1.00	-
Pollack	Gadidae	-	-		1.00	1.00	-		-	-
Sturgeon	Acipenseriformes	-	-						-	0.77
Trout	Oncorhynchus mykiss	-	-		-	-	1.00	1.00	-	-
rockfish	Sebastes spp.	-	-	1.00	-	-	-	- -	-	-
octopus	Octopus	-	-	1.00	0.60	-	-	_	-	-

Appendix G8. Habitat Suitability Scores for Fish and Shellfish within Each Estuary Habitat.

Appendix G9. Summary of Habitat Suitabi	ility Score Calculations.
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	Terres	strial (Animal)	Es	tuary/Water	Terre	estrial (Plant)	Average	Top Six
Habitat	Raw	standardized	Raw	standardized	Raw	standardized		
Annual Grassland	408.87	0.75	-	-	123.00	0.21	0.32	
Barren	82.99	0.15	-	-	-	-	0.05	
Beaches	133.82	0.24	68	0.24	0.00	-	0.16	
Blue Oak Woodland	488.96	0.89	-	-	446.00	0.76	0.55	Terrestrial
Blue Oak-Foothill Pine	499.43	0.91	-	-	446.00	0.76	0.56	Terrestrial
Chamise-Redshank Chaparral	339.47	0.62	-	-	100.00	0.17	0.26	
Closed-Cone Pine Cypress	312.72	0.57	-	-	0.00	0.00	0.19	
Coastal Marsh	108.88	0.20	216.5	0.76	-	-	0.32	Estuary
Coastal Oak Woodland	495.20	0.90	-	-	590.00	1.00	0.63	Terrestrial
Coastal Scrub	425.93	0.78	-	-	145.00	0.25	0.34	
Desert Wash	245.93	0.45	-	-	50.00	0.08	0.18	
Douglas Fir	475.89	0.87	-	-	214.00	0.36	0.41	
Estuarine	111.82	0.20	87	0.30	-	-	0.17	
Eucalyptus	332.80	0.61	-	-	-	-	0.20	
Fresh Emergent Wetland	327.91	0.60	30	0.10	399.00	0.68	0.46	Estuary
Lacustrine	118.15	0.22	30	0.10	97.00	0.16	0.16	
Lagoon	-	-	274.5	0.96	-	-	0.32	Estuary
Mixed Chaparral	427.46	0.78	-	-	100.00	0.17	0.32	
Montane Chaparral	369.51	0.67	-	-	100.00	0.17	0.28	
Montane Hardwood	462.73	0.84	-	-	214.00	0.36	0.40	Terrestrial
Montane Hardwood-Conifer	493.80	0.90	-	-	214.00	0.36	0.42	Terrestrial
Montane Riparian	548.67	1.00	-	-	71.00	0.12	0.37	
Pasture	294.03	0.54	-	-	123.00	0.21	0.25	
Perennial Grassland	435.16	0.79	-	-	123.00	0.21	0.33	
Redwood	431.76	0.79	-	-	137.00	0.23	0.34	
Riverine	119.44	0.22	71.2	0.25	-	-	0.16	
Shallow Bay/Channel	-	-	171.5	0.60	-	-	0.20	Estuary
Saline Emergent Wetland	170.14	0.31	52.5	0.18	45.00	0.08	0.19	Estuary
Tidal Flats	38.5	0.07	61	0.21	-	-	0.09	
Tidal Marsh	38.5	0.07	285.9	1.00	-	-	0.36	Estuary
Valley Foothill Riparian	537.83	0.98	-	-	71.00	0.12	0.37	
Valley Oak Woodland	488.18	0.89	-	-	471.00	0.80	0.56	Terrestrial
Wet Meadow	451.62	0.82	-	-	-	-	0.27	

Appendix G10. Acres of Each Habitat Type within Each Watershed.

Watershed	AG	BAR	BOW	BOF	CRC	CCP	CM	COW	CS	DBC	DW	DF	DUN	EST	FEW	JUN	LAC	LAG	MAR	MXC	MOC	MH	MHC	MR PAS
Alameda Creek	123,344	86	5,569	4,082	1,610	5	-	22,739	2,707	-	-	-	-	-	615	-	605	-	-	5	-	7,251	-	
Angel Island	-	-	-	-	-	-	721	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	
Benicia	27,028	-	2,392	806	1,227	-	79	10,596	3,098	4,998	-	-	-	73	205	-	586	-	-	433	-	1,159	-	
Berkeley	2,133	12	-	-	-	354	1,298	5,021	9,577	6,745	-	-	-	253	-	-	19	-	-	-	-	5	-	
Bolinas	95	233	-	-	1,942	6	-	7,608	19,357	-	-	43	-	-	27	-	-	-	-	-	-	-	-	
Coyote Creek	43,021	5	206	138	5	-	-	4,440	12,750	-	-	-	-	-	219	-	235	-	-	-	-	2,670	-	
Delta Sloughs	102,323	-	-	-	2,861	-	5	5,725	-	1,894	-	-	-	-	149,089	-	17,246	-	17,189	-	-	17	-	
East Bay Cities	46,145	233	-	505	608	788	385	44,209	27,729	5,913	-	-	-	834	7	-	1,051	-	-	258	-	1,260	-	- 84
Elmira	129,667	-	275	1,649	-	-	9	-	-	-	-	-	-	-	3,253	-	228	-	-	-	-	-	-	
Fremont Bayside	25,059	1,023	-	-	-	-	15	1,212	3,425	909	-	-	-	2	114	-	77	-	-	-	-	-	-	
Grizzly Island	-	-	-	-	-	-	-	-	-	2,334	-	-	-	-	-	-	2	-	-	-	-	-	-	
Guadalupe River	17,079	10	41	-	258	-	-	1,360	120	-	-	-	-	-	771	-	257	-	-	-	-	19	-	25 -
Half Moon Bay	1,425	-	-	-	-	10	-	3,622	10,715	-	-	1,700	-	-	-	-	121	-	-	434	-	12	-	
Lagunitas Creek	1,679	-	-	1,067	6	-	-	19,347	11,587	-	-	-	-	-	-	-	-	-	-	-	-	4	-	
Marsh Creek	51,989	5	11,442	1,110	2,626	-	-	1,862	12	-	-	-	-	-	17	15	30	-	-	220	-	2,463	42	
Martinez	11,632	-	57	3,040	141	-	37	9,089	1,330	2,159	-	-	-	170	-	-	582	-	-	-	-	306	-	
Napa River	21,721	-	923	1,614	1,153	-	867	11,789	12,466	1,607	-	54	-	279	583	-	373	-	-	-	-	2,003	-	9 -
Novato	9,464	1,117	75	8,198	1,186	-	106	8,032	596	2,146	-	-	-	104	-	-	697	-	-	59	25	1,445	-	
Pacifica	3,007	128	-	-	-	18	-	442	14,727	-	-	16	-	-	-	-	16	-	-	-	-	-	-	
Palo Alto	33,096	7	477	6,978	15,602	26	5	23,887	2,200	32	-	1,671	-	49	497	-	178	-	-	3,389	-	6,589	-	124 -
Pescadero Creek	1,608	-	-	-	515	14	-	1,293	761	-	-	647	-	-	-	-	-	-	-	25	-	1,492	-	
Petaluma River	22,859	-	476	1,042	246	-	237	18,520	20,498	282	-	-	-	151	-	-	132	-	-	-	-	698	-	
Pinole	29,737	-	-	450	284	5	738	15,385	10,651	14,225	-	-	-	439	-	-	941	40	-	11	-	829	-	59 2
Pittsburg	43,959	42	2,660	2,649	2,129	-	145	7,364	180	4,214	-	-	-	230	536	131	706	-	-	956	-	1,049	82	
San Francisco Bayside	-	-	-	-	-	-	40	556	5,227	6,999	-	-	62	143	-	-	173	5	-	-	-	-	-	
San Francisco Coastal	1,197	147	-	-	-	82	-	610	11,181	-	-	-	-	-	-	-	460	-	-	-	-	-	-	
San Gregorio Creeek	10,087	-	-	-	112	-	-	4,785	6,508	-	-	1,425	-	-	-	-	9	-	-	160	-	1,982	-	- 2
San Mateo Bayside	22,046	-	-	1,112	2,254	277	185	19,510	21,926	25,918	-	204	-	524	-	-	1,689	15	-	1,366	-	345	-	
San Rafael	817	-	-	5,622	2,109	-	391	14,208	9,645	17,704	-	-	-	717	-	-	569	20	-	-	2	-	-	
Sonoma Creek	25,852	-	-	52	937	-	62	9,612	2,480	448	-	-	-	5	-	-	115	-	-	-	-	85	-	
Suisun Creek	1,910	-	3,466	84	-	-	-	1,350	-	-	-	-	-	1	-	-	-	-	-	17	-	1,312	-	
Suisun Slough	53,311	-	1	220	-	-	253	-	-	1,039	-	-	-	536	6,005	-	217	-	-	-	-	-	-	
Treasure Island	-	-	-	-	-	-	126	-	-	26	-	-	-	-	-	-	-	-	-	-	-	-	-	
Tunitas Creek	2,889	-	-	-	12	-	-	2,584	10,440	-	-	143	-	-	-	-	-	-	-	285	-	222	-	
Walker Creek	4,805	-	-	-	69	-	-	5,438	271	-	27	-	-	-	-	-	-	-	-	10	25	246	-	
Walnut Creek	21,123	-	1,488	9,127	2,645	-	-	5,333	118	-	-	-	-	-	-	-	-	-	-	-	-	2,073	-	

Watershed	PG	RED	RIV	SEW	SP	SB	SBC	SFL	SMD	TF	ТМ	VFR	vow	WAT	WM	Total Acres
Alameda Creek	-	-	-	-	-		-	-	-	-	-	2,723	3,011	-	10,853	185,207
Angel Island	-	-	-	-	-	-	34	-	-	-	-	-	-	-	-	757
Benicia	-	-	-	-	-	-	3,406	-	-	359	7,954	27	-	-	-	64,445
Berkeley	-	-	-	-	-	15	14,869	-	-	1,905	941	-	-	-	-	44,335
Bolinas	2	3,585	-	1,354	-	-	-	-	-	-	-	20	-	101	-	34,712
Coyote Creek	-	-	-	346	-	-	662	-	-	322	6,348	1,944	8,988	-	6,347	88,649
Delta Sloughs	12,376	-	-	359,059	-	-	1,327	-	-	79	1,690	33,115	22,335	94	696	727,210
East Bay Cities	-	1,085	-	320	1,315	54	41,545	-	2	14,856	17,521	352	-	-	3,377	211,799
Elmira	18,086	-	-	73	-	-	-	-	-	-	14	19,505	22,211	168	-	195,399
Fremont Bayside	-	-	-	33	-	-	2,170	-	15	2,718	11,767	81	-	-	3,362	51,981
Grizzly Island	-	-	-	-	-	-	12,372	-	-	153	23,410	-	-	-	-	38,271
Guadalupe River	-	-	-	57	-	-	-	-	-	-	-	2,384	8,234	-	4,421	35,036
Half Moon Bay	-	15	-	-	-	-	-	-	-	-	-	-	-	-	441	18,499
Lagunitas Creek	-	26,809	-	-	-	-	-	-	-	-	-	-	-	-	-	60,499
Marsh Creek	-	-	-	-	-	-	-	-	-	-	-	15	7,739	-	270	79,857
Martinez	-	-	-	-	-	2	374	-	-	203	543	-	2,509	-	-	32,270
Napa River	-	18	62	759	-	-	14,292	-	-	3,112	18,826	3,134	20,349	-	10,550	126,545
Novato	-	-	-	2	215	2	16,423	-	-	5,200	6,479	22	4,746	-	-	66,338
Pacifica	-	-	-	-	-	-	-	-	-	-	-	-	-	36	35	19,127
Palo Alto	-	4,239	-	961	-	-	2,037	-	-	3,127	9,357	1,272	18,167	-	17,920	152,115
Pescadero Creek	-	3,679	-	-	-	-	-	-	-	-	-	-	-	-	-	10,034
Petaluma River	-	-	-	-	-	-	9,787	-	-	2,046	12,548	131	2,907	-	-	92,573
Pinole	-	-	-	82	40	10	8,250	-	-	2,429	2,065	420	474	-	-	88,728
Pittsburg	-	-	-	44	-	-	4,484	-	-	1,599	7,585	5	5,078	-	2,783	88,610
San Francisco Bayside	-	-	-	-	7	47	1,019	-	-	41	111	-	-	-	-	14,490
San Francisco Coastal	7	-	-	-	-	-	-	-	-	-	-	-	-	2	-	14,322
San Gregorio Creeek	-	8,109	-	-	-	-	-	-	-	-	-	7	-	-	74	33,325
San Mateo Bayside	-	476	-	719	-	12	27,287	383	-	7,816	19,798	12	8,518	-	-	163,307
San Rafael	-	410	-	69	-	22	5,568	-	-	3,474	3,731	-	-	-	-	65,101
Sonoma Creek	-	-	-	-	-	-	6,202	-	-	537	15,255	-	89	-	-	61,730
Suisun Creek	-	-	-	-	-	-	-	-	-	-	28	-	-	-	-	8,168
Suisun Slough	-	-	-	20	-	-	2,125	-	-	52	24,159	-	22	-	-	87,961
Treasure Island	-	-	-	-	-	-	394	-	-	9	-	-	-	-	-	555
Tunitas Creek	-	4,174	-	-	-	-	-	-	-	-	-	40	-	7	350	21,448
Walker Creek	-	84	-	-	-	-	-	-	-	-	-	2	-	-	-	10,977
Walnut Creek	-	-	-	-	-	-	-	-	-	-	-	113	10,633	-	-	52,668

		BOW	BOF	COW	MH	MHC	VOW	Terrest	rial Total
Watershed	Suitability	0.55	0.56	0.63	0.40	0.40	0.56	%	Stand.
	Total Acreage								
Alameda Creek	185,207	3.0%	2.2%	12.3%	3.9%	-	1.6%	0.13	0.32
Benicia	64,445	3.7%	1.3%	16.4%	1.8%	-	-	0.14	0.34
Berkeley	44,340	-	-	11.3%	0.0%	-	-	0.07	0.18
Bolinas	34,712	-	-	21.9%	-	-	-	0.14	0.34
Coyote Creek	88,649	0.2%	0.2%	5.0%	3.0%	-	10.1%	0.10	0.25
Delta Sloughs	727,210	-	-	0.8%	0.0%	-	3.1%	0.02	0.05
East Bay Cities	211,799	-	0.2%	20.9%	0.6%	-	-	0.14	0.33
Elmira	195,399	0.1%	0.8%	-	-	-	11.4%	0.07	0.17
Fremont Bayside	51,981	-	-	2.3%	-	-	-	0.01	0.04
Grizzly Island	38,271	-	-	-	-	-	-	-	-
Guadalupe River	35,036	0.1%	-	3.9%	0.1%	-	23.5%	0.16	0.39
Half Moon Bay	18,499	-	-	19.6%	0.1%	-	-	0.12	0.30
Lagunitas Creek	60,499	-	1.8%	32.0%	0.0%	-	-	0.21	0.52
Marsh Creek	79,857	14.3%	1.4%	2.3%	3.1%	0.1%	9.7%	0.17	0.41
Martinez	32,270	0.2%	9.4%	28.2%	0.9%	-	7.8%	0.28	0.68
Napa River	126,545	0.7%	1.3%	9.3%	1.6%	-	16.1%	0.17	0.41
Novato	66,338	0.1%	12.4%	12.1%	2.2%	-	7.2%	0.19	0.48
Pacifica	19,127	-	-	2.3%	-	-	-	0.01	0.04
Palo Alto	152,115	0.3%	4.6%	15.7%	4.3%	-	11.9%	0.21	0.52
Pescadero Creek	10,034	-	-	12.9%	14.9%	-	-	0.14	0.35
Petaluma River	92,573	0.5%	1.1%	20.0%	0.8%	-	3.1%	0.16	0.38
Pinole	88,728	-	0.5%	17.3%	0.9%	-	0.5%	0.12	0.29
Pittsburg	88,610	3.0%	3.0%	8.3%	1.2%	0.1%	5.7%	0.12	0.30
San Francisco Bayside	15,041	-	-	3.7%	-	-	-	0.02	0.06
San Francisco Coastal	14,322	-	-	4.3%	-	-	-	0.03	0.07
San Gregorio Creeek	33,325	-	-	14.4%	5.9%	-	-	0.11	0.28
San Mateo Bayside	163,307	-	0.7%	11.9%	0.2%	-	5.2%	0.11	0.27
San Rafael	65,859	-	8.5%	21.6%	-	-	-	0.18	0.45
Sonoma Creek	61,730	-	0.1%	15.6%	0.1%	-	0.1%	0.10	0.25
Suisun Creek	8,168	42.4%	1.0%	16.5%	16.1%	-	-	0.41	1.00
Suisun Slough	87,961	0.0%	0.2%	0.0%	-	-	0.0%	0.00	0.00
Tunitas Creek	21,448	-	-	12.0%	1.0%	-	-	0.08	0.20
Walker Creek	10,977	-	-	49.5%	2.2%	-	-	0.32	0.79
Walnut Creek	52,668	2.8%	17.3%	10.1%	3.9%	-	20.2%	0.31	0.75
Treasure Island	555	-	-	-	-	-	-	-	-
Angel Island	757	-	-	-	-	-	-	-	-
Note: Stand. – Standardized	percentage.								

Appendix G11. Percentage of Each Important Terrestrail Habitat and Resulting Suitability Score.

Appendix G12. Percentage of Each important Estuary Habitat and Resulting Suitability Scol

		СМ	FEW	LAG	SEW	SBC	ТМ	Estu	ary total	Watershed S	score
Watershed	Suitability	0.32	0.46	0.32	0.19	0.20	0.36	0/	Stand	Raw Score	Final Sooro
	Total Acreage							70	Stanu.	(60/40 terrestnai) estuary)	Final Score
Alameda Creek	185,207	-	0.3%	-	-	-	-	0.00	-	0.19	0.32
Benicia	64,445	0.1%	0.3%	-	-	5.3%	12.3%	0.06	0.18	0.28	0.46
Berkeley	44,340	2.9%	-	-	-	33.5%	2.1%	0.08	0.27	0.21	0.35
Bolinas	34,712	-	0.1%	-	3.9%	-	-	0.01	0.02	0.21	0.35
Coyote Creek	88,649	-	0.2%	-	0.4%	0.7%	7.2%	0.03	0.09	0.19	0.31
Delta Sloughs	727,210	-	20.5%	-	49.4%	0.2%	0.2%	0.19	0.60	0.27	0.46
East Bay Cities	211,799	0.2%	0.0%	-	0.2%	19.6%	8.3%	0.07	0.22	0.29	0.48
Elmira	195,399	0.0%	1.7%	-	0.0%	-	0.0%	0.01	0.02	0.11	0.19
Fremont Bayside	51,981	0.0%	0.2%	-	0.1%	4.2%	22.6%	0.09	0.29	0.14	0.23
Grizzly Island	38,271	0.0%	-	-	-	32.3%	61.2%	0.28	0.91	0.36	0.60
Guadalupe River	35,036	-	2.2%	-	0.2%	-	-	0.01	0.03	0.24	0.41
Half Moon Bay	18,499	-	-	-	-	-	-	-	-	0.18	0.30
Lagunitas Creek	60,499	-	-	-	-	-	-	-	-	0.31	0.52
Marsh Creek	79,857	-	-	-	-	-	-	-	-	0.25	0.41
Martinez	32,270	0.1%	-	-	-	1.2%	1.7%	0.01	0.03	0.42	0.70
Napa River	126,545	0.7%	0.5%	-	0.6%	11.3%	14.9%	0.08	0.26	0.35	0.58
Novato	66,338	0.2%	-	-	-	24.8%	9.8%	0.09	0.27	0.40	0.66
Pacifica	19,127	-	-	-	-	-	-	-	-	0.02	0.04
Palo Alto	152,115	-	0.3%	-	0.6%	1.3%	6.2%	0.03	0.09	0.35	0.57
Pescadero Creek	10,034	-	-	-	-	-	-	-	-	0.21	0.34
Petaluma River	92,573	0.3%	-	-	-	10.6%	13.6%	0.07	0.23	0.32	0.53
Pinole	88,728	0.8%	-	0.0%	0.1%	9.3%	2.3%	0.03	0.10	0.21	0.35
Pittsburg	88,610	0.2%	0.6%	-	0.1%	5.1%	8.6%	0.04	0.14	0.24	0.39
San Francisco Bayside	15,041	1.1%	-	0.0%	-	9.4%	0.7%	0.03	0.08	0.07	0.11
San Francisco Coastal	14,322	-	-	-	-	-	-	-	-	0.04	0.07
San Gregorio Creeek	33,325	-	-	-	-	-	-	-	-	0.17	0.28
San Mateo Bayside	163,307	0.1%	-	0.0%	0.4%	16.7%	12.1%	0.08	0.25	0.26	0.43
San Rafael	65,859	1.7%	-	0.0%	0.1%	8.5%	5.7%	0.04	0.14	0.33	0.54
Sonoma Creek	61,730	0.1%	-	-	-	10.0%	24.7%	0.11	0.35	0.29	0.48
Suisun Creek	8,168	-	-	-	-	-	0.3%	-	-	0.60	1.00
Suisun Slough	87,961	0.3%	6.8%	-	-	2.4%	27.5%	0.14	0.43	0.18	0.29
Tunitas Creek	21,448	-	-	-	-	-	-	-	-	0.12	0.20
Walker Creek	10,977	-	-	-	-	-	-	-	-	0.47	0.79
Walnut Creek	52,668	-	-	-	-	-	-	-	-	0.45	0.75
Treasure Island	555	22.6%	-	-	-	71.0%	-	0.21	0.68	0.27	0.46
Angel Island	757	95.1%	-	-		4.5%	-	0.31	1.00	0.40	0.66
Note: Stand. – Standardized	percentage.		I	I							

APPENDIX H

EXAMPLE FIELD FORMS

Auger Record Burial Inventory Record-Form ¹⁴C Sample Log Daily Excavation Summary Feature Record Ground Stone In-Field Analysis GPS Log Sheet List of Units Photo Record Probe Level Record Site Survey Record Soil Sample Log Surface Transect Unit Form Surface Artifact Collection Trenching Form Unit Level Record **Excavation Unit Summary**

AUGER RECORD

•-

Site (Permanent No.):

(Temporary No.):

AUG Mesh	# Size:	1/4"	1/8*	Location	n: Bearing	°	_' Distance _	[*] *	m from Datum
			Depth	Diameter (cm)	Sediments an	id Non-	Cultural Const	tituents	Cultural Material
				20 / 8					
				20 / 8					
		-		20 / 8		×			
				20 / 8					
			• .	20 / 8					
				20 / 8					
				20 / 8		·			
				20 / 8	÷				
				20 / 8					
				20 / 8	, .		-		
				20 / 8					

.

Excavators:

_ Date: _____

BURIAL INVENTORY FORM

Page 1 of ____

Site:	Burial:	Recorder:	Date:
Sex: A	ge: (see comments)		
CRANIUM: (se Frontal: Occipital: Parietal: Temporal: Zygomatic: Maxilla: Maxillary Dentit	e comments) L /R /Unsided L /R /Unsided L /R /Unsided L /R /Unsided on: (Permanent)	Mandible: L Palatine: L TMJ: L Sphenoid: Hyoid: Unidentified:	/R /Unsided /R /Unsided /R /Unsided
Left: Right: Mandibular Dent Left: Right:	$I _ : {}^{2}I _ : C _ : {}^{1}P _ \\ I^{1} _ : {}^{2}I _ : C _ : {}^{P}I _ \\ ition: (Permanent) \\ I _ : {}^{2}I _ : C _ : {}^{P}I _ \\ I _ : {}^{2}I _ : C _ : {}^{P}I _ \\ I _ : {}^{2}I _ : C _ : {}^{P}I _ \\ I _ : {}^{2}I _ : C _ : {}^{P}I _ \\ I _ : {}^{2}I _ : {}^{2}I _ : {}^{2}I _ : {}^{2}I _ \\ I _ : {}^{2}I _ : {}^{2}I _ : {}^{2}I _ : {}^{2}I _ \\ I _ : {}^{2}I _ \\ I _ : {}^{2}I _ : {}^$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	³ M M ³ ₃ M M ₃
Maxillary Dentiti Left: Right: Mandibular Dent Left: Right: Supernumerary T	on: (Deciduous) i: ² i: c: ¹ m ¹ : i ² : c: m ¹ ition: (Deciduous) i: ² i: c: ¹ m ¹ : i ₂ : c: m ₁	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	
VERTEBRAE: Cervical/7: Thoracic/12: Lumbar/5: Sacrum:	(see comments) Centrum: Neural Arc Centrum: Neural Arc Centrum: Neural Arc Coccyx:	INNOMINATES: Ilium: L Ischium: L Pubis: L	(see comments) /R /Unsided /R /Unsided /R /Unsided
RIBS: (see comm 1st: L 2nd: L 3rd-10th: L 11th: L 12th: L Unidentified	nents) /R /Unsided /R /Unsided /R /Unsided /R /Unsided /R /Unsided	STERNUM: (see Manubrium: _ Body: Xiphoid:	comments)
MISCELLANE Clavicle: I Scapula: I Body: I Glenoid f. I	OUS POST CRANIAL BOI /R/Unsided /R/Unsided /R/Unsided /R/Unsided	NES (see comments)	
Patella: I	/R /Unsided		
Codes: + = p	resent; - = absent; c = comp	olete; i = incomplete; f = frag	mented; p = pathology; o = n

des: + = present; - = absent; c = complete; i = incomplete; f = fragmented; p = pathology; o = no information; e = eruption; # = caries; a = abscess; i.c. = in crib, crown formed; a.m. = absent antemortem.

BURIAL INVENTORY FORM

Page 2 of ____

Site:	Burial:		Recorder:		Date:	
LONG BONES: (se	e comments _)				
				Diaphysis		
		Proximal	Proximal	Middle	Distal	Distal
	Complete	Epiphysis	Third	Third	Third	Epiphysis
Left Humerus:						
Right Humerus:						
Left Radius:						
Right Radius:						
Left Ulna:			<u></u>			
Right Ulna:						
Left Femur:						
Right Femur:						
Left Tibia:						
Right Tibia:						
Left Fibula:						
Right Fibula:						
CADDAI S. (see co	mments)		TARSALS	: (see comments	:)	
Navicular.	/R	/Unsided	Talus:	L.	/R	/Unsided
Lunate: L	/R	/Unsided	Calcane	eus: L	/R	/Unsided
Triquetral: L	/R	/Unsided	Cuboid	: L	/R	/Unsided
Pisiform I	_ /R	/Unsided	Navicul	ar: L	/R	/Unsided
Tranezium. I	- / <u>R</u>	/Linsided	1st Cun	eiform: L	/R	/Unsided
Trapezoid: L	/R	/Unsided	2nd Cu	neiform: L	/R	/Unsided
Canitate: L	/R	/Unsided	3rd Cur	neiform: L	/R	/Unsided
Hamater L	/R	/Unsided				
			•			
METACARPALS:	(see commen	ts)	METATA	RSALS: (see co	mments	_)
First: L_	/R	/Unsided	First:	L /	R/U	nsided
Second: L_	/R	/Unsided	Second	: L /	R/U	nsided
Third: L_	/R	/Unsided	Third:	L /	R/U	nsided
Fourth: L_	/R	/Unsided	Fourth:	L /	R/U	nsided
Fifth: L_	/R	/Unsided	Fifth:	L_ /	R /U	nsided
Unidentified:			Uniden	tified:		
PHALANGES - H	AND: (see con	nments)	PHALAN	GES - FOOT: (see comme	ents)
Proxi	mal Media	l Distal		Proximal	Medial	Distal
First: L/R	/U	L/R/U	First:	L/R/U		L/R/U
Second: L/R	/U L/R/	U L/R/U	Second	L/R/U	L/R/U	L/R/U
Third: L/R	/U L/R/	U L/R/U	Third:	L/R/U	L/R/U	L/R/U
Fourth: L/R	/U L/R/	U L/R/U	Fourth	L/R/U	L/R/U	L/R/U
Fifth: L/R	/U L/R/	U L/R/U	Fifth:	L/R/U	L/R/U	L/R/U
COMMENTS: (us	e extra sheets	as needed)				
	and the second se					

BURIAL	INVENT	ORY	FORM
--------	--------	-----	------

Site:	Burial:	Recorder:	Date:
COMMENTS: (continue	ed)		
			<u> </u>
<u></u>			
		,, _,	
		· · · · · · · · · · · · · · · · · · ·	

Page 3 of ____

C₁₄ SAMPLE FORM

C ₁₄ SAMPLE NO.	<u>#C</u>			_ DATE		
SITE NO			LOCUS			
FEATURE			UNIT			
DEPTH: from		to		cm bs		
PROVENIENCE (cm	from SW	/ corner c	of unit): N		cm	E
COMMENTS	(#	of	bags,	why	taken,	etc.):

PLOT SAMPLE LOCATION ON LEVEL RECORD

GIVE THIS INFORMATION TO THE CREW CHIEF NOW

THEN PLACE FORM IN LABELED BAGGIE INSIDE THE SAMPLE

RECORDED BY

DAILY EXCAVATION SUMMARY

SITE NO._____

Unit Levels Locus Unit Size Screen Unit Level Cubes Comments Dug Designation NSxEW Size Туре Interval

DATE

FEATURE RECORD

SITE NO:			FEATURE NO:						
Unit:			FEATURE TYPE: _	FEATURE TYPE:					
DIMENSIONS									
(N-S):	to	cm	Depth:	to	cm				
(F-W):	to	_ cm		to	0.111				
(2).		_ 0111							
DESCRIPTION:									
<u>Soils/Stratigraphy</u> :									
ASSOCIATED ARTIFACTS	?	_ (List on re	everse side)						
14									
<u>C SAMPLES TAKEN</u> ?		_							
Sample No:	Description:								
Sample No:	Description:								
SOIL SAMPLES TAKEN?									
Sample No:	_ Approx. volun	ne:							
Stratum/Locus:									
Sample No:	_ Approx. volun	ne:							
Stratum/Locus:									
OTHER SAMPLES?	Description:		Provenience:						
<u>Рното</u> :	B&W:		Date:						
	Color:		Recorded by:						

	I	Revised June 2015	ARTIFACT #
		*All measurements in	
		millimeters (mm)	Max. *Length
ge	2		Max. Width
Pa D		Millingstone (Thin, Thick, Block); Mortars (Bowl,	Max. Thickness Artifact Type
	der(s)	Hopper,) Handstone, Pestle, Battered Cobble; Misc. Whole, nearly complete, fragment, end frag, medial	Condition
a	ecor	frag, margin frag, interior frag, face frag, rim frag, half	
Feati	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	[R]ectangular, [Q]uadrilateral, [EL]ongated, [T]riangular, [LE]nticular, [LA]nceolate, Plano-Convex	Art. Plan Shape
		[PLC], [M]orphic/ornamental, [I]rreg., Ind.	Art: X-Section
		None, Ground, Crushed, Pecked, Pounded, Flaked, Ind.	Manufacture Wear Type
hth		Unshaped, Slightly Shaped, Shaped, Ind.	Manufacture Wear Level
ΔŪ			Rim Thickness (Mortars)
			# of Wear Surf.
		End, Edge, Face, Ind.	Location 1
		Basin, Concave, Slightly Concave, Flat, Slightly Convex, Convex, V-concave, V-convex, Irreg., Ind.	X-Section 1
.±		Grinding, Crushing, Pecking, Pounding, Ind.	Wear Type 1
u l v		Light, Moderate, Heavy, Worn Out, Ind.	Level of Wear 1
nalvci	ic kipi		Wear Length 1
4			Wear Width 1
			Depth/Height 1
		Circular, Parallel To Long Axis, Parallel To Short Axis, Irregular, Ind., None	Striations 1
_	í .	Yes, No, Ind.	Polish 1
		See Surface 1 Attributes (if applicable)	Location 2
			X-Section 2
ORM			Wear Type 2
YSIS F			Level of Wear 2
	, no		Wear Length 2
	ormati		Wear Width 2
	Infc		Depth/Height 2
LI IN	ance		Striations 2
STOI	/enie		Polish 2
GROUND	Other Prov	Cortex, Burning, Residue, Reworked/scavenged, Other Attributes and/or Comments	Comments; Photo # if applicable

	GPS LOG	Page	OF
Project:	PROJECT NO.:		
Operator:	_CREW CHIEF:		
GPS UNIT:	_DATA DICTIONARY:		

GPS FILE #	Item/Feature	NOTES (COLLECTED, DIMENSIONS, RAW MATERIAL, ETC.)

LIST OF UNITS

SITE NO.

Unit Designation	Datum	Locus	Other Provenience	Unit Type	Screen Size	Final Depth	Unit Size NSxEW

Crew Chief_____

DIGITAL CAMERA PHOTOLOG

Project: _____ Camera: _____

Photographer: _____

Date:

Date	Frame #	Resource and Description	View

PROBE LEVEL RECORD

SITE NO	LC		DATE	
	SCRE	EN SIZE		
UNIT SIZE (NS)	X (EW)	EXCAVATORS		

TECHNIQUES

SOILS STRATIGRAPHY	ARTIFACTS	ECOFACTS	DISTURBANCES COMMENTS
0-10cm			
10-20cm			
20-30cm			
30-40cm			
40-50cm			
50-60cm			

COMMENTS (justify unit termination):

Sample Unit:			Date:
Corner: UTM	N /	E	% completed to date
Crew:			

Geomorphology: (forms and plot locations on next page)

Hydrology: (types and plot location on next page)

Vegetation:

Disturbances:

Sites: (note whether or not recorded)

Number of Isolates Recorded: (map and add to isolate list)

Artifacts: (list of any artifacts collected and where they were collected from e.g. Isolate #1 or Site KH1)

Comments:

COMMENTS NO OF BAGS DEPTH SIZE N-S x E-W UNIT & LOCATION W/IN UNIT OR SIDE-WALL FEATURE LOCUS NO. SAMPLE TYPE SAMPLE NO.

SOIL SAMPLE LOG

SITE NO.

CREW CHIEF

SURFACE TRANSECT UNIT LEVEL RECORD FORM

SITE #:	_ CONC./LOCUS:		DATE:	
UNIT:	BEARING/DIST/	ANCE/DATUM:		
UNIT SIZE: (N/S)	X (E/W)	SCREEN:	EXCAVATORS:_	

TECHNIQUES:

SOILS STRATIGRAPHY	ARTIFACTS	ECOFACTS	DISTURBANCES COMMENTS
0-20 cm			
20-40 cm			
40-60 cm			
60-80 cm			

COMMENTS (justify unit termination):

SITE SURFACE COLLECTION FORM

SITE NO. _____

LOCUS _____

ART NO.	PROVENIENCE Distance and bearing from datum	ARTIFACT TYPE (Material, dimensions, etc.)	COLLECTED Yes/No
TRENCHING FORM

SITE NO

DATE	RECORDED BY	
TRENCH NO.		
PROVENIENCE (from datum to S	W corner)	
ORIENTATION OF TRENCH (from	n SW corner)	
LENGTHV	WIDTH	DEPTH
REASON FOR PLACEMENT OF	TRENCH	

SOIL DESCRIPTION (Geomorph. has described? Yes/No)

DISTURBANCES

SKETCH QUICK TRENCH PROFILE ON BACK

ARTIFACT NO.	ARTIFACT TYPE	PROVENIENCE (be as specific as possible)	COLLECTED Yes/No

Date_____ Page _____of_____

Site No	Unit No	Level Last Level?
Depthto_	🛛 cmbs 🖾 cmbd 🖾 other	Unit Size □1x1m □1x2m □2x2m □other
Screen Size 🗆]¼"(6mm) □ "(3mm) □other	Screening Method 🛛 Wet 🖾 Dry 🖾 other
Excavator(s)	Sc	reener(s)
Soil Color:		LABORATORY INVENTORY
Munsell Chrom	na: or 🗖 see profile	
Texture and Ty	/pe:	Indicate number of bags for this level:
		Sub-bags:
		Faunal Debitage Artifact
		Other (count and type)
Stratigraphy		
Stratigraphy.		Indicate specific/estimate (circle) counts/weights:
		ECR Faunal Shell
		Other
		List Specific Artifacts and indicate provenience of in situ
Disturbanco:		1.
Disturbance.		2
		3
		- <u> </u>
		- 6.
Describe Feat	tures Present and Map on Reverse	7
		8
		10.
		Indicate number of special studies samples taken. Show
		location on level diagram on reverse:
		¹⁴ C Soil Eloat/Eloral
Macroconstitue	ents: (describe floral, faunal, charcoal, rock	Other(Describe)
contents and	size, roots, FCR, cultural material)	
		Special Handling Instructions:
Attached Form	<u>s</u> : ☐ None ☐ Burial Record	
Feature Red	cord 🛛 Stratigraphic Profile	
Photos Taken?		
RollFr	rame ⊔ B/W ⊔ Color	
RollFr	rame ⊔ B/W ⊔ Color	
notes/Commen	ns:	

Date					
	 	 _			_

UNIT LEVEL RECORD

Unit	Level	toto
Scale: 1 cm=	Draw Scale Bar: North	Last Level? 🛛 Yes 🗍 No
		Last Level? Yes No Artifact Key 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Feature Key

No.	Key	Description							

Comments/Notes:

UNIT SUMMARY

DATE:_____

SITE: _____LOCUS: _____

UNIT:_____

UNIT SIZE: 1x1 1x2 ____ SCREEN SIZE: 1/8" 1/4"

LEVEL	PRJ PT	BIF	FLK TL	COR	DEB OBS	DEB OTH	GND STN	BON	SHL	OTHER
0-10										
10-20										
20-30										
30-40										
40-50										
50-60										
60-70										
70-80										
80-90										
90-100										
100-110										
110-120										
120-130										
130-140										
140-150										

COMMENTS:	

APPENDIX I

DETAILED ANALYTICAL METHODS FOR FLAKED AND GROUND STONE

FLAKED STONE ANALYSIS

Text in **bold** indicate attributes that should be recorded as separate columns in Flaked Stone Analysis, including Edge and Debitage Analyses. <u>Underlined</u> texts indicate potential values for each artifact under that particular attribute. For all attributes, the following values can be assigned where they apply: (1) <u>Indeterminate;</u> (2) <u>Not applicable;</u> (3) <u>Not recorded;</u> and (4) <u>None</u>. Incomplete measurements are designated by a negative sign (-) before the value. If an artifact is too fragmented to determine an attribute, it should be "indeterminate."

Maximum Length – maximum distance between the proximal and distal ends of the artifact, in millimeters.

Maximum Width - maximum distance between the lateral ends of the artifact, in millimeters.

Maximum Thickness – maximum distance between the dorsal (exterior) and ventral (interior) faces of the artifact, in millimeters.

Artifact Type – using relevant typology:

Projectile Points should be typed under regional typologies (e.g. Elsasser 1978; Milliken et al. 2007)

Crescents should be typed according to Tadlock (1966, Figure 1).

Bifaces can be typed acording to size (e.g., arrow or dart) or regional typologies.

Blank Type – the mostly likely original type of material used to make the tool: <u>cobble</u> (64–256 millimeters in circumference), <u>pebble</u> (4–64 millimeters in circumference), <u>cortical flake</u>, <u>biface</u> <u>reduction flake</u>, <u>interior flake</u>, <u>indeterminate flake/shatter</u>, <u>reworked biface</u>, and <u>chunk</u>.

Primary Flaking Form – produced by intentional flake removal; if more than one flaking form is present, the most prevalent is recorded.

- <u>Unifacial</u> flake scars on a single face up to an edge or end.
- Bifacial flake scars on opposing faces up to an edge or end.
- <u>Unidirectional</u> flake removal from a single direction, not forming an edge or end.
- Bidirectional flake removal from opposing directions, not forming an edge or end.
- <u>Multi-directional</u> flake scars showing removal of flakes from multiple, erratic directions.
- <u>Bipolar</u> flake scars showing flake removal using two opposing forces, such as a hammer and anvil. Scars are typically flat with no bulbs of percussion and small, mirrored hit marks.
- <u>Tested</u> one or two flakes removed.

Facial Use Wear – type of wear present on a face or multiple faces:

- <u>Grinding</u> smooth surface with rounded peaks, usually caused by horizontal movement of the artifact on another surface.
- <u>Pecking</u> battered surface usually caused by short-distance strokes from another hard surface.
- <u>Striations</u> lines produced through abrasion showing stroke direction across the artifact.

Cortex Present – outer layer present.

Heat Treated – heat-altered texture or color variation.

Weathering:

- <u>Heavy</u> edges and removal scars are heavily rounded and dulled or completely obliterated.
- <u>Moderate</u> edges and removal scars are obviously rounded and dulled, but still quite visible.
- <u>Light</u> very little evidence of weathering, slightly dulled edges and removal scars are relatively fresh.
- <u>None</u> no evidence of weathering is present, edges and removal scars are sharp and new.

Number of Edges with Use Wear or Intentional Flaking – each edge is analyzed with a standard set of attributes (see page 14-17 below).

CONTINUE ONLY IF THE ARTIFACT IS A DRILL (if other, continue below)

Bit Cross-Section – diamond, lenticular, and triangular.

Bit Length – maximum distance between the proximal and distal ends of the drill bit in millimeters.
 Bit Width – maximum distance between the lateral ends of the drill bit in millimeters, measured at maximum distance from tip with use wear.

CONTINUE ONLY IF THE ARTIFACT IS A BIFACE

Artifact Plan Shape – only be recorded for complete or nearly complete artifacts, or if the shape before discard/break can be determined. Un-pictured shape types include morphic/ornamental and irregular.



Note: "Rectangular" describes a shape with four parallel sides and roughly right angles while "Quadrilateral" refers to a shape with four sides that does not qualify as rectangular. Notches on artifacts, such as those on projectile points, are ignored when determining shape.

Artifact Cross-Section Shape – between lateral edges. Only record for complete or nearly complete artifacts, or if the shape before discard/break can be determined.

Biface Class:

- <u>Roughout</u> minimal modification of a blank; flaking on margins sufficient to provide a
 generally ovate shape, but not necessarily one that is bifacial all around; edgeline not
 centered; attributes indicative of the blank morphology are present, such as cortex,
 detachment scar, plano-convex cross-section, and longitudinal curvature.
- <u>Rough Percussion</u> inconsistent flaking, but a bifacial margin extends around the entire artifact with the occasional exception of small unifacial instances; presence of remnant blank attributes are common; scars show mixed pattern of step and feathered flake terminations.
- <u>Fine Percussion</u> attention to symmetry through uniform percussion flaking; flake removals
 often extend across the midline of each face; edgeline is centered; remnant blank evidence is
 rare; scars indicate predominantly feathered flake terminations.
- <u>Rough Pressure</u> pressure flaking is present on what would otherwise be a fine percussion biface; also includes small flake blanks on which pressure flaking is the only technique used, but not in a systematic or refined manner.
- <u>Fine Pressure</u> pressure flaking is usually the exclusive flaking technique indicated, but some percussion scars may remain at the midline of larger bifaces; the intent to provide symmetry through systematic pressure flaking is clear.

Biface Stage describes the production stage of bifacially flaked tools:

- <u>Stage 1</u> roughly produced with a thick, possibly sinuous, margin.
- <u>Stage 2</u> percussion shaped and roughly formed.
- <u>Stage 3</u> percussion shaped and well-formed.
- <u>Stage 4</u> has late-thinning flake scars and intermittent pressure flaking.
- <u>Stage 5</u> extensively pressure flaked and represents a finished tool.

Type of Fracture or Break:

- <u>Twisting</u> fractures occur when the applied force is redirected through the material in a helical fashion, resulting in a somewhat sinuous break.
- <u>Miss-hit</u> (Outre-passe [overshot]) fractures are caused by errors during edge-to-edge or misdirected percussion flaking, resulting in a break that extends to, and cuts under, the opposing end or edge of the artifact.
- <u>Material flaw</u> fractures are caused by excessive force at a point of flaw in the material, producing an uneven break at or around the flaw.
- <u>Thermal</u> (crenated) fractures result from rapid temperature changes, resulting in sugary and irregular or sinuous breaks.
- <u>Impact</u> fractures are caused by direct use of the artifact end on a hard surface, usually
 resulting in a break along the short axis at one of the ends of the artifact.
- <u>Radial</u> fractures are caused by excessive force on the tool face, resulting in multiple breaks radiating from the point of contact. The subsequent tool fragment can resemble a slice of pie.
- <u>Bending without finial fractures are caused by excessive force on the tool face, resulting in a slightly curved break along, usually, the short axis of the tool.</u>
- <u>Bending with finial</u> fractures are bending fractures as defined above, but with a distinctive finial termination.

- <u>Bipolar</u> fractures are caused by two opposing forces, such as a hammer and an anvil, on opposite faces of the artifact, resulting in two setup platforms, no bulbs of percussion, and a usually flat break surface.
- <u>Modern</u> fractures are post-depositional breaks, suggested due to the freshness of the break (e.g. cattle trampling, shovel impact).

Serrated records the presence or absence of a row of notches on the artifact edges.

Reworked/maintained – irregular shaping of an artifact due to multiple series of flaking, flaked edges with multiple levels of use wear, residual and out-of-place artifact attributes (e.g., tang on a drill left over from previous use as a projectile point), etc.

CONTINUE ONLY IF THE ARTIFACT IS A PROJECTILE POINT

- **Axial Length** is the length of a projectile point along its longitudinal axis, measured in millimeters. This measurement can differ from maximum length if the projectile point has a basal notch or if the artifact is broken at an angle.
- **Basal Width** is the maximum distance between the two lateral edges of the base, measured in millimeters.

Neck Width is the maximum distance between the apexes of both notches.

- **Proximal Shoulder Angle** is the angle formed between the line that runs along the proximal edge of the notch and the line that both runs perpendicular to the longitudinal axis and intersects the proximal notch edge line at the longitudinal axis.
- **Distal Shoulder Angle** is the angle formed between the line that runs along the distal edge of the notch and the line that both runs perpendicular to the longitudinal axis and intersects the distal notch edge line at the longitudinal axis.
- **Notch Opening Angle** is the distal shoulder angle minus the proximal shoulder angle, representing the angle of the notch opening.
- **Maximum Width Position** is the distance between the proximal end and the point of maximum width along the longitudinal axis divided by maximum length, represented as a percentage.

Stem Length is the length of the projectile point stem along the longitudinal axis.



EDGE ANALYSIS

Performed on flake tools, formed flake tools, cobble tools, or other tools with used edges.

Position - where the analyzed edge is located on the artifact. The artifact should be oriented so that the flake blank dorsal side is showing and the proximal margin is on top (away from the analyst):

Proximal . Distal

.

- Proximal/left lateral
- Proximal/right lateral
- Distal/left lateral

Left lateral •

Right lateral

- Distal/right lateral
- Semi-radial use wear/flaking is continuous along multiple, but not all, margins. •
- Radial use wear/flaking is continuous around all margins.
- Break use wear/flaking is not on an original flake margin, but occurs on a broken edge of the flake.

Surface describes which surface of the tool has use wear. The use wear can be located on the dorsal surface, ventral surface, or both dorsal and ventral surfaces of the original flake.

Edge Flaking Form records the form of intentional flaking on the analyzed edge.

- Unifacial flake scars on a single face up to an edge.
- Bifacial – flake scars on opposing faces up to an edge.
- Alternating Unifacial unifacial flake scars on opposing faces of same edge.

Shape -of the edge relative to the artifact: straight, convex, concave, notched, pointed or beaked,

serrated, irregular, or sinuous.

Broken Edge – presence or absence.

Scavenged – e.g., use wear over weathered flaking from prior use.

Grinding/polishing - indicative of working softer materials. There is full obliteration of the edge, creating almost a plateau. The edge is dulled and many types of fractures can be visible.

- Micro-chipping indicative of working softer materials. There are small flake scars on the edge that change the edge angle but not necessarily dulling the edge.
- Flaking indicative of working harder materials. These flakes scars are made through use as opposed to intentional flaking.
- **Stepping** indicative of working harder materials. The material is fractured from the edge to an abrupt right angle, creating uneven scars at the edge and moderate dulling.

Angle - of the analyzed edge, measured in 5 degree increments.

Spin Angle - intersection of exterior (dorsal) and interior (ventral) flake sides, measured in 5 degree increments.

Height or Retouch - vertical thickness from exterior (dorsal) to interior (ventral) surface.

- Height of Potential Retouch vertical thickness at the location defined as the height that could be reached if the tool was fully retouched.
- Index of Unifacial Retouch calculated as "Height or Retouch" divided by "Index of Unifacial Retouch," recorded to two decimal places.

DEBITAGE ANALYSIS

Each catalogued group of debitage is separated into piles by size grade, and each size grade is given a unique entry as the debitage is analyzed.

Size Grade: < 1/4" 1/4" - 1/2" 1/2" - 1" 1" - 2" > 2"

Size Count records the total number of flakes in each size grade. Each flake is then assigned a flake type:

Primary Decortication Flakes – more than 70% of the dorsal surface covered by cortex. **Secondary Decortication Flakes** – 0–70% of its dorsal surface covered by cortex. **Simple Interior Flakes** – percussion flakes with straight longitudinal cross-sections and dorsal surfaces with salient bulbs of force: (1) "U" shaped platforms; (2) no more than two arrises; and (3) no cortex.

Complex Interior Flakes – percussion flakes with straight longitudinal cross-sections and dorsal surfaces with: (1) salient bulbs of force; (2) "U" shaped platforms; (3) more than two arrises; and (4) no cortex.

Bipolar Flakes – display opposing forces of impact with distinct cones of force and compression rings.

Linear Flakes – long, blade-like interior flakes that are twice as long as they are wide. **Early Biface Thinning Flakes** – curved longitudinal cross-sections, platform angles less than 70 degrees, and few dorsal surface arrises.

Late Biface Thinning Flakes – display curved longitudinal cross-sections, thinner and with greater dorsal flake scar complexity than early biface-thinning flakes.

Platform Preparation Flakes – typically result from the light percussion of a bifacial edge to prepare a flake detachment platform.

Pressure Flakes – small flakes with salient bulbs of force, minute oblique platforms, and simple dorsal surfaces.

Platform Preparation/Pressure Flakes – Small, rounded, with remnant tool or core margin platforms and complex dorsal surfaces.

Indeterminate Percussion Flakes

Indeterminate Flake Fragments – proximal, medial, interior, lateral, or distal flake margins. **Potlid Flakes** – small, rounded and heat-crazed flakes.

Shatter Flakes – cortical or non-cortical chunky, cuboidal, or acutely angled waste with no discernable platform or bulb of percussion.

Flakes with Cortex – with outer layer, by size grade.

Flakes with Heat Treatment – heat-altered color variation or texture by size grade.

GROUND STONE ANALYSIS

Text in **bold** indicate attributes that should be recorded as separate columns in Ground Stone Analysis, including Surface Analysis. <u>Underlined</u> texts indicate potential values for each artifact under that particular attribute. For all attributes, the following values can be assigned where they apply: (1) <u>Indeterminate;</u> (2) <u>Not applicable;</u> (3) <u>Not recorded;</u> and (4) <u>None</u>. Incomplete measurements are designated by a negative sign (-) before the value.

Maximum Length – maximum distance between the proximal and distal ends of the artifact, in millimeters.

Maximum Width - maximum distance between the lateral ends of the artifact, in millimeters.

Maximum Thickness – maximum distance between the dorsal (exterior) and ventral (interior) faces of the artifact, in millimeters.

Sub-Description: <u>thin</u> [≤60 mm], <u>thick</u> [>60 mm], and <u>block</u> [≥130 mm] for millingstones, and <u>bowl</u>, <u>hopper</u>, and <u>cobble</u> for mortars.

Artifact Plan Shape - see description and figure under Flaked Stone Artifact Plan Shape.

Artifact Cross-Section Shape – short axis in cross-section view—see description under Flaked Stone Artifact Cross-Section Shape.

Artifact Manufacture Wear Type:

- <u>Ground</u> smooth with rounded peaks, usually caused by horizontal movement on another surface.
- <u>Crushed</u> small breaks on surface usually caused by downward pressure on another surface.
- <u>Pecked</u> battered surface usually caused by short-distance strokes from another hard surface.
- <u>Pounded</u> highly battered surface usually caused by long-distance strokes from another hard surface.
- Flaked flake scars on surface usually caused by angular hits from another hard surface.

Artifact Manufacture Wear Level – degree of manufacture wear, or shaping—<u>shaped</u>, <u>slightly</u> <u>shaped</u>, or <u>unshaped</u>.

Rim Thickness - in millimeters; primarily for mortars. As a standard control, this attribute should be measured three centimeters from the apex of the rim.

Cortex, Burning, or Residue Present

Re-working Present - usually represented as pecking.

Number of Surfaces with Use Wear

