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Understanding the Role of Interior Sites and Terrestrial Resources During the Middle Holocene on Santa Cruz Island

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Anthropology

by

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June 2017

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ABSTRACT

Understanding the Role of Interior Sites and Terrestrial Resources
During the Middle Holocene on Santa Cruz Island

by

Kristin Michele Hoppa

The Chumash, complex marine hunter-gathers of the Santa Barbara Channel region, have occupied both the northern Channel Islands and parts of the California mainland for around 13,000 years (Johnson et al. 2000). On the islands, where there are no terrestrial game animals, there is a dichotomy of marine faunal and terrestrial floral resources. Whereas fish, shellfish, and marine mammals are abundant in the waters surrounding the islands, terrestrial plants are less abundant and diverse than on the mainland. Nonetheless, dense shell middens throughout the northern Channel Islands attest to the fact that islanders regularly transported marine resources to interior and high elevation locations. The use of interior sites as residences (rather than logistical encampments) is most pronounced during the Middle Holocene (5500-1500 BC), after which there is a shift to permanent, coastal settlements (Kennett 2005). Scholars have hypothesized that this interior settlement pattern could be motivated by access to freshwater, toolstone, plants, travel routes, defensive locations, or locations used for community aggregation (Glassow 2014; Kennett 2005; Orr 1968; Perry and Delaney-Rivera 2011; Perry and Glassow 2015).

There are several lines of indirect evidence suggesting that plant resources were important during the Middle Holocene, including the development of the mortar and pestle circa 3850-3050 BC (Glassow 1997a), higher frequencies of plant processing tools deposited as grave goods (Hollimon 1990, 2001), and higher rates of dental caries (associated with carbohydrate rich plant foods) in burial populations (Walker and Erlandson 1986). Recent macrobotanical studies on the northern Channel Islands (e.g., Gill 2015; Martin 2010; Martin and Popper 2001; Reddy and Erlandson 2012; Thakar 2014) provide direct evidence that many ethnographically important plant resources were locally available, and were used throughout prehistoric occupation; however, none of these studies explicitly address the role of terrestrial resources in Middle Holocene settlement patterns.

The current study combines faunal and macrobotanical data from three interior Middle Holocene sites with starch granule residue analysis of groundstone artifacts from these and other interior Middle Holocene sites. The low densities of macrobotanical remains recovered do not support the long-held belief that interior sites were used to exploit terrestrial plant resources; indeed, the minimal seeds identified are largely from plants with ethnographic uses as medicine, rather than food. However, starch granules, including acorn (*Quercus* spp.), pine (*Pinus muricata*) and cherry (*Prunus illicifolia*), indicate that ethnographically important food resources were being processed at interior sites, but are not preserving in the macrobotanical record. Starch granules identified in this study provide the first *direct* evidence of what plants different types of groundstone were used to process on the northern Channel Islands. Moreover, this study demonstrates the value of integrating multiple lines of evidence to provide a more holistic understanding of prehistoric foodways, and sets baseline expectations for future paleoethnobotanical research in this region.

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CHAPTER 1

INTRODUCTION

The California Channel Islands are located off the Southern California Bight, stretching from Point Conception southward to San Diego (Figure 1). The Chumash and their predecessors have occupied the northern Channel Islands, as well as parts of mainland California, for about 13,000 years (Johnson et al. 2000; Kennett 2005; Rick et al. 2001); they relied heavily on the abundant marine resources available in the Santa Barbara Channel, as reflected in dense shell middens throughout the region. Marine resources were especially important on the Channel Islands, where there are no terrestrial game animals. Although terrestrial plant resources are less abundant and diverse than on the mainland, they were still an important source of food, medicine, and raw material throughout prehistory.

By the time of historic contact, the Chumash were living in large coastal villages with hereditary chiefs and a high degree of social and political complexity (Arnold 2001; Gamble 2008; Kennett 2005; King 1990). Much of the archaeological research in this region has focused on the earliest Pleistocene and Early Holocene sites, or on the timing and emergence of social and political complexity during the Late Holocene, with relatively less attention paid to the intervening period, the Middle Holocene (see Figure 2). Middle Holocene data are crucial for understanding how settlement and subsistence changed during this transition from the low-density populations and relatively egalitarian social structure of the Early Holocene to the high-density populations and marked social stratigraphy of the Late Holocene.

Kennett (2005:169) argues there was a shift from residential to logistical mobility on the northern Channel Islands from the Middle to Late Holocene, citing the many interior sites dating to the Middle Holocene, compared with dense coastal villages in the Late Holocene. Glassow (2014:118) notes that on Santa Cruz Island, the largest of the northern Channel Islands, most sites are located more than 0.5 km from the coast, but it remains unclear how these sites articulated with coastal settlements and marine-based subsistence. Compared to coastal settlement sites, most interior sites are small (less than 100 m diameter) and shallow (<50 cm) (Glassow 2014:118; Perry and Glassow 2015:6). Nonetheless, many interior sites contain diverse faunal assemblages and artifacts reflecting a range of manufacturing activities (e.g., basket making, flint knapping), demonstrating they were more than simple logistical locations (Glassow 1997a, 2014; Glassow et al. 2008; Kennett 2005; Perry and Delaney-Rivera 2011; Perry and Glassow 2015; Perry and Hoppa 2012).

Scholars have suggested several reasons for the occupation of interior sites, such as their proximity to travel routes and to terrestrial plant resources Glassow 1993a, 1997b, 2014; Kennett 2005; Perry and Delaney-Rivera 2011; Perry and Glassow 2015). There are several lines of indirect evidence supporting the importance of terrestrial resources during the Middle Holocene, including the development of the mortar and pestle circa 3850-3050 BC (Glassow 1997a), which (ultimately) allowed for intensive processing of acorns. Storage of acorns has been credited with setting the stage for the subsequent increased population density and cultural development of the Late Holocene (Basgall 1987; Baumhoff 1963; Jones 1996; King 1990), although early acorn processing may not have been aimed at surplus storage. Understanding when food storage became important may have significant implications for settlement/mobility patterns, as storage is associated with increased

sedentism (Kelly 1992, 1995), and is a defining characteristic of collectors (versus foragers) in Binford's (1980) characterization of hunter-gatherer settlement systems. Despite the presumed importance of terrestrial plant foods in Middle Holocene settlement decisions, there have been few studies incorporating substantial paleoethnobotanical data to provide direct evidence of how plants were being used. This study incorporates both macrobotanical and microbotanical evidence to better understand the role of interior sites and terrestrial resources during the Middle Holocene on Santa Cruz Island.

Figure 1. Map showing the Channel Islands.

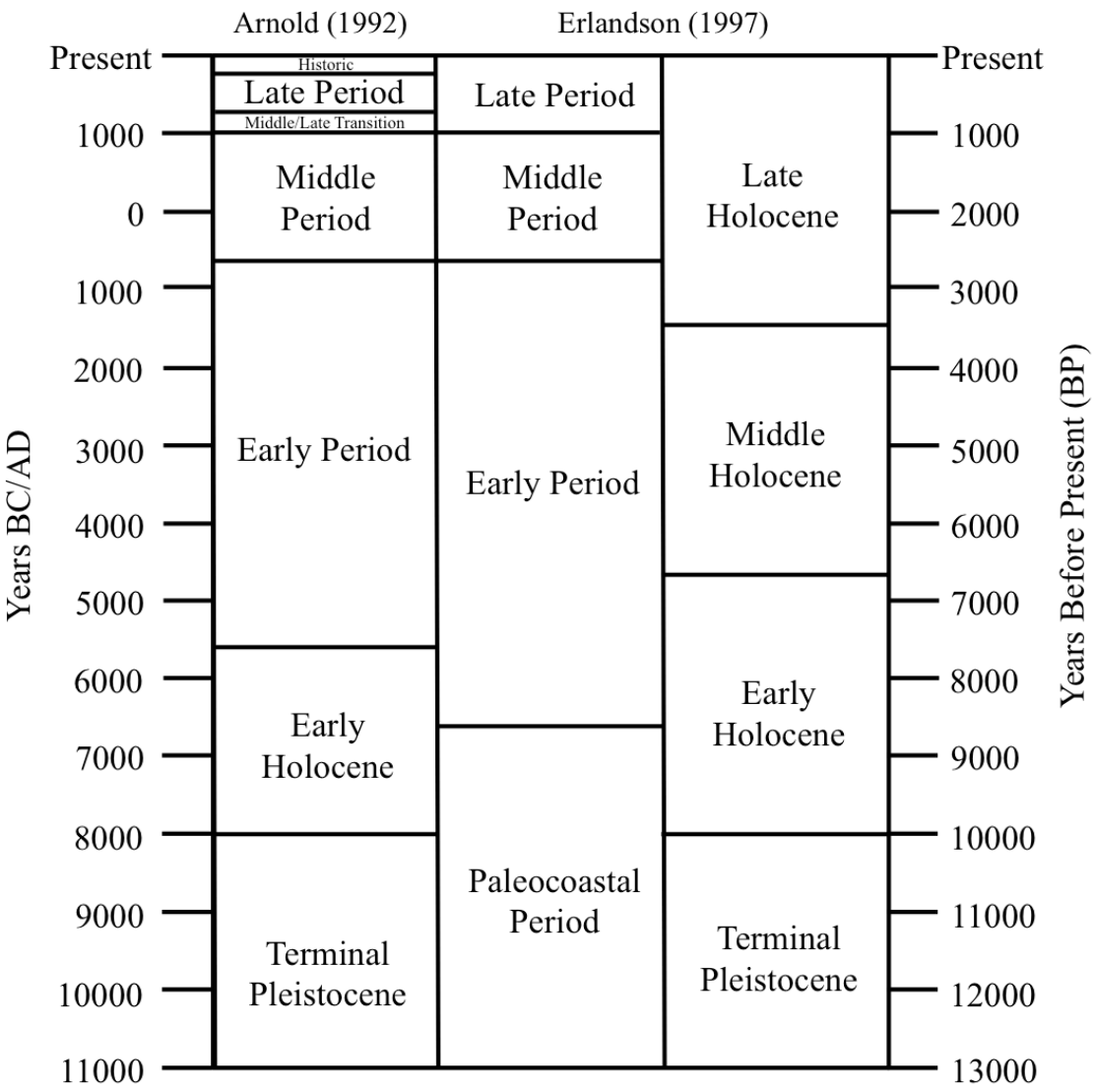


Figure 2. Santa Barbara Channel cultural chronology.

Theoretical Framework

Understanding patterns of subsistence and mobility is crucial to reconstructing how hunter-gatherers interact with their environments. Binford (1980) characterizes hunter-gatherers along a continuum from foragers to collectors. In terms of subsistence, foragers gather their foods on a daily basis, whereas collectors rely on stored food for at least part of the year (Binford 1980). In terms of settlement and mobility, foragers use a residential

procurement strategy, making residential moves to exploit different resource patches; collectors use a logistical procurement strategy, traveling to different resource patches and returning to a main central residential base. Discerning the relative importance (and potential staple status) of resources and the extent to which resource distribution affected settlement decisions will inform our understanding of residential versus logistical procurement. While technological innovations (e.g., circular shell fishhooks, mortars and pestles) and food preferences may be considered cultural changes (Friesen 2004), it is important to note that environmental fluctuations (e.g., drought or ENSO events) could also have made resource distribution more or less homogenous, and that procurement strategies may have changed accordingly.

Optimal foraging theory assumes that human beings will make decisions about diet, foraging location and time, and settlement to "maximize net *rate* of energy gain" (Bettinger 1987:131, emphasis original). Central place theory further suggests that the energetic efficiency of specific resources is affected by their transportation costs to residential bases (Bettinger et al. 1997; Orians and Pearson 1979). Some resources (e.g., abalone [Jazwa et al. 2015]) may be made more efficient if they are processed at their site of procurement, thus reducing their transport cost (Jochim 1976, 1981; Kelly 1995; Winterhalder 1992). This pattern should be observable in the archaeological record, as processing debris should be located at logistical encampments rather than central residential bases (Barlow and Metcalfe 1996; Beck et al. 2002; Bettinger et al. 1997; Bird and Bird 1997).

In the Santa Barbara Channel Region, it remains unclear how or when a shift from residential to logistical procurement occurred. Occupants of the permanent coastal village sites typical of the Late Holocene would certainly be characterized as collectors using a

logistical procurement strategy. In contrast, the ephemeral nature of Early Holocene sites suggests that occupants were likely foragers, with a more residentially mobile strategy. Several coastal sites dating to the Middle Holocene have deeply stratified deposits and associated cemeteries. Kennett (2005) has argued for logistical mobility for all of the Middle Holocene (which he defines as 5550-1050 BC), in which primary and secondary villages played the role of central residential bases. In this model, primary and secondary villages are large, residential sites (the former distinguished by the presence of cemeteries), while logistical encampments are processing sites located some distance from primary villages (Kennett 2005:129). Interior residences are interior sites that are smaller than primary and secondary villages and lack the processing evidence of a logistical encampment. Kennett (2005:129) notes that some "interior residences" may have been used as logistical encampments for terrestrial resources like seeds and bulbs. Glassow and colleagues (Glassow 2013; Glassow et al. 2008) have argued that Kennett's model is too simplistic, and that residential patterns likely shifted throughout the Middle Holocene, according to environmental changes and cultural practices. They note that, "unless food storage is an important aspect of a subsistence system, generally it would be more economical to consume foods at locations where they are obtained" (Glassow et al. 2008:30). The appearance of the mortar and pestle during the Middle Holocene demonstrates that technology for processing a storable food (e.g., acorn flour) existed, but the extent to which people *relied* on food stores is unclear. This study does not attempt to define or classify subsistence and settlement systems for all of the Middle Holocene, or even at the specific study sites. Jochim (2013:192) writes "the search for specific functional signatures of site types may be frustrated by a variety of plausible interpretations," noting that hunter-

gatherers often use the same locations for different functional or seasonal purposes. Rather, this study addresses the need for direct evidence of plant processing at interior sites. By analyzing starch granules recovered from the surface of groundstone artifacts from Middle Holocene sites, this study is the first on the northern Channel Islands to provide direct evidence of what plants different types of groundstone were used to process. Moreover, by integrating faunal, macrobotanical, and microbotanical evidence, this study provides a more holistic understanding of prehistoric foodways and sets baseline expectations for future paleoethnobotanical research.

Previous Paleoethnobotanical Research on the Northern Channel Islands

There have been systematic paleoethnobotanical studies at 23 sites on the northern Channel Islands, with a total of 1,610 liters of soil analyzed (Gill 2013, 2015; Gill and Hoppa 2015; Gusick 2012; Hoppa 2014; Martin and Popper 1999, 2001; Popper 2003; Reddy and Erlandson 2012; Thakar 2014). With the exception of Daisy Cave (SMI-261) on San Miguel Island, all of these sites are on Santa Cruz Island; and fewer than 50 liters have been analyzed from most (60%) sites (see Table 1). Reddy and Erlandson (2012:36) analyzed 86 liters from Paleocoastal, Early Period, and Late Early Period deposits from Daisy Cave (SMI-261) on San Miguel Island; there were only 11 seeds in the 86 liters, but there were 109 fragments of corms in strata from all three time periods. I analyzed 38 liters from Paleocoastal deposits from the Punta Arena Site (SCRI-109) for Gusick (2012), and Martin and Popper (1999) analyzed an additional 95 liters from Early Period deposits for Glassow and colleagues (2008); there were no seeds in the Paleocoastal deposits, but several corm fragments, a single acorn fragment with attachment scar, an unidentified piece of nutshell, and two unidentified seed fragments in the Early Period deposits (Glassow et al.

2008; Martin and Popper 1999). Thakar (2014) analyzed 354-, 225-, and 200-liter samples from sites SCRI-236, SCRI-568, and SCRI-823, respectively. Each of these sites consisted of a Late Early Period, Middle Period, and Late Middle Period component, and had high densities of seeds, particularly in the Middle Period deposits (Thakar 2014). Gill (2015) analyzed 244 liters from Early Period, Late Early Period, Middle Period and Late Period strata at the Diablo Valdez site (SCRI-619/620); approximately 65 liters came from 15 Early Period contexts, which contained relatively high densities of corms and seeds (see Gill 2015; Gill and Hoppa 2016).

The boxplots below (Figure 3) show densities of plant foods through time. Box plots summarize the entire distribution of data, with the narrowest portion of each box indicating the median of the distribution; if the notches do not overlap, then there is significance at the 0.05 level (Cleveland 1994; McGill et al. 1978; VanDerwarker 2010a:80-81; Wilkinson et al. 1992). The Early Period and Middle Period data have been further refined to include Late Early Period (1550-600 BC) and Late Middle Period (AD 600-1150) as most of these data are from Thakar's (2014) study, which uses these chronological designations.

The most ubiquitous plant food taxon in all of the Northern Channel Islands samples is Brodiaea corms, with no statistically significant change in density from the Paleocoastal through Late/Historic periods. Toxic nuts (acorn and cherry [*Prunus illicifolia]*) also remain stable through time, while small seeds, greens, and Manzanita berry pits (*Arctostaphylos* spp.) have significantly higher densities in the Middle or Late Middle Periods, and significantly lower densities in the subsequent Late Period. Each of these categories is represented in plant assemblages from each time period, but it is possible that differences in

sample sizes and the location of sites are responsible for this diachronic pattern (Gill and Hoppa 2016:64).

In general, seed densities are very low in Paleocoastal deposits, and relatively low in Early Period deposits (Table 2). With the exception of the 95 liters from Early Period strata at coastal site Punta Arena (Glassow et al. 2008; Martin and Popper 1999), there have not been any paleoethnobotanical studies explicitly targeting Middle Holocene data. Small samples from coastal site SCRI-724 and interior sites SCRI-174, SCRI-183, SCRI-194, and SCRI-724 were analyzed in a preliminary study for the current research (see Hoppa 2014). The low density of seeds in Middle Holocene deposits could indicate that: (1) plants were not important to the diet, (2) there was overall poor preservation of seeds due to time and/or soil conditions, or (3) that plants were being consumed, but were not being prepared in ways that would favor preservation (i.e., they were not being cooked/carbonized). The current study combines macrobotanical analysis of large (>100 liter) samples with microbotanical residue analysis of groundstone artifacts from Middle Holocene sites in an effort to address the known low seed densities, as well as the possibility that plants did not preserve as carbonized remains.

Table 1. Sample sizes (L) for previous archaeobotanical studies on the Northern Channel Islands (Gill and Hoppa 2016).

	Paleocoastal 11500-6600 BC	**Early Period** 6600-1550 BC	**Late Early Period** 1550-600 BC	**Middle Period** 600 BC – AD 600	**Late Middle Period** AD 600-1150	**Late/ Historic Period** AD 1150-1819
SMI-261	59[1]	10[1]	17[1]			
SCRI-109	38[2]	95[3]				
SCRI-174		**116**				
SCRI-183		**270**				
SCRI-191				13[4*]		
SCRI-192						28[4]
SCRI-194		20[5]				
SCRI-236			81[6]	217[6]	56[6]	
SCRI-240						2[4]
SCRI-330						40[4]
SCRI-393		**158**[7]				
SCRI-427		6				
SCRI-474				14[4*]		
SCRI-547	22[2]					
SCRI-549	39[2]					
SCRI-568			76[6]	74[6]	75[6]	
SCRI-691	39[2]					
SCRI-724		20[5]				
SCRI-798	46[2]					
SCRI-813						15[8]
SCRI-814			20[8*]			
SCRI-823			40[6]	28[6]	132[6]	
SCRI-619/620		65[8]	40[8]	4[8]		135[8]
Totals (L)	243	760	481	571	310	220

[1]Reddy and Erlandson 2012; [2]Gusick 2012; [3]Martin and Popper 1999; [4]Martin and Popper 2001; [5]Hoppa 2014; [6]Thakar 2014; [7]Popper 2003 (8 liters); [8]Gill 2015; [*]Sample spans multiple time periods due to mixed strata. Samples analyzed for this study are in bold.

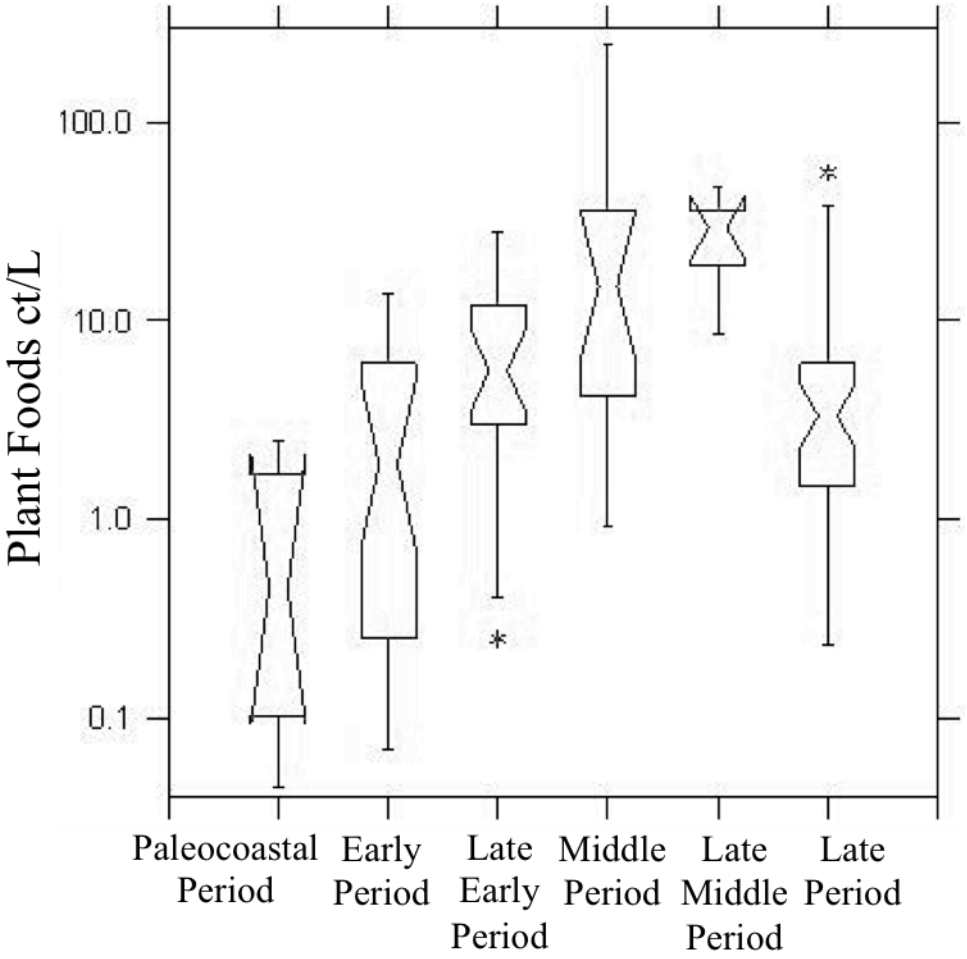


Figure 3. Density of plant remains by time period.

Table 2. Density of plant remains (ct/L) for previous archaeobotanical studies on the Northern Channel Islands (Gill and Hoppa 2016).

	Paleocoastal 11500-6600 BC	**Early Period** 6600-1550 BC	**Late Early Period** 1550-600 BC	**Middle Period** 600 BC – AD 600	**Late Middle Period** AD 600-1150	**Late Period** AD 1150-1819
Fruits	0.00	0.46	0.18	8.78	1.38	0.50
Geophytes	6.79	74.22	102.89	13.24	20.20	64.34
Greens	0.00	4.70	11.97	37.21	35.19	6.79
Non-Toxic Nuts	0.05	3.17	6.78	15.57	4.34	31.69
Small Seeds	0.20	22.49	53.89	549.05	132.71	48.83
Toxic Nuts and Pits	0.00	3.03	7.57	4.25	2.37	11.67
Total L	**243**	**760**	**481**	**571**	**310**	**220**
Total ct/L	**7.05**	**108.06**	**183.28**	**628.11**	**196.18**	**163.82**

Indirect Evidence for the Importance of Plants during the Middle Holocene

There are several lines of indirect evidence supporting the idea that terrestrial plant resources were important during the Middle Holocene. The first is the development of the mortar and pestle circa 3850-3050 BC (Glassow 1997a). Although early mortars and pestles may have been used to process a variety of foods, including cherry (*Prunus ilicifolia*) fruits or starchy roots, tubers, and corms (Erlandson 1997; Glassow 1996, 1997a; Schroth 1996), the development of the basket hopper around 2050 BC suggests that people were processing acorns, which is "likely is related to the increasing efficiency…because hoppers would reduce loss of seeds or nuts during milling" (Glassow 1997a:87-88). In addition to portable mortars and pestles, bedrock mortars are present on Santa Cruz Island, including at interior site Diablo Valdez (SCRI-619-620) (Gill 2013, 2015).

A second line of indirect evidence for the importance of plants during the Middle Holocene comes from burials. Sandra Hollimon's (1990) analysis of mortuary goods from Santa Cruz Island found that artifacts related to procuring and processing plant foods were more common in Early Period burials, whereas artifacts related to fishing activities were more common in Middle and Late Period burials (Hollimon 1990:97). Furthermore, Hollimon (1990, 2001) found that groundstone tools, basketry impressions, and digging stick weights were found with both male and female burials. Sutton (2014a:37–38) also noted that digging stick weights (e.g., digging roots, corms, and tubers) were buried with children, who may have played a significant role in procuring plant foods on the islands. The use of groundstone as a grave good suggests that processing plants was an important part of the identity of islanders during this time period, whether they were men, women, or children.

A third line of evidence comes from the burials themselves. Walker and Erlandson (1986) found higher rates of dental caries in human remains from Early Period burials, indicating a higher intake of carbohydrate rich plant foods. They found caries rates to be higher among females than males, presumably due to higher consumption of plants during gathering activities.

The fourth line of indirect evidence is the abundance of interior sites. The only terrestrial mammals on the Channel Islands are the island fox (*Urocyon littoralis*), the spotted skunk (*Spilogale gracilis amphiala*), and the deer mouse (*Peromyscus maniculatus*), none of which were eaten by the Chumash (Jazwa and Perry 2013). Interior shell middens largely consist of faunal remains that were carried in from the coast. While there are interior sites dating to the Late Holocene, these seem to reflect logistical forays for resources like toolstone, versus residential Middle Holocene sites (Kennett 2005; Perry and Glassow 2015). Phil Orr (1968) first noticed this pattern while working on Santa Rosa Island, and suggested interior sites may have been used for defensive purposes during what he called the "Highlander Phase." More recently, Perry and Glassow (2015:15) summarized hypotheses for the occupation of interior sites, as "1) access to freshwater sources; 2) utilization of interior resources (e.g., plants and chert); 3) meal breaks or stop-overs during land-based travel; 4) defense; and 5) aggregation of economically independent social units at central loci (Arnold 1987; Glassow 2014; Kennett 2005; Kennett and Clifford 2004; Perry 2003, 2004; Perry and Delaney-Rivera 2011)." Perry and Glassow (2015) note that any combination of the above reasons may influence settlement decisions related to a given site; for example, the Central Valley, Santa Cruz Island's biggest and highest ranking watershed (Kennett 2005) may have been attractive for both its fresh water and its proximity to economic plant resources.

Taken together, this indirect evidence supports the idea that terrestrial resources were important during the Middle Holocene and that interior sites may have been positioned to take advantage of proximity to these terrestrial resources. However, there is a need for direct evidence. Archaeological research on the northern Channel Islands has focused on the abundant faunal remains of marine resources, with little attention paid to terrestrial resources. Indeed, some scholars have suggested that plants were likely unimportant on the islands, where there is a lower density and diversity of plants compared to the mainland (Arnold and Martin 2014; Munns and Arnold 2002). In part, this perception has been influenced by the fact that historic grazing and the introduction of European grasses have altered the landscape and lowered botanical diversity in present times. Recent archaeobotanical studies on Santa Cruz Island suggest the prehistoric landscape had a much greater density and diversity of plants than what is observed today (Gill 2015; Gill and Hoppa 2016).

Direct Evidence for the Importance of Plants during the Middle Holocene

The macrobotanical evidence recovered from an additional 500 liters of soil from three interior Middle Holocene sites for this study (SCRI-174, SCRI-183, and SCRI-393) does not support the assumption that Middle Holocene interior sites were used to exploit terrestrial resources, as low densities of economically important plants were recovered. It is possible that low densities reflect preservation bias rather than an unimportance of plant resources, as will be discussed in Chapter 6. Microbotanical analysis of groundstone collections from these and other Middle Holocene sites indicate that both starch granules and phytoliths preserve well on *in situ* and extant (i.e., museum collection) groundstone, and are not contaminated by soil or handling. While phytoliths were not identified beyond the family

level (e.g., grass), starch granules were identified to the genus and species level when possible. Starch granule evidence indicates that early mortars and pestles were used to process a variety of economically important plants, not just acorn, and that acorns were also processed with manos. Furthermore, the plant taxa identified in the starch granule record largely do not overlap with those identified in the macrobotanical record, indicating that preservation bias is a factor affecting sites from this, and likely other, time period(s). This study sets baseline expectations for macrobotanical and microbotanical studies of Middle Holocene sites and demonstrates the viability of using existing groundstone collections for starch and phytolith analysis. Furthermore, this study provides a deeper understanding of Middle Holocene subsistence and the role of small, interior sites as residential bases.

The following chapters provide background on the environment and cultural chronology of the northern Channel Islands, a description of field and laboratory methods, a description and analysis of the study sites, and finally a discussion of preservation bias, starch granule evidence, and the role of interior sites and terrestrial resources during the Middle Holocene.

CHAPTER 2

ENVIRONMENTAL AND CULTURAL BACKGROUND

Chumash territory includes parts of San Luis Obispo, Santa Barbara, Ventura, and Los Angeles counties, as well as the northern Channel Islands, which are the focus of this study. Tribal boundaries are not exact, and have been mapped based primarily on linguistic grounds. There were multiple tribes and spoken languages within the Chumash territory, connected through exchange, marriage patterns and a shared belief system; however, the island Chumash maintained their own identity. During the 13,000 years of occupation, islanders adapted to rising seas, changing environmental conditions, and population growth. These adaptations are reflected in the material culture, with evidence for changes in technology (e.g., circular shell fishhooks and the *tomol* plank canoe), subsistence practices (e.g., subtidal diving and pelagic fishing), regional exchange networks, and socio-political organization (Erlandson at al. 2011; Johnson et al. 2000; Kennett 2005; Rick et al. 2001). The following discussion of the natural environment of the northern Channel Islands and the regional cultural chronology provide context for understanding the role of terrestrial resources and interior sites in Middle Holocene subsistence and settlement decisions.

The Northern Channel Islands

The northern Channel Islands are located 20-44 km off the Southern California Bight. From west to east, they are San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands. The islands are part of the Santa Monica Mountain Range and have a maximum elevation of 753 km at Mount Diablo on Santa Cruz Island. During the lowest sea levels of the Pleistocene

(16050-15050 BC), the four northern islands were connected as one large (1874 km^2) landmass known as Santa Rosae, which was approximately 7 km from the mainland (Junak et al. 1995:2; Kennett et al. 2008). Today San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands are 37, 217, 249, and 2.9 km^2, respectively (Junak et al. 1995:3). Variability in both the surrounding marine and terrestrial environment of each island contribute to different resource distribution and therefore unique factors in subsistence and settlement decisions.

Marine Environment

The Southern California Eddy is the most ecologically significant eddy in the California Current System because of its high biological productivity (Owen 1980:237). The southern flowing California Current brings cool water from the northern Pacific and mixes with the northern flowing California Countercurrent along the Southern California Bight (Figure 4). The Channel Islands create westward obstacles to the southward flow, leading to the upwelling of cold, nutrient rich water, which supports a dense and diverse population of marine species, including large marine mammals (Owen 1980).

Along the islands, the waters cool from east to west, favoring different species distributions. Nearshore habitats, including kelp forests, rocky headlands, and sandy beaches, support dense populations of shellfish, fish, and marine mammals. Rocky intertidal habitats are more common on the north end of the island, while sandy substrates are more common on the south shores (Glassow 1993a; Munns and Arnold 2002). Abundant seaweeds (e.g., surf grass [*Phyllospadix torreyi*]) provide food and raw material. Productive mussel (*Mytilus californianus*) beds and other economically important shellfish species such as black abalone (*Haliotis cracherodii*) occur throughout the rocky intertidal zone. Subtidal shellfish species such as wavy top (*Megastraea undosa*) occur closer to shore in warmer

water; while red abalone (*Haliotis rufescens*) occur closer to shore in cooler water (Glassow 1993b; Glassow et al. 2008; Perry and Hoppa 2012). Evidence from Early Period deposits indicates that dolphin and pinniped hunting took place throughout prehistoric occupation (Glassow et al. 2008).

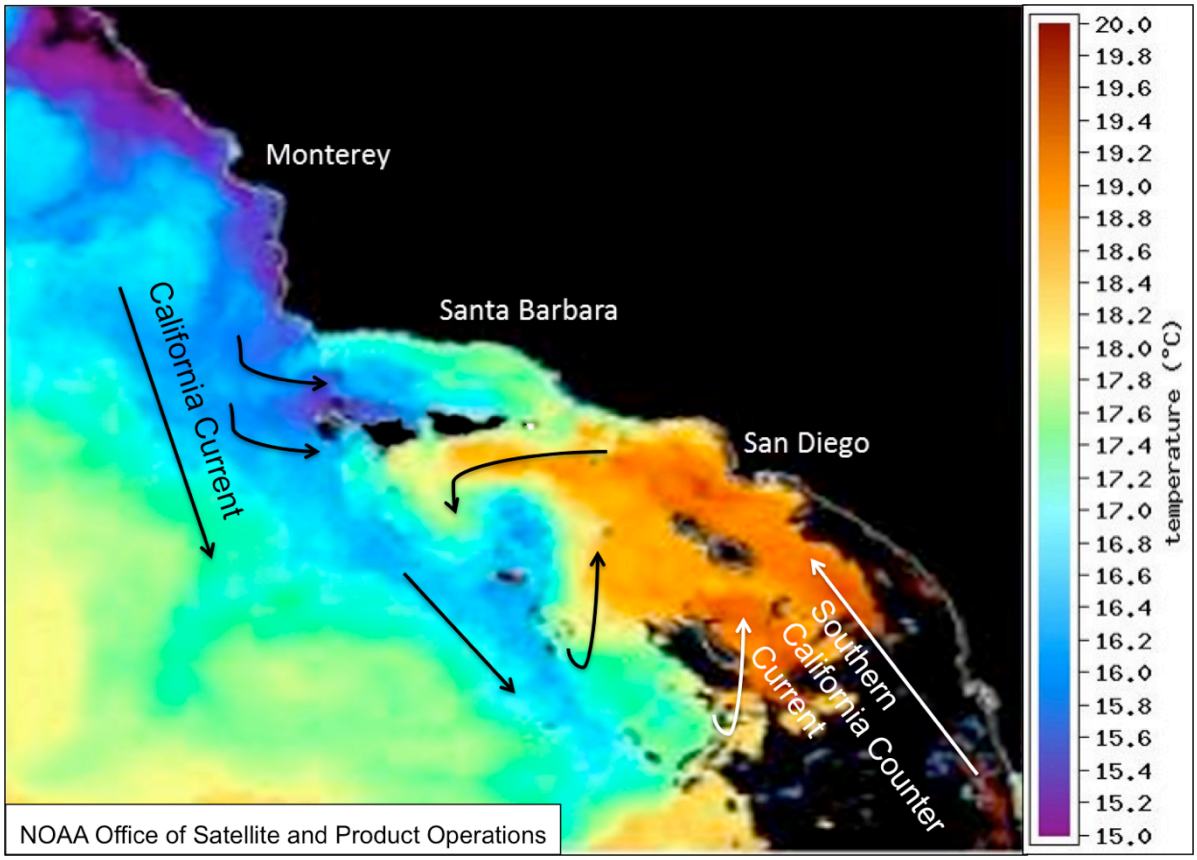


Figure 4. Variable sea surface temperature in the Santa Barbara Channel (NOAA base map).

Terrestrial Environment

The terrestrial environment of each of the Channel Islands varies based on the island's size, relative isolation, elevation, geologic substrate, freshwater availability, precipitation, and historic impact. In general, the northern islands have a Mediterranean climate with minimal temperature fluctuation (the average annual temperature range on San Miguel

Island is only 3°C [Dunkle 1950; Junak et al. 2007:230]). The prevailing weather in the Santa Barbara Channel moves west to east, meaning high winds and fog are more severe on the westernmost islands. These weather patterns affect temperature and precipitation, and in some cases impact the growth of certain plant taxa (Baguskas 2014); Pesendorfer and colleagues (2014:256) observe that oak trees on Santa Rosa are smaller than those on Santa Cruz Island due to its cooler and windier condition.

As the largest of the northern Channel Islands, Santa Cruz Island has the most diverse terrestrial environment—a factor of the island's size and elevation, as well as its range of soil types, created by varying geological substrates (Junak et al. 2007:231). There are three distinct ridgelines: the North and South ridges run east-west, and El Montañon ridge runs northwest-southeast on the eastern side of the island, which connects to the western portion via an isthmus. Nestled between the North and South ridges is the large Central Valley (actually three connected valleys [Junak et al. 1995:3]). The island has 10 major watersheds with canyons up to 4 km long and elevation drops up to 610 m (Junak et al. 1995:3).

Junak and colleagues (1995) build on previous classifications of plant communities on Santa Cruz Island (Holland 1986; Minnich 1980; Philbrick 1978; Philbrick and Haller 1977), describing 16 plant communities: (1) southern beach and dune, (2) valley and foothill grassland, (3) coastal-bluff scrub, (4) coastal-sage scrub, (5) coyote-brush scrub, (6) island chaparral, (7) island woodland, (8) southern coastal oak woodland, (9) bishop pine forest, (10) intertidal and subtidal marine community, (11) coastal marsh and estuary, (12) freshwater seeps and springs, (13) vernal ponds, (14) riparian herbaceous vegetation, (15) mule-fat scrub, and (16) southern riparian woodland. Ethnographically important plants, including blue dicks (*Dichelostemma capitatum*), pine (*Pinus muricata*), acorn (*Quercus*

spp.), cherry (*Prunus illicifolia*), red maids (*Calandrinia* spp.), chia (*Salvia columbarieae*), and cattail (*Typha* spp.) all occur on the island.

The perception that the islands have insufficient terrestrial resources has been shaped in part by the decreased diversity brought on by historic ranching activities, which have significantly altered the modern distribution of plant communities. Don Romualdo Pacheco, then commandante of the Santa Barbara Presidio, brought the first livestock to Santa Cruz Island in 1830. There were an estimated 60,000 sheep on the island by 1875; 100,000 by 1890 (Junak et al. 1995:28-30). Grazing stripped grasslands and brought about increasing erosion. The unintentional and intentional introduction of non-native plant species has also dramatically altered the landscape. Eucalyptus trees were planted around the main ranch in 1886 (Junak et al. 1995:30) and would have lowered the water table (Rodríguez-Suárez et al. 2011), while invasive mustard and fennel have taken over large swaths of land.
Despite historic impacts, the Northern Channel Islands are now recovering thanks to conservation efforts by Channel Islands National Park and the Nature Conservancy. The last feral sheep were removed from the island in the late 1980s and the last of the pigs in 2006 (Chiles 2011:222). Systemic rare plant mappings began in the 1970s and ongoing efforts to remove invasive plant species are restoring native grassland (Junak et al. 2007:247).

Cultural Chronology

The cultural chronology of the northern Channel Islands can be discussed in terms of cultural periods (e.g., Early Period) or geological periods (e.g., Early Holocene). There is some variation on how dates are reported, and I have based this chronology on several others (Arnold 1992; Erlandson and Colten 1991; Erlandson 1997; Gamble 2015; King 1990). The Middle Period (600 BC-AD 1150), Late Period (AD 1150-1782), and Historic

Period (AD 1782-1819) all fall within the Late Holocene (AD 1500-1819); therefore I refer to cultural periods in the following chronology. However, the Middle Holocene (5500-1500 BC) falls within the Early Period (6600-600 BC) and therefore is a more specific frame of time to which I refer throughout this study (Figure 5).

<table>
<tr><td colspan="2">Paleocoastal
11500-6600 BC</td><td colspan="2">Early Period
6600-600 BC</td><td>Middle Period
600 BC-AD 1150</td><td>*</td></tr>
<tr><td>Terminal Pleistocene
11500-9000 BC</td><td>Early Holocene
9000-5500 BC</td><td>Middle Holocene
5500-1500 BC</td><td colspan="3">Late Holocene
AD 1500-1819</td></tr>
<tr><td colspan="6">*Late Period (AD 1150-1782); Historic Period (1782-1819)</td></tr>
</table>

Figure 5. Simple cultural chronology of the Santa Barbara Channel Region.

Paleocoastal Period

Melting global ice sheets caused rapid sea level rise during the Terminal Pleistocene and Early Holocene. Anacapa, Santa Cruz, and finally Santa Rosa and San Miguel became separate islands approximately 9900, 9300, and 9000 years ago, respectively, and modern shorelines did not fully stabilize until roughly 4000 BC (Gusick 2012, 2013; Kennett et al. 2008). Culturally, the time period earlier than 6600 BC is sometimes referred to as the Paleocoastal Period (Erlandson 1994, 1997; Erlandson et al. 2009; Erlandson et al. 2011; Gusick 2012; Rick et al. 2001). Paleocoastal archaeological sites are relatively rare, as more than 80% of the Terminal Pleistocene coastal lowlands are now submerged; however, the 11 sites that have been dated to this time period indicate a substantial population with advanced lithic technology (Braje et al. 2013:26). Islanders relied on locally available resources and practiced seasonal residential mobility (Erlandson 1994; Gusick 2012, 2013). Faunal assemblages are dominated by California mussel (*Mytilus californianus*); macrobotanical remains are scarce, possibly due to preservation issues (Gill and Hoppa 2016; Gusick 2012).

Although most Paleocoastal sites are largely composed of shellfish remains, delicate lithic technology including Channel Island barbed points, amol points, and crescents were likely used to acquire fish, marine mammals, and waterfowl (Braje et al. 2013; Erlandson et al. 2011). At site CA-SRI-512W, 67 on Santa Rosa Island, Channel Islands barbed points and 19 crescents were found with over 5,000 bone fragments from waterfowl (majority), marine mammals and fish; Braje and colleagues (2013) suggest that the reason bones are scarce at most sites containing Paleocoastal points may be that these sites are relatively far from contemporary coastlines where prey may have been butchered to reduce transportation costs.

Early Period

The Early Period (6600-600 BC) encompasses all of the Middle Holocene, as well as parts of the Early and Late Holocene. Throughout the Early Period, people were relatively mobile, though there were some large, permanent settlements, including the coastal site Punta Arena (SCRI-109) (Glassow et al. 2008). There is an increase in sites dating to the Early Period, suggesting increasing population. There is also an increase in interior occupation, specifically during the Middle Holocene; these sites typically have a lower density of artifacts than Late Holocene sites and can be difficult to recognize without radiocarbon dates (Kennett 2005:129). Groundstone milling implements used throughout the Early Period, as well as the development of the mortar and pestle circa 3850-3050 BC (Glassow 1997a) have been interpreted as evidence of plant processing. Similarly, the higher proportion of dental caries (linked to consumption of plant foods [Walker and Erlandson 1986]), as well as a higher proportion of plant processing implements deposited as grave goods (Hollimon 1990, 2001), suggest plants were more frequently consumed during the

Early Period and that plant processing was more tied to identity during the Early Period than the subsequent Middle or Late Period.

Middle Period

During the Middle Period (600 BC-AD 1150) there was a shift to coastal settlement (Kennett 2005), and village sites appear to have been occupied year-round (Erlandson and Rick 2002; Kennett and Conlee 2002). The development of the circular shell fishhook (circa 550 BC) allowed for more efficient fishing (Glassow 1997a; McKenzie 2007), and there appears to be a greater emphasis on fishing during the time period. Hollimon (1990) notes that common grave goods transition from artifacts associated with plant processing during the Early Period to those associated with fishing during the Middle and Late Periods. The development of the *tomol* plank canoe (circa AD 450) allowed for pelagic fishing and increased trade. In the Late Middle Period (AD 900-1150) trade intensified, and abundant trapezoidal microblades indicate intensified *Olivella* shell bead production (Arnold 1987, 2001; Perry 2004). After approximately 1050 BC there are very few interior sites classified as residential bases, signaling a shift to coastal settlement, centered around increased fishing and inter-island and mainland trade (Kennett 1998; Perry 2004). A notable exception to this pattern is Diablo Valdez (SCRI-619/620), a high elevation site occupied from the Early Period into the Historic Period (Gill 2015).

Late Period

Throughout the Late Period (AD 1150-1819), growing populations concentrated in permanent coastal villages with high degrees of social stratification. Ranked hierarchy may have emerged as early as the Middle Period (see Gamble et al. 2001, 2002), but it was

certainly in place by the Transitional Period (AD 1150-1300), with growing cultural complexity (Arnold 1992). Triangular dorsal retouched (TDR) microblades were produced starting in the Transitional Period to manufacture high quantities of callus beads; unlike their trapezoidal predecessors, these TDR microblades are primarily found at coastal village sites, not near quarries (Arnold 1992; Perry 2004). During this time period bead making became relatively rare on the mainland, shifting to a specialized craft production on the islands (Munns and Arnold 2002). During the Historic Period (AD 1782-1819) European goods, including iron needles used as drill tips and glass beads, changed bead production, but it continued to take place. European disease epidemics brought about cultural disruption, with the death of many individuals having political or religious leadership roles, and those with specialized, restricted knowledge. The last recorded islander was removed from Santa Cruz Island in 1819, and brought into the mainland mission system (Johnson 2001:64; Munns and Arnold 2002:133). It is possible some Chumash briefly re-occupied Santa Cruz Island after an 1824 revolt at the Mission of Santa Barbara, but only for a few weeks (Johnson 1982; Munns and Arnold 2002). Although the Chumash continue to live in mainland territories, 1819 marks the end their >10,000-year occupation of Santa Cruz Island.

John P. Harrington (1884-1961) recorded over a million pages of ethnographic notes on the Chumash, which include a wealth of ethnobotanical knowledge based on interviews with Chumash consultants Luisa Ygnacio, Lucrecia García, Mary Yee, Juan Justo, María Solares, Rosario Cooper, Fernando Librado, Simplico Pico, and Candelaria Valenzuela (Timbrook 2007:15). Fernando Librado, who was born on Santa Cruz Island, provides specific information about Cruzeño plant use. Timbrook (1984, 1990, 2007) has poured over Harrington's handwritten notes to produce wonderful syntheses of Chumash ethnobotany.

Other ethnobotanical syntheses of California Indians (Mead 1972, Strike 1994) provide additional information for comparison. The traditional ecological knowledge recorded by Harrington and others are invaluable resources for interpreting the archaeobotanical record.

Importance of the Middle Holocene

The Early Period spans 6,000 years of prehistory, during which there was a significant increase and stabilization of populations, as well as the development of important technological innovations. The occupation of interior sites and the presumed importance of groundstone during the Middle Holocene suggest that terrestrial resources were of particular importance during this time period, after which there was a shift to permanent coastal villages and a greater emphasis on fishing. It remains unclear whether interior sites were positioned to take advantage of plant resources, and whether early mortars and pestles signal intensive processing of acorns as a storable staple resource. Two goals of this research address the need for direct evidence of (1) plant exploitation at interior occupations, and (2) what resources Middle Holocene groundstone was used to process.

CHAPTER 3

FIELD AND LABORATORY METHODS

In order to address the role of interior sites and terrestrial resources, I targeted two locations on Santa Cruz Island: the Central Valley and the isthmus (Figure 6). As discussed in Chapter 1, reasons to occupy interior sites include proximity to freshwater, plants, or toolstone resources, and access to travel routes, defensive locations, and community aggregation areas (Perry and Glassow 2015:15). The Central Valley is the highest ranked watershed on Santa Cruz Island (Kennett 2005) and has a variety of economically important plants, such as manzanita (*Arctostaphylos* spp.), cherry (*Prunus illicifolia*), cattail (*Typha* spp.), acorn (*Quercus* spp.), and blue dicks (*Dichelostemma capitatum*). The isthmus that connects the eastern and western portions of the island is located near several large chert quarries to the east (Perry and Jazwa 2010) and hosts a variety of plant foods, including acorn, pine (*Pinus muricata*), and various grasses. Chert is the highest-quality toolstone material on the Northern Channel Islands and occurs in the greatest density on the eastern end of Santa Cruz Island where there are 26 quarries within 30 km^2 (Perry and Jazwa 2010). Additionally, both the isthmus and the Central Valley are along important intra-island travel routes. The isthmus is highly defensible (Perry 2004), and the Central Valley's location between major travel routes could make it an ideal place for community aggregation (Perry and Delaney-Rivera 2011). These two locations complement ongoing work addressing the role of interior sites on the eastern and western ends of Santa Cruz Island (Glassow 2014; Perry 2003; Perry and Delaney-Rivera 2011; Perry and Glassow 2015).

I selected three sites with known Middle Holocene occupation dates within the Central Valley and isthmus based on information from previous research by Arnold and Perry (Graesch and Arnold 2003; Perry 2008; Perry and Hoppa 2012). Excavation units were scaled toward recovering macrobotanical remains. A preliminary study of 8-, 16-, and 20-liter bulk soil samples from SCRI-174, SCRI-183, and SCRI-393 had low seed densities (1.45, 1.38, and 0 count per liter, respectively) (Hoppa 2014; Popper 2003). To compensate for low seed density, I subsequently excavated 100-250 liter samples in order to recover a larger numbers of plant remains. Using existing digital contour maps of each site, I placed units to avoid previous testing or, in the case of SCRI-393, to explore a known feature.

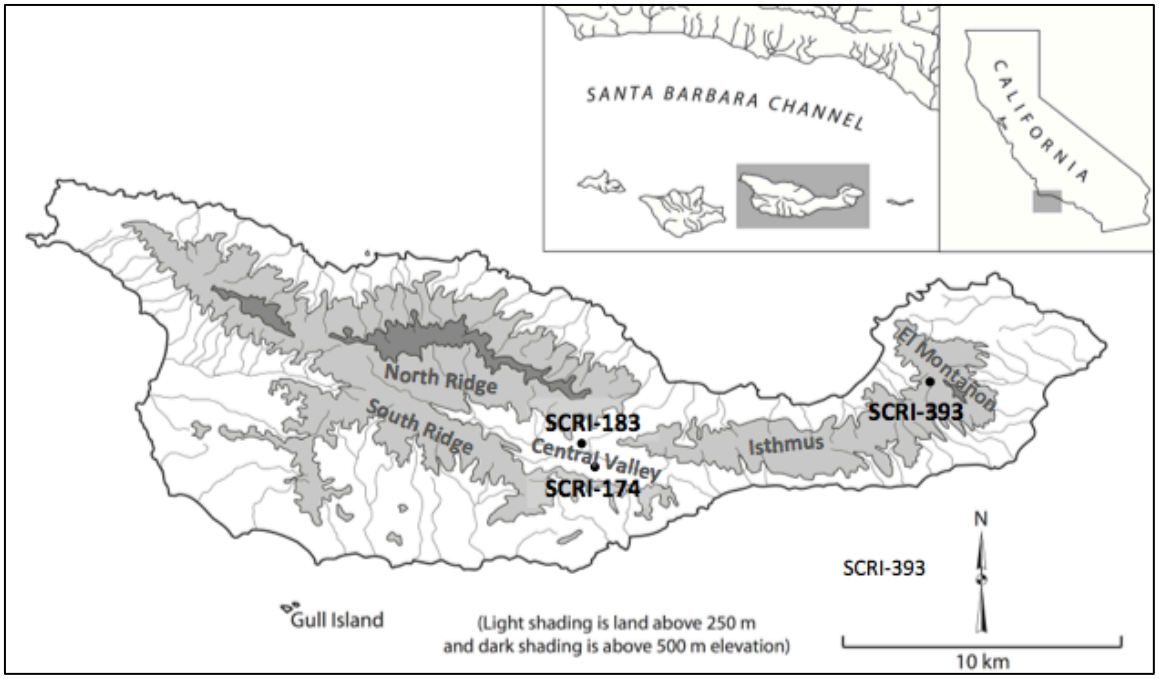


Figure 6. Map of study sites.

Previous Research at the Central Valley Sites

In 2007 I assisted Jennifer Perry (Principal Investigator) in mapping and testing both SCRI-174 and SCRI-183. These two sites are located near Stanton Ranch in the Central Valley. At each site we flagged the boundaries based on midden exposure and artifacts

visible on the surface and within boot or trowel scrapes. We selected a datum for each site based on permanence or visibility, established a grid, and took auger samples at 5-10 meter intervals in order to assess depth and density of cultural deposits. We judgmentally placed a 1 x 1 meter test unit to target the deepest and most dense deposits within undisturbed areas of the site. We excavated these units in arbitrary 10 cm levels (unless we encountered a feature or cultural stratum) to sterile, and placed an adjacent 20 x 20 cm column sample based on the profile exposure. Materials from the 1 x 1 m test unit were screened through 1/16" mesh in the field and the materials from the 20 x 20 cm column sample were collected as bulk samples (by level). All material (Table 3) was transported back to the Collections Processing Laboratory at Pomona College, where Perry oversaw analysis of all screened material. Kristina Gill and I floated the bulk column samples at the Collections Processing Laboratory at the University of California, Santa Barbara, using a Flote-tech machine-assisted system (see Hunter and Gassner 1998 for a review of this system). I analyzed the light-fraction materials at UCSB (Hoppa 2014) and Perry sorted all heavy fraction column sample materials (no plants were recovered from the heavy fraction).

Table 3. Previous Excavations at Central Valley study sites.

Site	Provenience	Size	Depth	Volume (L)
SCRI-174	Unit 15 N 4 W	1 x .5 m	0-20 cm	100
SCRI-174	Unit 15N 3.5W	1 x 1 m	0-50 cm	500
SCRI-174	Column Sample 1	.2 x .2 m	0-40 cm	16
Totals				**616**
SCRI-183	Unit 0N 3E	1 x 1 m	0-60 cm	600
SCRI-183	Column Sample 1	.2 x .2 m	0-50 cm	20
Totals				**620**

Previous Research on the Isthmus

Jeanne Arnold (Principal Investigator) mapped and tested SCRI-393 with UCLA field school students in 2001. Surface testing consisted of six shovel test pits (25-30 cm diameter) to depths of <30 cm, and two augers (10 cm diameter) to depths of <40 cm, for a combined volume of 158 liters (Table 4) (Graesch and Arnold 2003). Units were randomly placed within two judgmentally selected areas of the site, based on surface artifacts and rock features. They screened the 150 liters from STPs through 1/8" mesh in the field, and collected the 8 liters from augers as a bulk soil sample. Virginia Popper floated the bulk soil samples using the bucket flotation method (Pearsall 2010) and examined the light and heavy fractions for macrobotanical remains (Graesch and Arnold 2003; Popper 2003).

Table 4. Previous Excavations at isthmus study site.

Site	Provenience	Size	Depth	Volume (L)
SCRI-393	STP 9	25-30 cm diameter	0-20 cm	20
SCRI-393	STP 11	25-30 cm diameter	0-20 cm	20
SCRI-393	STP 12	25-30 cm diameter	0-20 cm	20
SCRI-393	STP 16	25-30 cm diameter	0-30 cm	30
SCRI-393	STP 19	25-30 cm diameter	0-30 cm	30
SCRI-393	STP 25	25-30 cm diameter	0-30 cm	30
SCRI-393	Auger 26	10 cm diameter	0-40 cm	6
SCRI-393	Auger 27	10 cm diameter	0-20 cm	2
Totals				**158**

Field Methods for Follow-up Research

Excavations at the Central Valley (Perry 2008; Perry and Delaney-Rivera 2011) and isthmus sites (Graesch and Arnold 2003) resulted in excellent data regarding faunal and artifact assemblages; however, the small bulk samples yielded very few seeds (Hoppa 2014; Popper 2003). For this study, I excavated bulk soil samples of 100-250 liters from each site in order to recover a larger sample of macrobotanical remains.

Like many of the small, interior sites dating to the Middle Holocene on Santa Cruz Island, the three study sites do not have discrete stratigraphic levels, but rather a homogenous dark midden; therefore, I excavated each unit in arbitrary 10 cm levels to sterile. At SCRI-174 and SCRI-183, 1 x 0.5 meter units were placed to avoid previous testing and were taken as bulk samples. At SCRI-393, I placed two adjacent 0.5 x 0.5 m units to extend within and beyond the surface boundaries of a circular rock feature documented as a possible house feature by the UCLA field school (Graesch and Arnold 2003). Both units were excavated in arbitrary 10 cm levels, but the northern unit (150 L) was collected as a bulk sample and the southern unit (150 L) was screened through 1/16" mesh in the field. I chose to excavate adjacent units in order to expose a larger cross-section of the rock feature, and because it can be cumbersome to excavate a 0.5 x 0.5 m unit deeper than arm's reach; however, I partially screened only a portion of the deposits from the southern unit based on the density of cultural materials and project constraints. In addition to the test units described above, I took one off-site bulk auger sample within the vicinity of SCRI-174 and SCRI-183, and another within the vicinity of SCRI-393, in order to compare non-cultural plant remains (e.g., wild plants carbonized by natural fire). Each auger sample extended to a depth of approximately 25 cm. All excavated materials were transported to the Collections Processing Laboratory at the University of California, Santa Barbara.

Laboratory Methods

All bulk soil samples were floated using the manual (bucket) flotation method (Pearsall 2010). This simple and reliable method involves gently hand-agitating samples in buckets of water so that lighter materials such as carbonized seeds and small bones float to the top.

Samples are then decanted through a fine cloth mesh, which captures the floating (light fraction) material, leaving the heavier (heavy fraction) material in the first bucket.

Each of the three study sites has a silty clay loam soil, which required deflocculating. Several deflocculants (e.g., baking soda, Alconox, laundry and dishwashing detergent) were tested, and dishwashing detergent was found to work best. Bulk samples were distributed into 5 gallon buckets (approximately 5 liters of soil per bucket) and covered with water, and approximately one tablespoon of dishwashing detergent. Samples were manually agitated and soaked for 4-12 hours, depending on the stickiness of the soil. Each sample was soaked and decanted 3-6 times in order to recover all light fraction material. Light fraction materials were hung on a clothesline to dry. Heavy fraction samples were transferred to 1/16" mesh wet screens, and additionally rinsed with a hose to remove remaining soil. Field-screened samples from the southern unit at SCRI-393 were deflocculated and wet screened alongside other heavy fraction materials.

All heavy fraction materials were size sorted through 1/4", 1/8", and 1/16" mesh. All 1/4" materials were sorted to the lowest taxonomic level possible; most shellfish remains were sorted to species level, while most bone was heavily fragmented and could only be sorted to class (e.g., fish, sea mammal). Lithics and artifacts were sorted by material (chert and volcanic) and type (flakes and debitage). Samples of 100 g from all 1/8" and 1/16" materials were scanned for macrobotanical material and artifacts (e.g., beads), but were otherwise not sorted (Table 5); no macrobotanicals or artifacts were recovered. Because bulk column samples from SCRI-174 and SCRI-183, as well as bulk auger samples from SCRI-393, have been sorted to the 1/16" level, there is a representative sample of small fraction materials from each of these sites.

All light fraction samples were screened through geological sieves (2.0 mm, 1.4 mm, 1.0 mm, and the pan) and sorted under a stereoscopic microscope (x40 magnification). Faunal remains and wood charcoal were pulled from the 2.0 mm level only. Nutshell was pulled from the 2.0 mm level, and from smaller fractions only if it was not present in the 2.0 mm level. Seeds were pulled from all levels. All carbonized plant material pulled was sorted to the lowest taxonomic level possible, using both published guides (e.g., Martin and Barkley 2000) and the comparative collection in the Integrated Subsistence Laboratory at the University of California, Santa Barbara. I consulted with Kristina Gill, Heather Thakar, and Amber VanDerwarker on questionable identifications, although any misidentifications are my own (see Appendix IV for photos of seeds). Wood charcoal was weighed but not counted, while all seeds were both weighed and counted. Remaining non-carbonized plant and non-bone material was weighed separately as contamination (from the 2.0 mm sieve) and residue (from <1.4 mm sieves). Several of the <1.0 mm (pan) samples were split because they were over 100 g; extrapolated counts (X) were calculated by dividing the subsample weight (n) by the sample weight (N).

$$X = \frac{\textit{weight N} * \textit{count}}{\textit{weight n}}$$

Table 5. Heavy fraction sample sizes at study sites.

Site	Provenience	Volume (L)	Sample Weight (g)		
			Sorted	Sampled	
			>1/4"	>1/8"	<1/8"
SCRI-174	Unit 3, 0-10 cm	50	2077	974	4114
SCRI-174	Unit 3, 10-20 cm	50	2571	1001	3529
SCRI-183	Unit 2, 0-10 cm	50	3771	1835	2128
SCRI-183	Unit 2, 10-20 cm	50	3873	4191	3596
SCRI-183	Unit 2, 20-30 cm	50	3364	4388	3021
SCRI-183	Unit 2, 30-40 cm	50	3151	4267	2268
SCRI-183	Unit 2, 40-50 cm	50	2467	3286	2937
SCRI-393	Unit 1N, 0-10 cm	25	2970	2875	4791
SCRI-393	Unit 1N, 10-20 cm	25	1993	2428	3411
SCRI-393	Unit 1N, 20-30 cm	25	6676	4624	4626
SCRI-393	Unit 1N, 30-40 cm	25	5656	3979	3746
SCRI-393	Unit 1N, 40-50 cm	25	4289	2019	2516
SCRI-393	Unit 1N, 60-60 cm	25	3050	1816	2990

Table 6. Light fraction sample sizes at study sites.

Site	Provenience	Volume (L)	Sample Weight (g)			
			>2.0 mm	>1.4 mm	>1.0 mm	<1.0 mm
SCRI-174	Unit 3, 0-10 cm	50	60	33	52	504
SCRI-174	Unit 3, 10-20 cm	50	24	8	9	112
SCRI-183	Unit 2, 0-10 cm	50	66	29	60	187
SCRI-183	Unit 2, 10-20 cm	50	25	18	36	707
SCRI-183	Unit 2, 20-30 cm	50	24	5	8	21
SCRI-183	Unit 2, 30-40 cm	50	48	10	14	31
SCRI-183	Unit 2, 40-50 cm	50	36	6	8	26
SCRI-393	Unit 1N, 0-10 cm	25	17	18	17	180
SCRI-393	Unit 1N, 10-20 cm	25	7	2	28	192
SCRI-393	Unit 1N, 20-30 cm	25	10	1	2	37
SCRI-393	Unit 1N, 30-40 cm	25	1	0	0	2
SCRI-393	Unit 1N, 40-50 cm	25	5	2	8	38
SCRI-393	Unit 1N, 60-60 cm	25	4	0	7	51

Microbotanical Analysis

The microbotanical component of this project involved a lot of trial and error. After spending a week in Deborah Pearsall's laboratory at the University of Missouri Columbia in

2009, I wrote a series of grant proposals to build a similar laboratory at UCSB with the help of Amber VanDerwarker. The first batch of artifacts I processed had starches, but the slides were so dirty that it was difficult to photograph or identify the starches. I modified my procedure several times, but I could not get high enough resolution to identify starch granules (although I could determine presence or absence based on the visibility of extinction crosses under polarized light). After additional training with Rob Cuthrell at the McCown Archaeobotany Laboratory at the University of California, Berkeley in 2012, I refined my technique (most importantly by removing clays from my samples prior to flotation, which led to significantly cleaner slides). During this time we also upgraded our microscope in the Integrated Subsistence Laboratory at UCSB, allowing for high-resolution photographs and measurements. Another important insight came from Cuthrell's experiment on starch recovery (Cuthrell and Murch 2014), demonstrating that a significant number of microbotanicals are lost using a fixed-rotor versus horizontal centrifuge. Because our lab had the former, I paused on processing additional artifacts until it could be replaced in the fall of 2016. I include this background to clarify that early samples were not processed under ideal conditions, and some artifacts from which no starches were recovered could be due to the use of a fixed-angle centrifuge. Nevertheless, these early samples demonstrated that both starch granules and phytoliths can be recovered from *in situ* and curated groundstone artifacts. The artifacts and recovered starch granules I discuss in chapters 5 and 6 were all processed under ideal conditions, following the protocol outlined below.

Both soil samples and groundstone artifacts were processed for both starch granules and phytoliths. Soil samples of 5-10 ml were taken from each stratigraphic level. No groundstone was recovered during excavation; however, I tested three groundstone artifacts

collected from the surface of isthmus site SCRI-393 during 2001 fieldwork (Graesch and Arnold 2003; Perry 2003), as well as 10 surface or *in situ* artifacts from other interior Middle Holocene sites (Table 7). All artifacts and soil samples were processed following Chandler-Ezell and Pearsall's (2003) "piggyback" method, which allows for the recovery of both starch granules and phytoliths from the same samples (see also Cuthrell 2011).

Table 7. Groundstone artifacts from other interior Middle Holocene sites tested for microbotanical residue.

Site	Provenience	Depth	Artifact	Material
SCRI-393	Surface		Groundstone Fragment	Volcanic
SCRI-393	Surface		Mortar Fragment	Volcanic
SCRI-393	Surface		Mortar Fragment	Sandstone
SCRI-649	Surface		Bowl Mortar Fragment	Volcanic
SCRI-649	Surface		Bowl Mortar Fragment	Volcanic
SCRI-724	2.5S/5.5W	20-30 cm	Groundstone Fragment	Volcanic
SCRI-724	2.5S/5.5W	0-10 cm	Groundstone Fragment	Basalt
SCRI-724	2.5S/5.5W	0-10 cm	Pestle Fragment	Volcanic
SCRI-724	2.5S/5.5W	10-20 cm	Mano Fragment	Basalt
SCRI-751	Surface		Mortar Bowl Fragment	Volcanic
SCRI-751	Surface		Mano Fragment	Volcanic
SCRI-751	Surface		Mano Fragment	Volcanic
SCRI-751	Surface		Mano Fragment	Volcanic

All artifacts sampled in this study were free of visible contaminants (i.e., adhering dirt), so I did not take dry brush samples, but took a wet brush sample (Sediment 1) and a sonicated sample (Sediment 2). I manually brushed each artifact with a new toothbrush and distilled water to create Sediment 1. I then placed each scrubbed artifact into a ziplock bag filled with distilled water, and then placed the bag into a water-filled sonicator for 10-30 minutes to create Sediment 2. While the sonication process will effectively capture all residues, creating separate samples allows one to distinguish between residues that are gently adhering to an artifact (e.g., contaminants), versus those that are more deeply

embedded in the surface of the artifact. Sediments 1 and 2 were poured into 50 ml tubes; for larger artifacts I had to repeatedly centrifuge and decant samples in order to fit all of the sediment into one centrifuge tube. For soil samples, I poured 5-10 g of soil in a 50 ml centrifuge tube with a deflocculant (0.1% Alconox) and left them on a laboratory shaker for a minimum of one hour (longer for stickier soils), resulting in Sediment 1. Once soil and artifact samples were prepared, I centrifuged the samples and removed the upper water column (and clay particles) with a syringe, repeating this step until the water was translucent.

I used lithium metatungstate (LMT) for both starch and phytolith flotation. For starch flotation, I added a mixture of LMT and distilled water with a specific gravity (sg) of 1.6, which is denser than most starches but not most phytoliths, meaning the starches can be decanted into a new sample, leaving the phytoliths (and any other dense material) in the lower column (Figure 7). After removing the starches, I subjected the remaining sediment to chemical digestion, removing organic materials with hydrochloric and nitric acid, but leaving silica phytoliths intact. After removing chemicals via repeatedly adding distilled water, centrifuging, and decanting, I added a mixture of LMT and distilled water with a specific gravity of 2.3, which is denser than most phytoliths, meaning they could be decanted into a new sample. Samples processed in the UCSB Integrative Subsistence Laboratory followed Environmental Health and Safety guidelines.

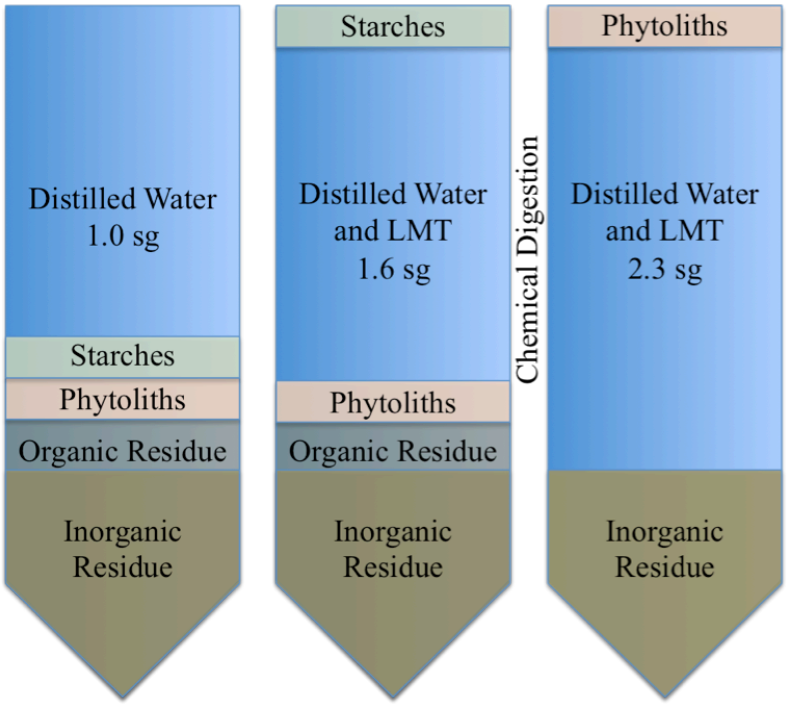


Figure 7. "Piggy Back Method" (Chandler-Ezell and Pearsall's 2003), allowing for extraction of starch granules and phytoliths from the same sample.

Extracted starch granules and phytoliths were mounted on slides using corn syrup and immersion oil, respectively. I added methylene blue dye to phytolith mounts; the dye is absorbed by amorphous silica but not by intact phytoliths (Figure 8), allowing for easier visual identification (Rob Cuthrell, personal communication 2012). Slides were examined using an Olympus CX31 upright microscope (100-400x) in the UCSB Integrative Subsistence Laboratory, as well as similar microscopes at UC Berkeley and Cottage Hospital in Santa Barbara. Slides were photographed and measured using an Altra20 camera and the Olympus Microsuite 5 software.

Identifications were made using a comparative collection created at UCSB for this study (Figure 9), as well as published sources (e.g., Herzog 2014; Scholze 2010, 2011; Wisely 2016). I was unable to identify phytoliths beyond the family level (e.g., grass family [Poaecae]), but many starch granules were identified to the genus level. As the comparative

collection is not exhaustive, photographs of archaeological starch granules are included alongside measurements and descriptions with the hope that further research will allow for additional or revised identifications. For each starch granule I took photographs with varying levels of polarization (Figure 10) and took measurements using Microsuite 5 (Figure 11). I categorized the shape of each starch granule as circular, diamond, ovoid, pear, reniform, semi-ovate, or irregular (Figure 12) and categorized the extinction cross as straight, curved, double-curve, wavy, or swirl (Figure 13). Visual categorization of starch granules can be difficult because the position of a starch granule on a microscope slide will affect the view; it is possible to move a starch granule within the mount, but then it may disappear from the field of vision completely. Furthermore, many starch granules fall between categories (e.g., pear or semi-ovate) and are subject to interpreter bias; I have provided illustrations of the categories used in this study for the purposes of clarity.

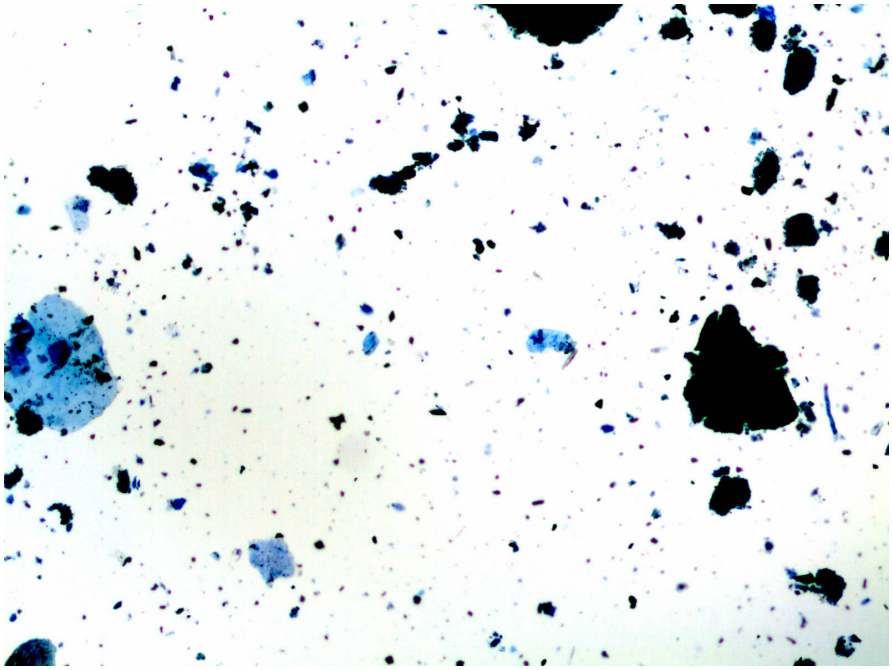


Figure 8. Phytoliths extracted from soil from SCRI-183 (amorphous silica dyed blue).

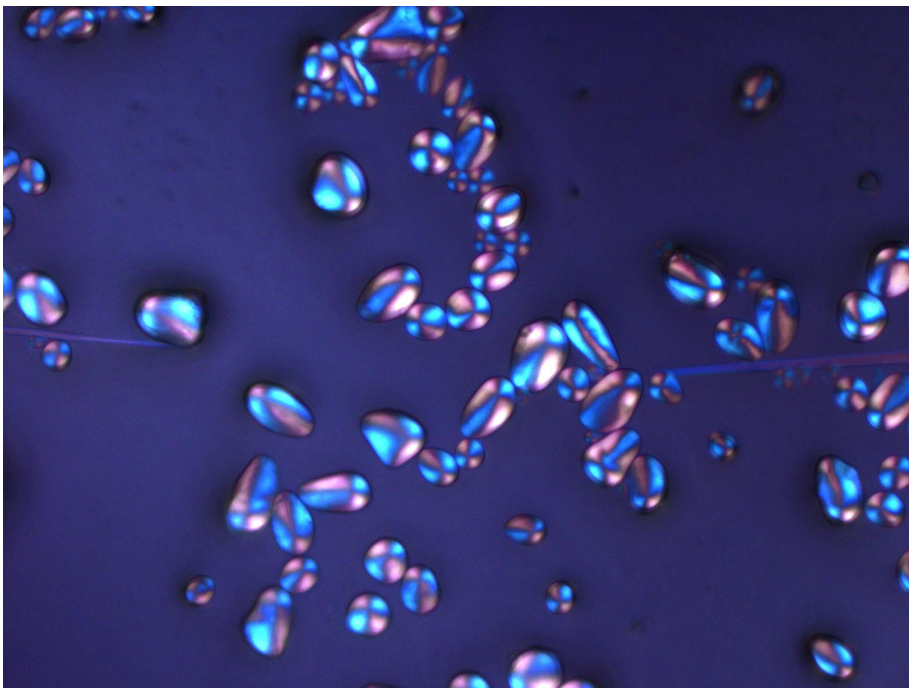


Figure 9. Starch granules from a blue dicks (*Dichelostemma capitatum*) corm, UCSB comparative collection.

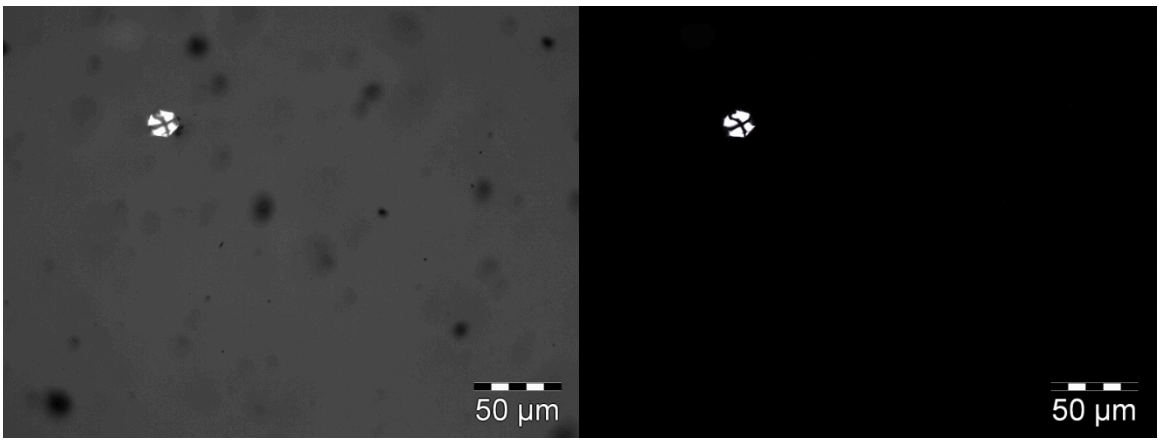


Figure 10. Starch granule at partial and full polarization.

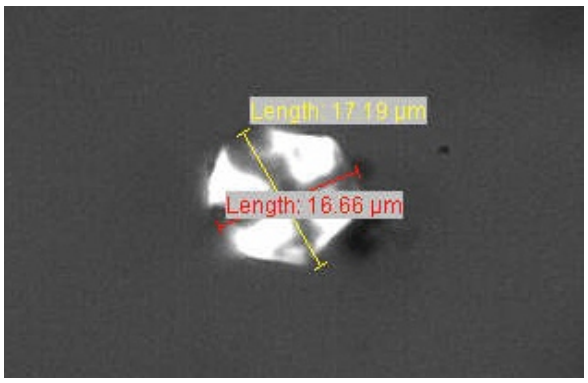


Figure 11. Starch granule with measurements.

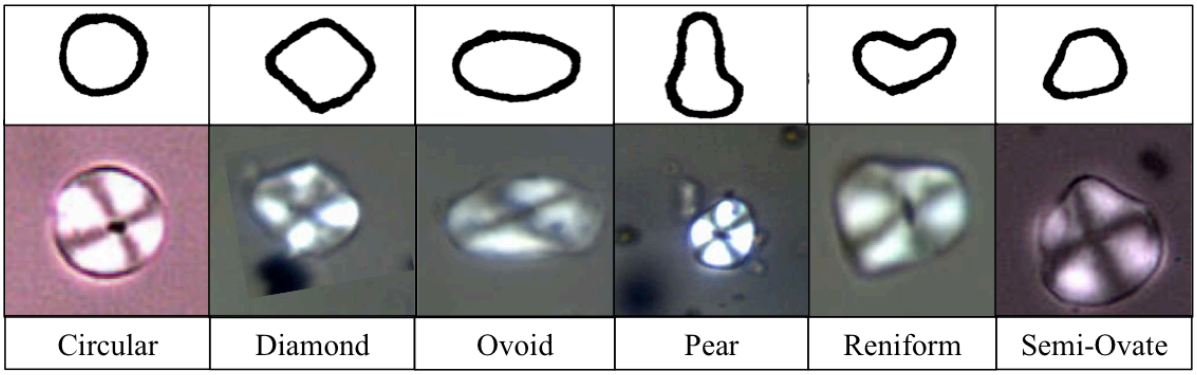


Figure 12. Starch shape classifications.

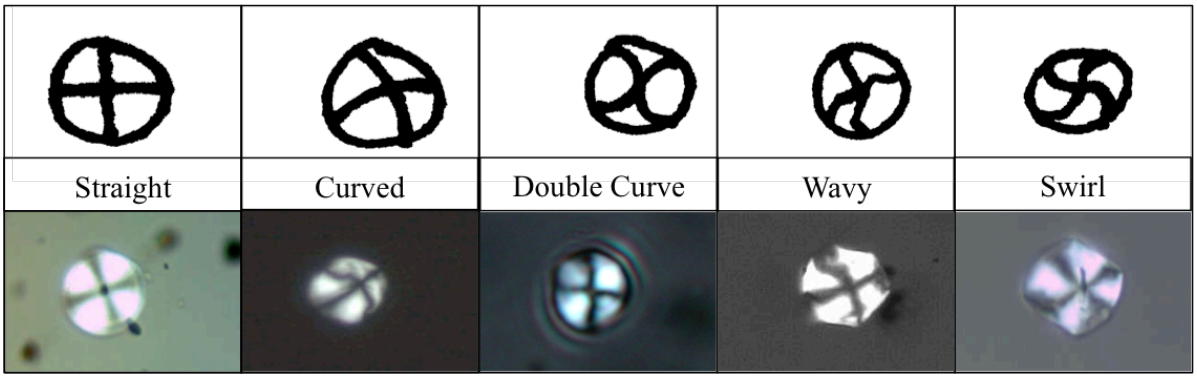


Figure 13. Extinction cross classifications.

CHAPTER 4

INVESTIGATIONS IN THE CENTRAL VALLEY

Santa Cruz Island's large Central Valley is unique among the Channel Islands, situated between the North and South ridgelines, with the isthmus rising to the east (Figure 6); it is actually a combination of multiple valleys from three different watersheds and has abundant groundwater and reliable streams (Junak et al. 1995:3-4) (Figure 14). It is protected from coastal storms, but also subject to more extreme temperatures in winter and summer; winter temperatures can drop below freezing in the Central Valley (whereas the rest of the island is frost-free), and summer temperatures average 14-15° C higher than nearby Prisoner's Harbor (Junak et al. 1995:4). Annual precipitation averages 508 mm in the Central Valley, compared to 450 mm at the Navy Base on the isthmus, 423 mm at nearby Prisoner's Harbor, and 321 mm at Christy Ranch on the western end of the island (Junak et al. 1995:9). The Santa Cruz Island fault runs through the middle of the valley, dividing major bedrock types, and consequently different soil substrates (Junak et al. 1995:10). The variation in elevation, soil substrate, and the valley's unique microclimate all contribute to the high levels of terrestrial diversity.

As discussed in Chapter 2, there are 16 distinct plant communities on Santa Cruz Island (Junak et al. 1995); eight of these occur in the Central Valley and include valley and foothill grassland, coastal-sage scrub, coyote-brush scrub, island chaparral, southern coastal oak woodland, riparian herbaceous vegetation, mule-fat scrub, and southern riparian woodland. Edible plants around the Central Valley include manzanita (*Arctostaphylos* spp.), elderberry

(*Sambucus mexicana*), lemonade berry (*Rhus intergrifolia*), prickly pear (*Opuntia* spp.), toyon (*Heteromeles arbutifolia*), cherry (*Prunus illicifolia*), cattail (*Typha spp.*), clover (*Trifolium* spp.), acorn (*Quercus* spp.), onion (*Allium* spp.), blue dicks (*Dichelostemma capitatum*), lily (*Lilium* spp.), red maids (*Calandrinia* spp.), rye (*Leymus* spp.), and fiddleneck (*Amsinkia* spp.). There are also medicinal plants, such as yarrow (*Achillea millefolim*) and catchfly (*Silene laciniata*), and plants used for basketry and construction, such as rush (*Juncus* spp.) and bulrush (*Scirpus* spp.). Marine resources were likely transported to the Central Valley from Prisoner's Harbor or Valley Anchorage, each of which is approximately 5 km from Stanton Ranch, along relatively flat terrain. Both areas have kelp forests and abundant near shore marine resources.

Archaeological sites throughout the Central Valley attest to the valley's prehistoric occupation (Perry and Delaney-Rivera 2011; Rogers 1929; Sutton 2014b), but the valley was also used intensively during the historic period. The first permanent ranch structures were built in the Central Valley in 1852 when the island was owned by Andres Castillero (through a Mexican land grant). Under Castillero's instruction, the ranch manager brought out approximately 1,000 sheep; the sheep population grew substantially and soon 200 acres of land were planted with animal feed (Chiles 2011:32-33). Significant developments, including the construction of new buildings and indoor plumbing took place in the 1880s, when Justinian Caire owned the island. Caire began planting grape vines around his main ranch in the Central Valley in 1884; at the peak, there were 187 acres of vineyards planted, with the winery producing 95,000 gallons of wine in 1910 (Chiles 2011; Pinney 1994). Horses pulled plows through the vineyards, and the grapes were crushed and fermented in the upper and lower winery buildings, respectively (Figure 15). Production dwindled after

1918 due to Prohibition, but the Caires were able to continue limited permitted production. In 1937 ownership passed from the Caire family to Edwin L. Stanton, who began to dismantle the island's wine industry. The last of the island's wine supply, unable to be sold due to a lack of market, and spoiling in its wooden containers, was dumped out in 1939 (Pinney 1994). In the 1950s both of the wineries caught fire, destroying the remnants and records of the wine industry; the brick walls remained and were re-roofed to be used as storage for equipment (Pinney 1994). Although the vineyards are long gone, historic maps and photos show that they covered much of the valley, stretching from the foothills of the South Ridge bordering the main ranch, to the east more than a third of the distance to Valley Anchorage (Chiles 2011:75). The intensive use of the Central Valley for ranch operations and vineyards during the historic period means that sites within the area would have been subject to considerably more human impact than elsewhere on the island, including surface collection, plowing, and in some cases bulldozing.

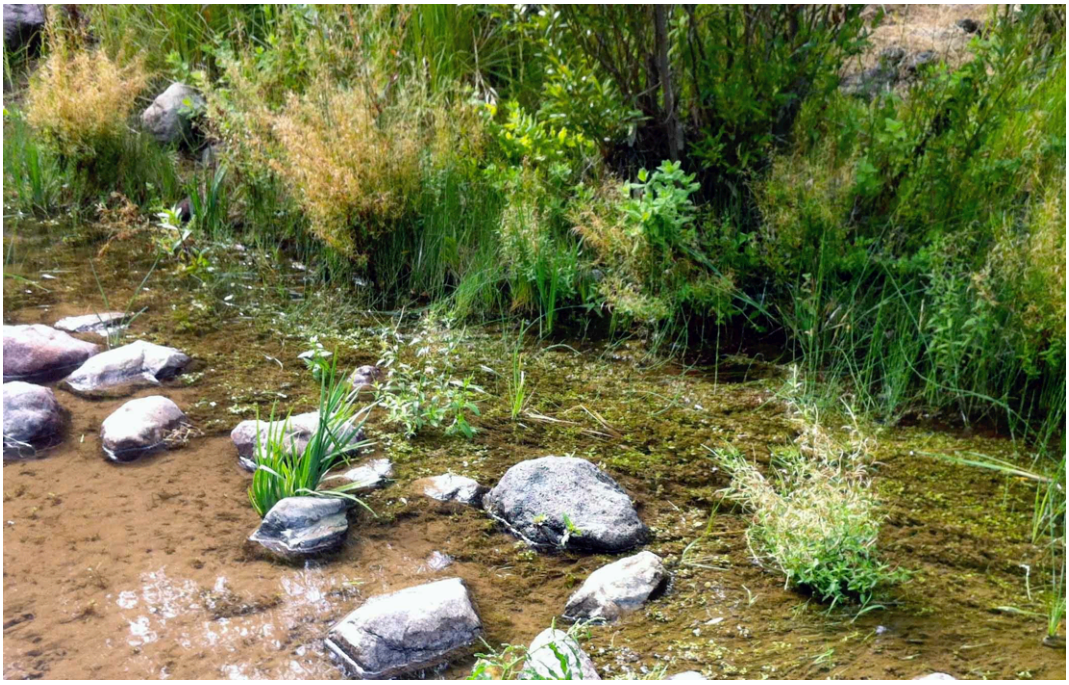


Figure 14. Freshwater in the Central Valley during a dry summer (2012).

Figure 15. Vineyards and upper and lower winery buildings, 1937. (Santa Cruz Island Foundation).

SCRI-174

SCRI-174 is located at 85 m elevation on a flat section of a ridgeline overlooking Stanton Ranch (Figures 16). The site is approximately 150 m from the upper winery building; a historic photo (Figure 17) shows grape vines on this landform (Rogers 1929). Radiocarbon dates place occupation of this site between 4665 and 2576 BC (Figure 17, Table 8). Radiocarbon dates show mixed strata, which could be the result of soil disturbance related to plowing the vineyard. Site SCRI-163, recorded just 80 m to the west, has been completely destroyed since it was recorded in 1973, likely due to ranch construction (e.g., bulldozing), bull wallowing, grazing, and related erosion (Michael Glassow, personal communication 2017); however, groundstone artifacts have been collected from the site and are stored in a small museum at Stanton Ranch (Jennifer Perry, personal communication

2017). While SCRI-174 appears relatively intact, it is likely that surface artifacts would have been encountered and removed or destroyed during ranch or vineyard activities, including plowing. Rogers (1929:310) refers to both sites (visible in Figure 17) as "historic village sites," suggesting significant surface deposits were visible.

SCRI-174 was originally recorded in 1973 as part of an NSF-funded project led by Glassow; the site record lists no surface artifacts. The site is approximately 2,000 square meters in area and extends to a maximum depth of 50 cm. As discussed in Chapter 3, I mapped and tested this site with Jennifer Perry (Principal Investigator) in 2007, excavating 616 liters. I returned to this site in 2012 and excavated a 1 x 0.5 m test pit to sterile (20 cm). The resulting sample had a volume of 100 liters (Table 5). The soil in this site is a dark gray silty clay loam with a homogenous fill. Although the radiocarbon dates confirm historical disturbance, this is not apparent in the soil stratigraphy.

Figure 16. SCRI-174, looking north-northwest toward the Chapel at Stanton Ranch; the roof of the upper winery building is visible on the left.

Figure 17. "Interior Valley, Santa Cruz Island" (Rogers 1929:310).

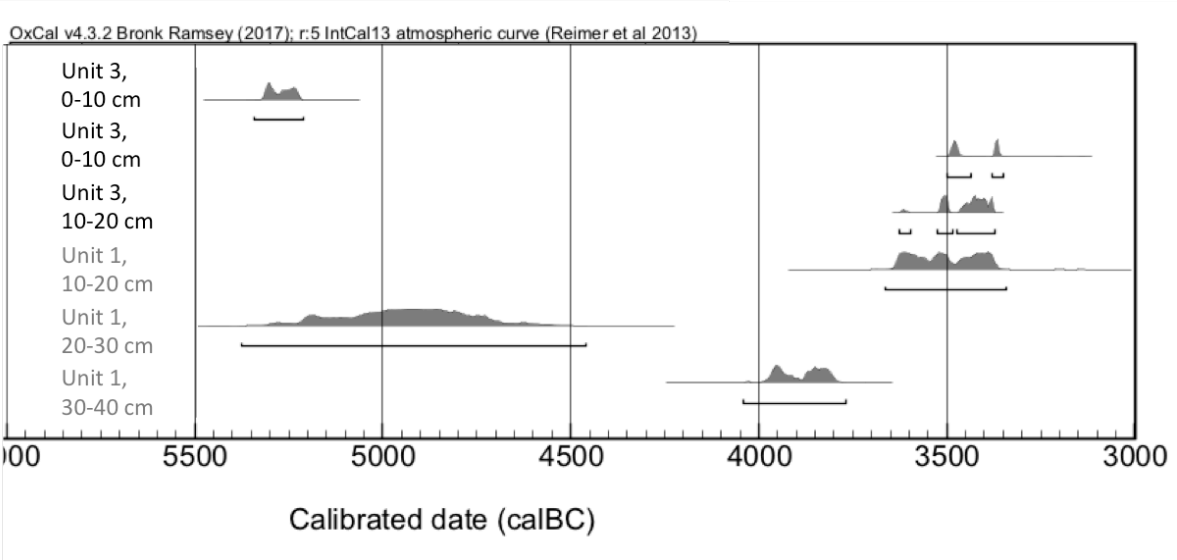


Figure 18. Radiocarbon dates from SCRI-174.

Table 8. Radiocarbon dates from SCRI-174.

Site	Provenience	Conventional age	Calibrated date, 2s interval	Lab #
SCRI-174	Unit 3, 0-10 cm	6300 ±20	4665-4447 BC	UCIAMS 186167
SCRI-174	Unit 3, 0-10 cm	4615 ±15	2731-2465 BC	UCIAMS 187576
SCRI-174	Unit 3, 10-20 cm	4690 ±15	2838-2576 BC	UCIAMS 186168
SCRI-174	Unit 1, 10-20 cm	4720 ± 60	2892-2545 BC	Beta 222702[1]
SCRI-174	Unit 1, 20-30 cm	6020 ± 130	4532-3952 BC	Beta 225908[1]
SCRI-174	Unit 1, 30-40 cm	5110 ± 40	3373-3049 BC	Beta 225909[1]

[1]Perry and Glassow 2015

Faunal Remains

Faunal remains at SCRI-174 are dominated by California mussel (*Mytilus californianus*), which makes up between 79 and 86% of the total faunal weight per level (Table 9). The next most abundant shellfish constituents are acorn barnacle (5%), wavy top (4%), and abalone (<2%). Acorn barnacle (*Balanus* spp.) can adhere to other shells and be inadvertently transported to the site as a result; however, there were numerous large and relatively intact barnacle shells that were not basally attached, indicating they may have been intentionally

harvested (see Moss and Erlandson 2010). Like California mussel, wavy tops preserve well inside of their shells and can be easily transported intact (Perry and Hoppa 2012).

Table 9. Percentage of total faunal weight (g) by species at SCRI-174.

Level	Volume (L)	California Mussel	Acorn Barnacle	Abalone	Wavy Top	Shell, undif	Other Shell	Bone
0-10	50	85.6	5.2	1.5	3.8	2.2	1.4	0.3
10-20	50	78.6	5.2	0.9	3.7	6.7	4.4	0.6
Totals	**100**	**81.9**	**5.2**	**1.2**	**3.7**	**4.6**	**2.9**	**0.4**

Abalone may be underrepresented at this interior site if individuals were processing (i.e., shucking) abalone at its collection site. Jazwa and colleagues (2015:40) demonstrate that red abalone (*Haliotis rufescens*) is most efficient to shuck at its collection site since the shells are relatively heavy and the meat can be removed quickly (5.22 minutes per kilogram), versus mussel which takes considerably more time to extract (34.28 minutes per kilogram). Due to commercial fishing regulations, Jazwa and colleagues were forced to use farmed red abalone, which are harvested relatively early, and were an average 10 cm in length. In a study of average shell sizes in San Miguel Island middens, Erlandson and colleagues (2008) estimate that during the Middle Holocene, the average shell length is 16 cm for red abalone, versus 10 cm for black abalone; therefore, the harvesting time estimated by Jazwa and colleagues can be applied to black abalone without a need for modification.

Unlike at Middle Holocene deposits on the west end of the island, red abalone is not common in sites from the Central Valley to the east. The black abalone (*Haliotis cracherodii*) recovered at SCRI-174 and other east end sites is a smaller species which is more abundant in the warmer waters on the eastern side of Santa Cruz than the larger red abalone, which is more abundant in the cooler waters on the island's western end (Glassow 1993b; Glassow et al. 2008; Perry and Hoppa 2012). It is worth noting that at least three

interior sites on the western portion of Santa Cruz Island have abundant red abalone shells, indicating that people did transport them intact to these locations (Glassow 2016; Thakar 2014).

Other shellfish represented at SCRI-174 include leaf barnacle (*Pollicipes polymerus*), urchin (*Strongylocentrotus* spp.), turban snail (*Tegula* spp.), worm tube (Polychaeta), norris's top (*Norrissia norrissii*), limpet (*Acmaea* spp.), and volcano limpet (*Fisurella volcano*). It is possible small limpets were brought in attached to seaweed, rather than specifically targeted for food (Ainis et al. 2014). Also present are fish bone, pinniped bone, undifferentiated mammal bone, and undifferentiated bone.

Floral Remains

A total of 55 seeds was recovered from the 100-liter bulk soil sample at SCRI-174 (0.55 ct/liter) (Table 10). The majority (36) of these seeds were from catchfly (*Silene laciniata*), which does not seem to be a food source; however, it may have been used medicinally by the Chumash to induce menstruation (Timbrook 2007:210), as a poultice for sores, or for other, unspecified medical purposes (Strike 1994:147). Because modern catchfly seeds can appear carbonized, all seeds were broken to confirm carbonization by examining the seed's interior; there were many un-carbonized seeds within the sample, suggesting these seeds may be natural rather than cultural inclusions. One amaranth (*Amaranthus* spp.) and one chenopod (*Chenopodium* spp.) seed were recovered, along with additional uncarbonized seeds of both genera. Off-site samples all contained a small amount of carbonized plant material. They contained both carbonized and uncarbonized catchfly, and uncarbonized chenopod seeds, demonstrating that these plants grow on site (or arrive through natural seed rain), and that their presence in the archaeological samples (even charred) may be incidental.

Eight seeds are of the bean (Fabaceae) family and could not be identified to a lower taxonomic level. One cryptantha (*Cryptantha clevelandii*) seed was recovered, as well as three yarrow (*Achillea millefolium*) seeds. Cryptantha and yarrow do not appear to be have been food sources; however, yarrow was used medicinally, as boiled liquid to treat toothache, and as a mashed poultice for cuts and sores (Biradent n.d.; Bingham 1890:36; Timbrook 2007:22). Catchfly, chenopod, and yarrow also occurred in the 16-liter column sample from this site, as well as knotweed (*Polygonum* spp.) (Hoppa 2014). Knotweed has no recorded uses among the Chumash, although Strike (1994:115) notes that, "seeds of Douglas knotweed were used in pinole by many California Natives. The young shoots of swamp knotweed and the young leaves of bistort were eaten by Maidu." Medicinally, knotweed was used to treat skin problems, toothaches, sores and boils. While the eight bean and single amaranth and chenopod seeds may be from food sources, it is impossible to say at the genus level. All seeds identified to the species level (40) come from three plants with medicinal uses, but no recorded uses as food.

Table 10. Macrobotanical remains recovered from SCRI-174.

SCRI-174, Unit 3 Level	0-10	10-20	Totals
Volume (L)	50	50	100
Sample Weight (g)	648.8	153.24	802.04
Bone Weight (g)	0	0	0
Wood Weight (g)	<0.01	<0.01	<0.01
Plant Weight (g)	0.07	<0.01	0.07
Nutshell (Weight)			**0.07**
Unidentifiable	0.07		0.07
Seeds (Count)			**57**
Amaranth (*Amaranthus*)	1		1
Bean Family (*Fabaceae*)	8		8
Catchfly (*Silene*)	34	2	36
Chenopod (*Chenopodium*)	1		1
c.f. Cryptantha (*Cryptantha*)	1		1
Yarrow (*Achillea millefolium*)	3		3
Unidentifiable Seed	3	2	5
Unidentifiable Plant Part		2	2

Technology

There were 22 flakes in the 100-liter bulk sample from SCRI-174 (18 chert and 4 volcanic), and 45 pieces of debitage (39 chert and 6 volcanic). An *in situ* digging-stick weight was encountered in the 40-50 cm level of Jennifer Perry's 1x1 m test unit; this digging stick weight was not tested for microbotanical residue because it appears to be stained with ochre, which would be removed during microbotanical processing. No other artifacts were recovered from this site.

SCRI-183

SCRI-183 is located at 70 m elevation on the eastern side of a low ridge just north of Stanton Ranch (Figure 19). The original site record (Ehmann and Pousson 1973) notes the presence of two groundstone fragments, 12 cores, and one bladelet on the site surface. I mapped and tested this site with Jennifer Perry (principal investigator) in 2007. We

excavated a 1x1 m unit to a depth of 60 cm, with an adjacent 20 x 20 cm bulk column sample to a depth of 50 cm (sterile), for a combined volume of 620 liters. I returned to this site in 2012 and excavated a 1 x 0.5 m bulk sample unit to sterile (50 cm), the volume being 250 liters (Table 5). This soil at this site is a dark gray silty clay loam with a homogenous fill. Perry acquired two dates for Unit 1 (2007), which did not indicate any disruptions to the stratigraphy. These dates place site occupation between 2814 and 1917 BC. I submitted 10 additional samples from my excavation (two from each level), which do not fall in chronological order by depth (Figure 20, Table 11). Due to the homogenous fill, stratigraphic disturbance was not detected during excavation. Unlike SCRI-174, there is no known evidence that this site was ever plowed or cultivated. One would expect, given its proximity to the main ranch, that humans and livestock have impacted the site; however, the surface artifacts identified in 1973 suggest that the site was not intentionally cleared. One possible explanation for the mixed chronology could be that the upper levels represent slope wash from SCRI-182 (which is located directly uphill), after grazing affected the vegetation (Michael Glassow, personal communication 2017).

Figure 19. SCRI-183, looking southeast toward the lower winery building.

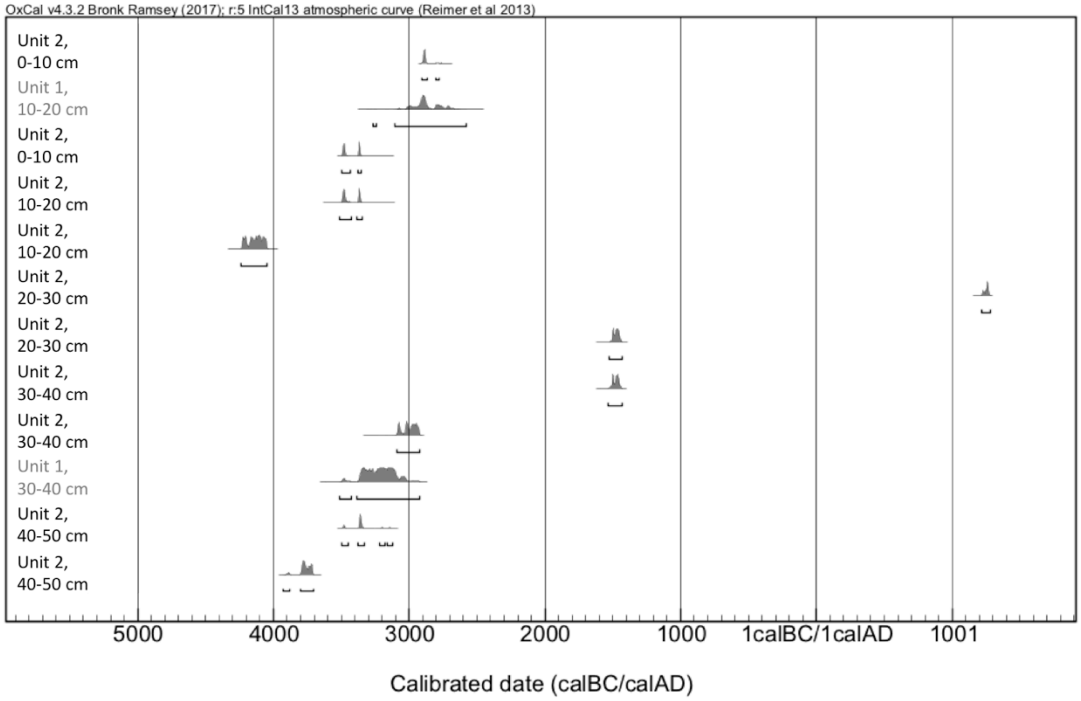


Figure 20. Radiocarbon dates from SCRI-183.

Table 11. Radiocarbon dates from SCRI-183.

Site	Provenience	Conventional age	Calibrated date, 2s interval	Lab #
SCRI-183	Unit 2, 0-10 cm	4245 ±15	2203-1952 BC	UCIAMS 186169
SCRI-183	Unit 1, 10-20 cm	4270 ± 60	2331-1917 BC	Beta 228026[1]
SCRI-183	Unit 2, 0-10 cm	4615±15	2731-2465 BC	UCIAMS 187578
SCRI-183	Unit 2, 10-20 cm	4615±20	2738-2463 BC	UCIAMS 187579
SCRI-183	Unit 2, 10-20 cm	5305 ±15	3600-3369 BC	UCIAMS 186170
SCRI-183	Unit 2, 20-30 cm	775 ±15	AD 1672-2890	UCIAMS 186171
SCRI-183	Unit 2, 20-30 cm	3215±15	899-750 BC	UCIAMS 187580
SCRI-183	Unit 2, 30-40 cm	3220 ±15	903-753 BC	UCIAMS 186172
SCRI-183	Unit 2, 30-40 cm	4395±15	2439-2181 BC	UCIAMS 187581
SCRI-183	Unit 1, 30-40 cm	4520 ± 60	2675-2255 BC	Beta 228027[1]
SCRI-183	Unit 2, 40-50 cm	4585 ±20	2684-2441 BC	UCIAMS 186173
SCRI-183	Unit 2, 40-50 cm	4995±15	3258-2930 BC	UCIAMS 187582

[1]Perry and Glassow 2015

Faunal Remains

Faunal remains at SCRI-183 are dominated by California mussel, which accounts for 72% of the total faunal weight, while acorn barnacle accounts for 21% (Table 12). In level 10-20 cm, acorn barnacle accounts for 46% of the total shell weight. This site also yielded large, fairly intact acorn barnacles, suggesting they may have been intentionally harvested rather than brought along incidentally (Moss and Erlandson 2010). Abalone and wavy top accounted for 1.4% and 1.2% of the total shell weight, respectively. Other shellfish taxa included slipper shell (*Crepidula* spp.), norris's top (*Norrissia norissii*), olive shell (*Olivella biplicata*), platform mussel (*Mytilisepta bifurcata*), leaf barnacle (*Pollicipes polymerus*), urchin (*Strongylocentrotus* spp.), worm tube (Polychaeta), owl limpet (*Lottia gigantea*), unidentified limpet, unidentified whelk, and unidentified clam. Bone consisted of California sheephead (*Semicossyphus pulcher*) fish bone, unidentified fish bone, unidentified mammal bone, unidentified bird bone, and unidentified bone.

Table 12. Percentage of total faunal weight (g) by species at SCRI-183.

Level	Volume (L)	California Mussel	Acorn Barnacle	Abalone	Wavy Top	Shell, undif	Other Shell	Bone
0-10	50	80.3	8.3	3.1	3.7	3.4	0.7	0.6
10-20	50	49.1	46.0	1.6	1.3	1.7	0.2	0.1
20-30	50	85.6	8.6	0.8	1.0	3.1	0.6	0.3
30-40	50	83.2	11.4	1.6	0.6	2.7	0.3	0.1
40-50	50	78.3	12.0	0.3	1.1	7.1	1.1	0.1
Totals	**250**	**72.4**	**21.3**	**1.4**	**1.2**	**3.0**	**0.4**	**0.2**

Floral Remains

A total of 17 seeds was recovered from the 250 liter bulk sample from SCRI-183 (0.07 count/liter), including eight amaranth, six catchfly, and two chenopod (Table 13). As previously discussed, these seeds may be incidental, as both catchfly and chenopod occur in the off-site sample, and modern seeds of each taxon were found in this sample. A single red maids (*Calandrinia brewerii*) seed was recovered from the 0-10 level. Red Maids are an important food source for the Chumash. They were usually toasted and ground into oily dough. Timbrook notes that red maids, or *pil*, were a prized food:

> Along with acorns, chia seeds (*Salvia columbariae*), and *islay* kernels (*Prunus ilicifolia*), *pil* was one of the most expensive foods in Chumash culture. All these were much sought after in trade and were measured in the standard unit of volume, the woman's basketry hat. Island Chumash people reportedly came to the mainland to buy hatfuls of these seeds, as much as they could carry…. For the Chumash, perhaps even more important than food was the use of red maids seeds in ritual offerings. For example, Harrington's consultants recounted that when visiting a sacred spring to collect water for curing the sick, a person would scatter offering of *pil*, chia, shell beads, and tobacco around the edges of the waterhole. They left similar offering at other kinds of shrines as well, and also placed them in graves [Timbrook 2007:47-48].

Red maid seeds have been found associated with burials, including one burial with twelve quarts of red maids, dated at 600±70 radiocarbon years before present (Orr 1968:200; Timbrook 2007:47-48).

Table 13. Macrobotanical remains recovered from SCRI-183.

SCRI-183, Unit 2 Level	0-10	10-20	20-30	30-40	40-50	Totals
Volume (L)	50	50	50	50	50	250
Sample Weight (g)	342.3	785.3	58.6	102.7	75.8	1364.8
Bone Weight (g)	0	<0.01	0.01	<0.01	0	0.01
Wood Weight (g)	0.06	0.02	0.02	<0.01	0	0.75
Plant Weight (g)	<0.01	<0.01	0	0	0	<0.01
Seeds (Ct)						**17**
Amaranth (*Amaranthus*)	6	2				8
Catchfly (*Silene*)	6					6
Chenopod (*Chenopodium*)		2				2
Red maids (*Calandrinia brewerii*)	1					1

Technology

There were 46 flakes (43 chert and three volcanic) and 102 pieces of debitage (77 chert and 25 volcanic) recovered from the 250-liter bulk sample from SCRI-183, as well as three *Olivella biplicata* beads (Figures 21, 22). Two spire ground beads and a worked piece of mussel shell were recovered from levels 0-10 and 30-40 cm; a Type C, split oval bead (Bennyhoff and Hughes 1987) was recovered from the 20-30 cm level. This bead type is associated with Terminal Middle Period (Munns and Arnold 2002:132); however, the radiocarbon dates from the 20-30 cm level are significantly later (AD 1672-2890 [Late Period]) compared to the other levels (Table 11), and match the timing for this bead.

Perry recovered an additional 396 flakes and 418 pieces of debitage from SCRI-183, including volcanic, basalt, quartz, schist, andesite, rhyolite, quartzite, fused shale, and chalcedony; as well as four *Olivella biplicata* barrel beads and three pieces of *Olivella* bead detritus. Two asphaltum stained stones were likely used in basketry manufacture (i.e., waterproofing), and a single piece of red ochre may have been used for decorative or ritual purposes (Perry and Delaney-Rivera 2011).

Figure 21. Class A, spire ground *Olivella* shell bead from the 0-10 cm level of SCRI-183 (left); Class C, split oval *Olivella* shell bead from the 20-30 cm level of SCRI-183 (right).

Figure 22. Class A, spire ground *Olivella* shell bead from the 30-40 cm level of SCRI-183.

Although both SCRI-174 and SCRI-183 have stratigraphically mixed deposits, they still fall within the Middle Holocene, with the exception of level 20-30 cm at SCRI-183. These two sites are only approximately 500 m apart, and were likely occupied within the same interval of time. The debitage at both sites indicates flint knapping took place on-site, and the asphaltum stones at SCRI-183 suggest basket making may have taken place there as well

(i.e., waterproofing bottles). These multiple activities, combined with diverse faunal assemblages (see Chapter 6), indicate these sites were not simple logistical encampments. Although no residential features were encountered, it seems likely these sites were residential bases rather than simply stop-over points.

There is a notable absence of plant food remains at both of these sites, other than a single red maids seed at SCRI-183. Returning to the hypothesized reasons to occupy interior sites (proximity to freshwater, plants or toolstone resources; and access to travel routes, defensive locations, and community aggregation areas [Perry and Glassow 2015:15]), we can evaluate the Central Valley sites. As will be discussed in Chapter 6, the lack of carbonized plant remains does not necessarily mean people were not using plants at these sites; however, the macrobotanical record does not provide evidence supporting this idea. The majority of the toolstone at these sites is chert, which was likely transported over 15 km from the quarries in the El Montañon vicinity. While the Central Valley would provide a convenient space for community aggregation, these sites do not provide any evidence of unique or large-scale subsistence events; however, social activities such as feasting and sweatlodges have been suggested at other Central Valley sites (Sutton 2014b). Finally, the wide Central Valley is not a particularly defensible location. There is, however, abundant freshwater and access to travel routes, including to the isthmus.

CHAPTER 5

INVESTIGATIONS ON THE ISTHMUS

The isthmus is the narrowest part of Santa Cruz Island, rising up at the western end of the Central Valley and abutting El Montañon ridge in the eastern sector of the island. The ridgeline is impacted by coastal weather, including wind and fog; however, it is still warmer and drier than the Central Valley and western end of the island. A large stand of pines (China Pines) is located in the center of the isthmus, and oak trees and grasses grow throughout. Edible plants around the isthmus include many of those in the Central Valley, such as manzanita (*Arctostaphylos* spp.), lemonade berry (*Rhus intergrifolia*), prickly pear (*Opuntia* spp.), toyon (*Heteromeles arbutifolia*), clover (*Trifolium* spp.), acorn (*Quercus* spp.), blue dicks (*Dichelostemma capitatum*), red maids (*Calandrinia* spp.), rye (*Leymus* spp.), lupine (*Lupinus* spp.), peppergrass (*Lepidium* spp.), and fiddleneck (*Amsinkia* spp.). An important plant resource occurs here that is not available in the Central Valley: pine (*Pinus muricata*). The China Pines stand is less than 3 km from site SCRI-393 (Figure 23). Unlike acorn or cherry pits, pine nuts do not require leeching, making them a highly ranked resource (Wohlgemuth 2010). Additionally, the higher elevation oaks on the isthmus may produce more acorns than those at lower elevations (Pesendorfer et al. 2014). Perhaps most importantly, there are a number of chert outcrops on the eastern boundary of the isthmus, where it connects to El Montañon; these outcrops contain the highest quality and concentration of toolstone on the island (Perry and Jazwa 2010). In terms of accessing marine resources, China Harbor on the north side of the isthmus is approximately 3 km

distant, down a steep slope. On the south coast, there is relatively easy access to a sandy beach environment near Loma Pelona (Michael Glassow, personal communication 2017). It is roughly 6-7 km to hike over the Montañon and down to either Scorpion Anchorage to the east or Smuggler's Cove to the southeast. Although all of these access points are relatively close, they cover strenuous terrain.

Figure 23. Aerial view of isthmus and site SCRI-393 (Google base layer).

SCRI-393

This site is located in a wide saddle on a ridgeline descending west from El Montañon at approximately 352 m in elevation (Figure 24); it is just downslope from a large chert quarry (SCRI-93), and has a reliable freshwater seep in the Cañada de la Calera to the north (Jennifer Perry, personal communication 2017). This site was originally recorded by Jeanne Arnold in 1981 (Arnold 1981), and was digitally mapped and tested in 2001 as part of a

UCLA field course. Surface testing consisted of six shovel test pits to depths of <30 cm, and two augers to depths of <40 cm, for a combined volume of 156 liters (Graesch and Arnold 2003). The single prior radiocarbon date from this site places the occupation between 2814 and 2287 BC (Table 14).

In 2015 I excavated two adjacent 50x50 cm units at this site to a depth of 60 cm (sterile); one was screened through 1/16" mesh in the field, and the other was collected as a bulk sample in order to recover larger macrobotanical samples (150 liters) (Table 5). I targeted the edge of a circular rock alignment (visible on the site surface) that Graesch and Arnold (2003:19) describe as being "clearly associated with cultural deposits," to look for subsurface definition. Graesch and Arnold (2003:7) report that two augers placed nearby "revealed an unambiguous anthrosol containing some of the highest subsurface densities of artifacts and ecofacts recorded for this site," and that the associated soil "may contain fairly high concentrations of carbon and organic residues, as they leave a dark, greasy stain on the surface of most permeable materials" (Graesch and Arnold 2003:16). They further note that, "while the rock features in the northern sector of SCRI-393 are clearly associated with cultural deposits, further investigation will be necessary before it can be determined whether the rocks are naturally exposed bedrock or might have been set in place (and thus could be remnants of dwellings)" (Graesch and Arnold 2003:19). My excavation showed that these rocks are not bedrock, but are placed within the cultural deposits (Figure 25). These large rocks extend throughout the depth of the unit, which are the product of approximately 2,000 years of occupation.

The radiocarbon dates fall into three clusters, with dates from 0-20 cm falling between 1820 and 1522 BC, dates from 20-40 falling between 2553 and 2367 BC, and the date from

the 40-50 cm level falling between 3588 and 3558 BC. The UCLA date from the 10-20 cm level of a shovel test pit approximately 40 m southwest of my excavation unit falls within the second date cluster, at 2814-2287 BC (Figure 26, Table 14). More dates are necessary to determine whether these gaps of 500 to 1,000 years indicate site abandonment or are result of the small sample size.

Figure 24. SCRI-393, looking east toward El Montañon.

Figure 25. Circular rock feature at SCRI-393, 10-20 cm below surface (left) and 40-50 cm below surface (right).

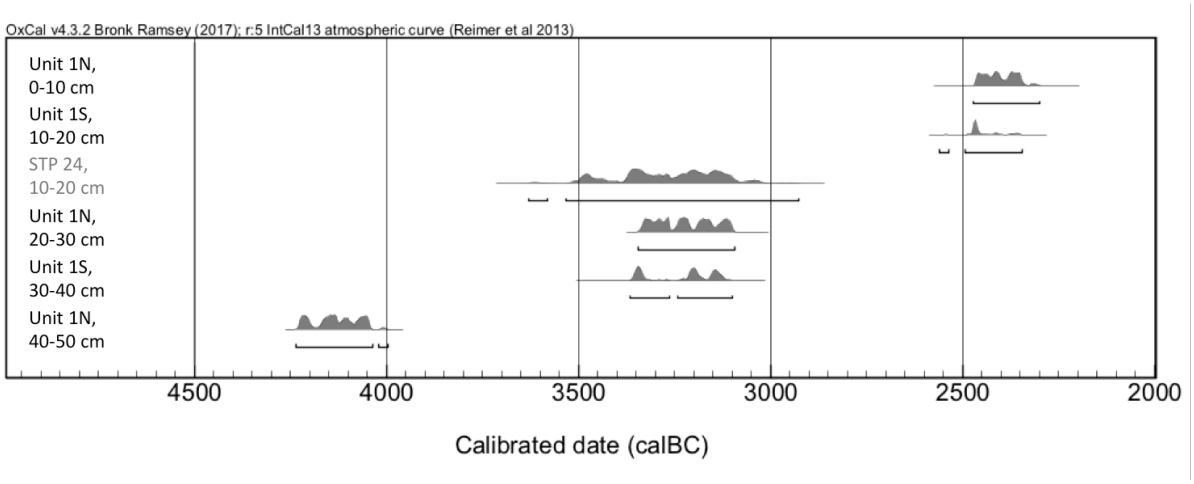


Figure 26. Radiocarbon dates from SCRI-393.

Table 14. Radiocarbon dates from SCRI-393.

Site	Provenience	Conventional age	Calibrated date, 2s interval	Lab #
SCRI-393	Unit 1N, 0-10 cm	3905 ±15	1748-1522 BC	UCIAMS 186174
SCRI-393	Unit 1S, 10-20 cm	3940 ±15	1820-1572 BC	UCIAMS 186175
SCRI-393	STP 24, 10-20 cm	4560 ± 70	2814-2287 BC	Beta 176931[1]
SCRI-393	Unit 1N, 20-30 cm	4495 ±15	2553-2309 BC	UCIAMS 186176
SCRI-393	Unit 1S, 30-40 cm	4540 ±20	2616-2367 BC	UCIAMS 186177
SCRI-393	Unit 1N, 40-50 cm	5290 ±20	3588-3358 BC	UCIAMS 186178

[1]Graesch and Arnold 2003

Faunal Remains

The faunal assemblage at SCRI-393 is dominated by California mussel, which makes up 70% of the total faunal weight, followed by acorn barnacle (17%), wavy top (4.7%), and abalone (1.4%) (Table 15). Other shellfish taxa include urchin (*Strongylocentrotus* spp.), chiton (Polyplacophora), leaf barnacle (*Pollicipes polymerus*), owl limpet (*Lottia gigantea*), giant keyhole limpet (*Megathura crenulata*), platform mussel (*Mytilisepta bifurcata*), turban snail (*Tegula* spp.), olive shell (*Olivella biplicata*), limpet (*Acmaea* spp.), worm tube (Polychaeta), and miscellaneous gastropods. Bone consisted of California sheephead (*Semicossyphus pulcher*), undifferentiated fish bone, undifferentiated mammal bone, undifferentiated bird bone, and undifferentiated bone.

Table 15. Percentage of total faunal weight by species at SCRI-393.

Level	Volume (L)	California Mussel	Acorn Barnacle	Abalone	Wavy Top	Shell, undif	Other Shell	Bone
0-10	25	86.3	6.3	0.5	0.2	5.3	1.0	0.4
10-20	25	80.7	11.8	1.9	0.6	4.0	0.8	0.3
20-30	25	66.1	20.7	1.0	5.3	5.3	1.3	0.2
30-40	25	64.8	20.3	1.3	7.2	4.7	1.5	0.1
40-50	25	65.0	9.7	4.1	5.8	14.2	1.0	0.1
50-60	25	79.9	11.1	0.0	0.0	7.7	1.3	0.0
Totals	**125**	**69.9**	**16.8**	**1.4**	**4.7**	**5.7**	**1.3**	**0.2**

Floral Remains

As previously discussed, Virginia Popper analyzed approximately 8 liters of soil from SCRI-393 and did not find any seeds, but did identify California lilac (*Ceanothus* spp.) wood (Graesch and Arnold 2003). I recovered a total of 364 seeds from the 150 liter bulk soil (Table 16), although the majority (327) of these were catchfly (*Silene laciniata*), and may be incidental. There were no carbonized seeds in the off-site sample, although there were abundant modern catchfly and some amaranth (*Amaranthus*) seeds. There were 10 grass family (Poaceae) seeds, two bean family (Fabaceae) seeds, one knotweed (*Polygonum* spp.) seed, one johnny jump-up seed (*Viola pendunculata*), one peppergrass seed (*Lepidium nitidum),* three manzanita seeds (*Arctostaphylos* spp.), and one pine (*Pinus muricata*) seed. As previously discussed, knotweed has no recorded uses among the Chumash, but was used for food and medicine elsewhere in California (Strike 1994:115). There is no record of the Chumash using johnny jump-up; however, the greens were eaten by other Native Californians (Mead 2003:440; Thakar 2014). The Chumash used peppergrass as food and medicine; they toasted the seeds and ground them into a pinole, and they made a tea with the leaves to treat diarrhea and dysentery (Birabent n.d.; Timbrook 2007:111). Manzanita was likewise an important food source for the Chumash:

> Chumash people gathered manzanita fruits in summer and dried them, then ground them on a metate and ate them in winter as a coarse meal. Sometimes they ground up the fruits while still fresh. It is not clear whether they ate the dry outer pulp and skin, or if it was the seed itself that was ground-up berries raw as pinole, mixed with a little water or, in historic times, with milk. Like some other California peoples, they made a beverage of manzanita, although they put branch tips as well as the fruits into the water for a pleasant drink [Timbrook 2007:34].

Manzanita was also a preferred wood for smoking fish, and the berries were boiled in water to treat poison oak; other groups in California even smoked the leaves in a pipe

mixture (Mead 2003:37-45; Strike 1994:17-19; Timbrook 2007:34; Weyrauch 1982:12). Pine seeds were also an important food source. While mainlanders prefer other species of pine (e.g., gray pine and sugar pine) for food, bishop pine seeds are good for eating. While on Santa Cruz Island, I placed a closed bishop pinecone from China Pines on the edge of a fire pit and it opened up from the heat, making it easy to shake out and eat the slightly toasted seeds. Pine was also used for medicine and construction. According to Weyrauch (1982:15), "some contemporary Chumash people throw pine needles into hot bath water as a treatment for rheumatism" (Timbrook 2007:142). Pine needles are also used as a foundation material in open coiled basketry (Timbrook 2007:142), and Santa Cruz Islanders may have used bishop pine wood for canoe (*tomol*) construction (Henshaw 1955:151; Timbrook 2007:142).

Table 16. Macrobotanical remains recovered from SCRI-393.

SCRI-393, Unit 1 North Level	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**Totals**
Volume (L)	**25**	**25**	**25**	**25**	**25**	**25**	**150**
Sample Weight (g)	233.28	229.12	48.9	3.46	54.17	61.94	630.87
Bone Weight (g)	0	<0.01	0.01	<0.01	0	0	0.01
Wood Weight (g)	0.16	0.07	0.27	0.08	0.16	0.01	0.75
Plant Weight (g)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Seeds (Count)							**364**
Bean Family (*Fabaceae*)	1			1			2
Grass Family (Poaceae)	9					1	10
Catchfly (*Silene*)	327						327
Manzanita (*Arctostaphylos*)		2	1				3
Peppergrass (*Lepidium*)	1						1
Pine (*Pinus*)				1			1
Knotweed (*Polygonum* spp.)				1			1
Johnny jump-up (*Viola pendunculata*)						1	1
Unidentifiable Seed	9		1	7	1		18

Three groundstone artifacts recovered from the surface of SCRI-393 during the 2001 UCLA field school were tested for microbotanicals: a sandstone mortar fragment, a volcanic mortar fragment, and a piece of volcanic groundstone. No starches were identified from this mortar fragment (Figure 27); however, the slides resulting from this extraction were difficult to scan because of a lot of background noise, which may be a result of this material type. Three starches were recovered from a volcanic mortar fragment (Figures 28, 29; Table 17), including one resembling cherry (*Prunus illicifolia*) and one resembling acorn (*Quercus* spp.) starch; the third starch has not been identified.

Figure 27. Sandstone mortar fragment from the surface of SCRI-393.

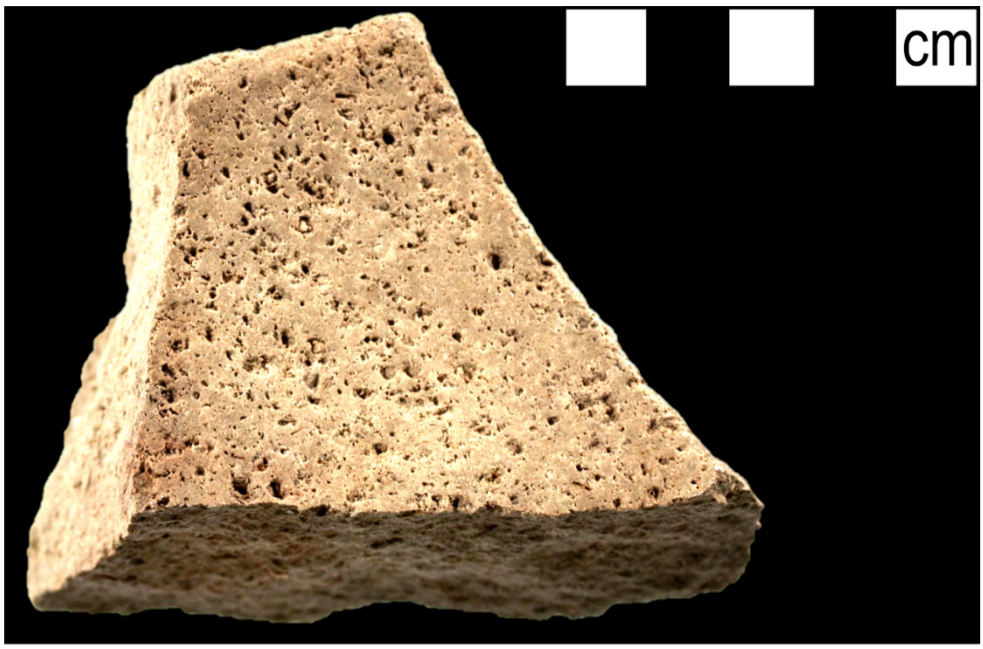


Figure 28. Volcanic mortar fragment from the surface of SCRI-393.

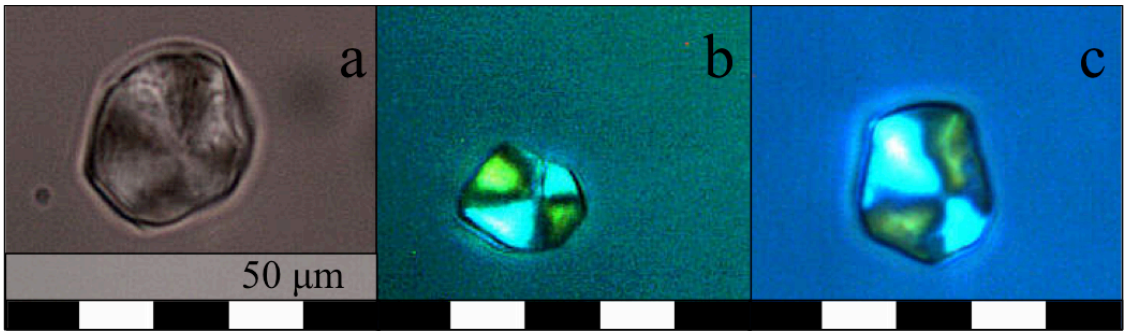


Figure 29. Starches recovered from volcanic mortar fragment, sediment 2 (Table 17).

Table 17. Starches recovered from volcanic mortar fragment, sediment 2.

	Possible ID	Hilum	Shape	Extinction Cross	Size	Length	Width
a		Eccentric	Semi-ovate	Straight	Xlarge	23.06	21.45
b	Cherry	Centric	Ovoid	2 curves	Large	16.24	11.97
c	Acorn	Eccentric	Irregular	Wavy	Xlarge	20.45	18.67

Technology

At isthmus site SCRI-393, Perry (2003:267) recovered one anvil, 10 cores, four core tools, three digging stick weights, one drill, six groundstone fragments, one mano fragment, 11 mortar fragments, one pestle, one tarring pebble, and two incised stones from the surface of the site. Graesch and Arnold's (2003:7) excavation yielded five chert cores, four chert tools, one sandstone grinding tool, and two *Olivella* shell beads. I recovered an additional *Olivella* barrel bead, a chert drill, a large chunk of asphaltum, and a shaped siltstone object. I also recovered 56 flakes from the 150-liter bulk sample at SCRI-393 (all chert), and well as 324 pieces of debitage (267 chert and 57 volcanic). The single *Olivella* barrel bead was recovered from the 0-10 cm level (Figure 30).

A siltstone object was recovered from the 30-40 cm level of the southern unit (Figure 31). This object appears to be a broken disc; it has a diameter of approximately 50 mm and a width of approximately 7 mm; there is a biconically-drilled hole in the center, with a diameter of approximately 5.5 mm. This object appears to be covered in asphaltum. The object is similar to items used cross-culturally as spindle whorls (Amber VanDerwarker, personal communication 2017), although no such objects are known in this region. King (1990:242) has a drawing of a siltstone bead (dated between 4500-200 BC) that is similar in shape, but only approximately 6 mm in diameter. Perry (2003:266) recovered two incised stones from the surface of SCRI-393 that are similar in size (49.1 and 58.2 mm in length):

> Two incised objects were found on the surface at SCRI-393, both of which are made of siltstone, rounded, and have obvious incised markings. The design on one is geometric, whereas the other one is more complex. The end of the latter has been shaped into a trapezoidal form and has been stained with red ochre along its edges. Incising is visible on both sides of the object; one of the sides exhibits parallel semi-circles and lines arranged in a sunburst fashion. The design clearly expresses some sort of symbolism, perhaps associated with the veneration of the sun based on comparisons with sun depictions on rock and portable art (Lee 1997) [Perry

2003:267-268].

Perry (2003, 2007, 2013) notes the important role of high elevations and mountains in the Chumash ritual landscape, as spaces between the human and upper world. She identifies approximately 20 rock features on the El Montañon and the North Ridge of Santa Cruz Island as possible rock shrines:

> When in good condition, these sites most commonly consist of oval to rectangular features made of intentionally-placed volcanic rocks that form a platform about 2 x 3 m in diameter and 10 to 20 cm in height (Perry 2003:265-274; S. Spaulding, personal communication 2003-2005). The rocks are sometimes fire-affected, but not in every context. Black silty loam soil is often found at these features, interspersed between the rocks. The dark soil and rocks are sitting atop and embedded into the ground surface, but none appear to have much depth. In most cases, no shellfish or fish remains have been found in association. However, in some areas the situation is more complicated due to the fact that the features are located directly on shell middens [Perry 2007:112].

The rock feature at SCRI-393 does not appear to be a house feature or a roasting pit. It does not fit the criteria of Perry's rock shrines, as it is nearly 60 cm deep and associated with dense cultural remains. Nonetheless, its presence on a ridgetop saddle and association with four siltstone objects is intriguing.

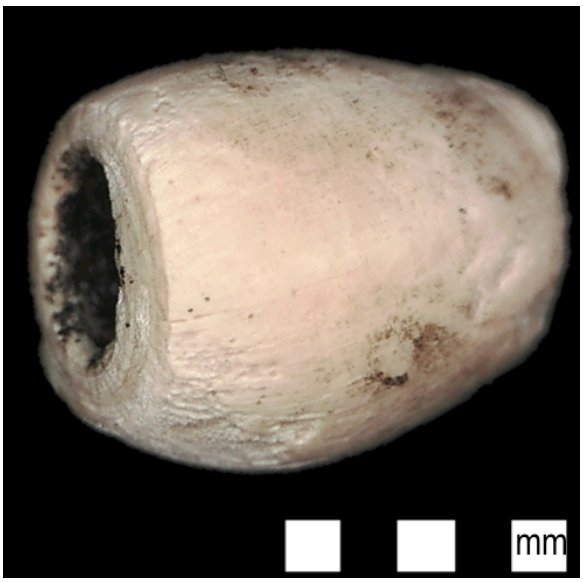


Figure 30. Class B, end ground *Olivella* shell barrel bead from the 0-10 cm level of SCRI-393.

Figure 31. Siltstone object from the 30-40 cm level of SCRI-393, possibly covered in asphaltum.

Returning to the hypothesized reasons to occupy interior sites (proximity to freshwater, plants or toolstone resources; and access to travel routes, defensive locations, and community aggregation areas [Perry and Glassow 2015:15]), the isthmus has nearly all of these (with the possible exception of community aggregation areas). Although the macrobotanical remains are SCRI-393 are scant, the three manzanita fragments and the single pine seed provided limited evidence that site occupants used locally available ethnographically important plant foods (Table 16). Similarly, the starch granules recovered from the volcanic mortar fragment (Figures 28, 29; Table 17) provide limited direct evidence for the processing of not only acorn, but also cherry and another unidentified plant. Relatively high densities of chert flakes and debitage in all levels indicate that site occupants took advantage of nearby chert outcrops (Perry and Jazwa 2010), while beads and asphaltum indicate other manufacturing took place on-site. There is a freshwater located approximately 500 m from SCRI-393 (Arnold 1981), and the isthmus is the only land-route from the eastern to western end of the island. Additionally, the high elevation and narrow terrain make the isthmus a defensible location; Perry (2004:114) notes that "abundant and predictable resources in concentrated or circumscribed areas, such as chert quarries on and around the ridges of El Montañon, are the most probable ones to be defended (Kennett 1998:46)." Finally, it is worth noting the potential importance of the isthmus in terms of the island's sacred landscape, and the possible ritual significance of the rock feature and siltstone objects recovered at SCRI-393 (Perry 2003, 2007).

CHAPTER 6

DISCUSSION AND CONCLUSIONS

Materials recovered from the three study sites provide information on manufacturing activities that took place in the Central Valley and on the isthmus, and how these sites articulate with Middle Holocene subsistence and settlement patterns. While no definitive residential features were identified, the diversity of faunal remains and manufacturing debris suggests they were residential bases rather than logistical encampments. In terms of terrestrial resources, the low density of macrobotanical remains is considered alongside starch granules adhering to groundstone artifacts from contemporary interior occupations. Starch granules indicate that economically important plant foods were processed at interior sites, despite the lack of macrobotanical evidence. The diversity of the starch assemblages indicates that groundstone tools were used to process a range of different plants. Furthermore, the recovery of starch granules from artifact surfaces demonstrates the value of working with existing collections as an additional line of evidence for plant processing at hunter-gatherer sites. By using an integrated approach, including faunal, macrobotanical, and microbotanical analysis, this study provides a more holistic picture of Middle Holocene subsistence and sets baseline expectations for future paleoethnobotanical work within the region.

Activities taking place in the Central Valley and on the Isthmus

Artifacts recovered from all three sites show a range of manufacturing activities, including flint knapping, bead making, and basketry, suggesting these sites functioned as

residential bases for related kin groups, as opposed to logistical encampments. There is a significantly higher density of flakes and debitage at isthmus site SCRI-393 than at Central Valley sites SCRI-174 and SCRI-183 (Table 18), which is to be expected given the proximity of SCRI-393 to several chert quarries, including SCRI-93 just upslope. Nonetheless, the presence of both chert and volcanic flakes and debitage at sites SCRI-174 and SCRI-183 shows that flint knapping also took place at both sites in the Central Valley, and that occupants used a variety of toolstone materials. Beads and bead-making detritus from SCRI-183 and SCRI-393 show that *Olivella* bead production took place on site. Asphaltum and asphaltum stones at these two sites are interpreted as evidence of basket making (i.e., waterproofing), although they could have been used for other manufacturing purposes. The location of SCRI-393 in a ridgeline saddle, combined with the presence of a non-residential circular rock feature and several siltstone objects hints at possible ritual significance for this site, but the evidence is far from clear.

Table 18. Lithics recovered from study sites.

	Flakes					**Debitage**				
	Chert		**Volcanic**		**Total**	**Chert**		**Volcanic**		**Total**
	Ct	**Wt**	**Ct**	**Wt**	**Ct/L**	**Ct**	**Wt**	**Ct**	**Wt**	**Ct/L**
SCRI-174	18	20.8	4	6.2	.22	39	29.7	6	61.4	0.45
SCRI-183	43	95.1	3	18.4	.18	77	77.2	25	41.3	0.41
SCRI-393	56	147	0	0	.37	267	276.7	57	97.7	2.2

Faunal assemblages from all three sites can be compared using notched boxplots, which summarize the distribution of data. There is no significant difference in the density of faunal remains or in the density of the two largest contributors by weight, California mussel and acorn barnacle, or in wavy top (Figure 32) across the three sites; however, there is a statistically significantly higher density of abalone and bone compared to SCRI-393. With the exception of wavy top, nearly all shellfish species occur in the intertidal zone; a small

quantity of red abalone was found in a single level in SCRI-393 but was otherwise absent from these sites. Given the warmer waters at likely foraging locations (i.e., Prisoner's Harbor, Valley Anchorage, or China Harbor), the absence of red abalone is not surprising. It may be the case that subtidal wavy top species occurred closer to shore during periods of warm sea surface temperatures (Perry and Hoppa 2012). Given that wavy top, abalone, and bone each make up less than 5% of the total faunal weight at each site (Table 19), these differences do not indicate different subsistence strategies. Moreover, there are no clear differences when comparing the Central Valley to the isthmus.

Table 19. Relative contribution of major shellfish species at study sites.

Site	Mussel	Barnacle	Wavy Top	Abalone	Other Shell	Bone
SCRI-174	81.9%	5.2%	3.7%	1.2%	7.5%	0.4%
SCRI-183	72.4%	21.4%	1.2%	1.4%	3.4%	0.2%
SCRI-393	69.9%	17.8%	4.7%	1.4%	6.0%	0.2%

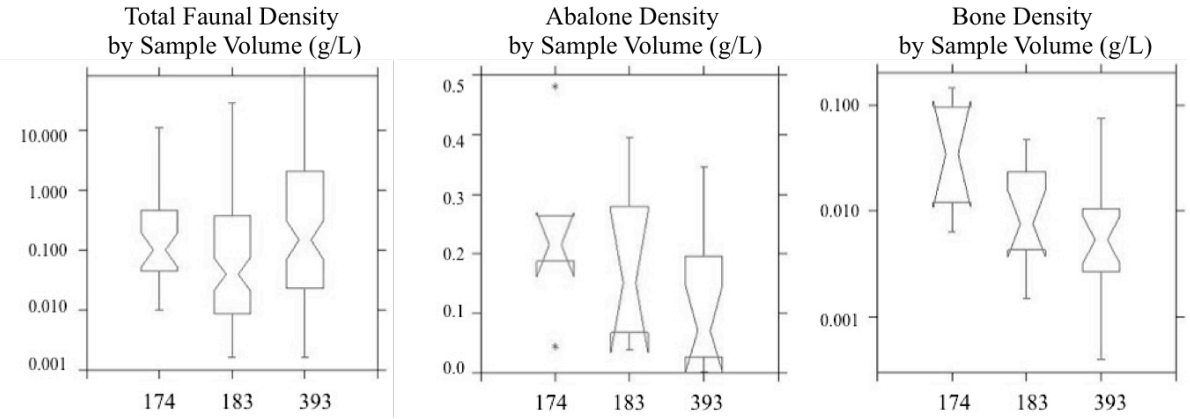


Figure 32. Faunal density (g/L) at study sites.

In order to compare the diversity and equitability of the faunal assemblage at each site, I used the Shannon-Weaver index, where the sample size is the total faunal weight. Higher Diversity Index values (H') indicate higher relative diversity, or species richness; Equitability Index values (V') range from 0 and 1, where values closer to 1 represent an

even distribution of categories (Popper 2008; VanDerwarker 2010b:67-68). This test does not account for sample size differences, which vary between 100 and 250 grams; however, SCRI-393 has the highest diversity and equitability values, despite falling between the two ends of the sample size range (Table 20). Although it is a shorter distance (~3 km) from SCRI-393 to the China Harbor than from the Central Valley to Prisoner's Harbor or Valley Anchorage (~5 km), the steep isthmus terrain and high elevation of SCRI-393 make it surprising that individuals would carry a wider array of (presumably lower ranked) fauna from the coast. While giant keyhole limpet (*Megathura crenulata*) may have been targeted for meat or for the shell (for adornment), smaller limpets (*Fissurella volcano*) may have been transported incidentally on seaweed (Ainis et al. 2014).

Table 20. Shannon-Weaver diversity and equitability values for faunal assemblages.

Site	Volume (L)	Total Faunal Weight (g)	# of Taxa (S)	Diversity (H')	Equitability (V')
SCRI-174	100	1,431.22	16	0.789	0.284
SCRI-183	250	6,769.19	23	0.834	0.266
SCRI-393	150	10,119.75	23	0.999	0.319

Plant densities were too low to make meaningful comparisons regarding density, but they are included with faunal taxa in a ubiquity analysis of each site's subsistence remains, which considers the number of samples in which a taxon appears within a group of samples (Popper 2008). In the ubiquity analysis, each 10 cm level is considered a context (Table 21). I also included plants identified as starch granules at SCRI-393 to reflect all identified taxa, but note that these samples come from only three groundstone artifacts at SCRI-393. While these data are not directly comparable, they still provide a qualitative overview of taxa present at each site (VanDerwarker 2010b:65-67). There were no economically important plant foods obtained from SCRI-174, and only a single red maids seed at SCRI-183. Isthmus

site SCRI-393 also had a very low density of seeds recovered (2.43 ct/L; only 0.25 ct/L if one excludes the likely incidental catchfly [*Silene laciniata*] seeds); however, the three manzanita (*Arctostaphylos* spp.) seed fragments and single pine (*Pinus muricata*) seed in the macrobotanical samples, as well as the single acorn (*Quercus* spp.) and cherry (*Prunus illicifolia*) starch granules all point to the presence of economically important plant foods at this site. The low density of seeds at all three sites provides a weak signature of season of occupation; nevertheless, the scant plant remains pinpoint a minimal occupation range between February and June (or through August if you include the possibly incidental catchfly seeds) at SCRI-174, between March and May (through August with catchfly) at SCRI-183, and for all months of the year at SCRI-393 (even excluding catchfly) (Table 22). At SCRI-393 in particular, it seems likely this site was used throughout the year, rather than during specific seasons. Factors such as the availability of toolstone and freshwater, as well as the use of the isthmus as a travel route or defensive location would make this site attractive throughout the year. In contrast, plant resources, protection from coastal weather, and the timing of social aggregations would be tied to specific seasons.

Table 21. Ubiquity of faunal and floral taxa at study sites.

Site Unit	174 Unit 3	183 Unit 2	393 Unit 1N	All Contexts
Shell	2 contexts	5 contexts	6 contexts	13 contexts
Undifferentiated shell	100.0%	100.0%	100.0%	100.0%
California Mussel *(Mytilus californianus)*	100.0%	100.0%	100.0%	100.0%
Acorn barnacle *(Balanus* spp.)	100.0%	100.0%	100.0%	100.0%
Wavy top *(Megastraea undosa)*	100.0%	100.0%	83.3%	92.3%
Black abalone *(Haliotis cracherodii)*	100.0%	80.0%	83.3%	84.6%
Undifferentiated abalone *(Haliotis* spp.)	100.0%	80.0%	83.3%	84.6%
Red abalone *(Haliotis rufescens)*	-	-	16.7%	7.7%
Leaf barnacle *(Pollicipes polymerus)*	100.0%	100.0%	100.0%	100.0%
Urchin *(Strongylocentrotus* spp.)	100.0%	100.0%	66.7%	84.6%
Worm tube (Polychaeta)	100.0%	80.0%	66.7%	76.9%
Limpet *(Acmaea* spp.)	50.0%	20.0%	50.0%	38.5%
Miscellaneous Gastropods	-	20.0%	66.7%	38.5%
Olive shell *(Olivella biplicata)*	-	60.0%	33.3%	38.5%
Norris's top *(Norrisia norrisii)*	50.0%	60.0%	-	30.8%
Owl limpet *(Lottia gigantea)*	-	20.0%	33.3%	23.1%
Platform mussel *(Mytilisepta bifurcata)*	-	40.0%	16.7%	23.1%
Undifferentiated limpet	-	20.0%	16.7%	15.4%
Turban snail *(Tegula* spp.*)*	50.0%	-	16.7%	15.4%
Chiton (Polyplacophora)	-	-	16.7%	7.7%
Undifferentiated Clam	-	20.0%	-	7.7%
Slipper shell *(Crepidula* spp.)	-	20.0%	-	7.7%
Volcano limpet *(Fissurella volcano)*	50.0%	-	-	7.7%
Giant keyhole limpet *(Megathura crenulata)*	-	-	16.7%	7.7%
Undifferentiated whelk	-	20.0%	-	7.7%

Bone	2 contexts	5 contexts	6 contexts	13 contexts
Undifferentiated bone	100.0%	100.0%	83.3%	92.3%
Undifferentiated mammal bone	100.0%	80.0%	66.7%	76.9%
Undifferentiated pinniped bone	50.0%	-	-	7.7%
Undifferentiated bird bone	-	20.0%	50.0%	30.8%
Undifferentiated fish bone	100.0%	-	16.7%	23.1%
Sheephead (*Semicossyphus pulcher)*	-	60.0%	50.0%	46.2%
Seeds	2 contexts	5 contexts	6 contexts	13 contexts
Unidentifiable Seed	100.0%	-	16.7%	23.1%
Unidentifiable Plant Part	50.0%	-	-	30.1%
Amaranth (*Amaranthus* spp.)	50.0%	40.0%	-	30.8%
Bean Family (Fabaceae)	50.0%	-	33.3%	30.8%
Catchfly (*Silene laciniata*)	100.0%	20.0%	16.7%	30.8%
Chenopod (*Chenopodium* spp.)	50.0%	20.0%	-	23.1%
c.f. Cryptantha (*Cryptantha clevelandii)*	50.0%	-	-	7.7%
Grass Family (Poaceae)	-	-	33.3%	30.1%
Johnny jump-up (*Viola pendunculata*)	-	-	16.7%	7.7%
Knotweed (*Polygonum* spp.)	-	-	16.7%	7.7%
Manzanita (*Arctostaphylos* spp.)	-	-	33.3%	30.1%
Peppergrass (*Lepidium* spp.)	-	-	16.7%	7.7%
Pine (*Pinus muricata*)	-	-	16.7%	7.7%
Red maids (*Calandrinia brewerii*)	-	20.0%	-	7.7%
Yarrow (*Achillea millefolium*)	50.0%	-	-	30.1%
Starch granules			3 contexts	3 contexts
Acorn (*Quercus* spp.)			33.3%	33.3%
Cherry (*Prunus illicifolia*)			33.3%	33.3%

Table 22. Seasonality of plants recovered (Junak et al. 1995).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SCRI-174												
Catchfly (*Silene laciniata*)				X	X	X	X	X				
Cryptantha (*Cryptantha clevelandii*)		X	X	X	X							
Yarrow (*Achillea millefolium*)		X	X	X	X	X						
SCRI-183												
Catchfly (*Silene laciniata*)				X	X	X	X	X				
Red maids (*Calandrinia brewerii*)			X	X	X							
SCRI-393												
Catchfly (*Silene laciniata*)				X	X	X	X	X				
Johnny Jump-Up (*Viola pendunculata*)			X	X	X							
Manzanita (*Arctostaphylos*)	X	X	X	X	X	X					X	X
Peppergrass (*Lepidium nitidium*)	X	X	X	X								
Pine (*Pinus muricata*)					X	X						
Smartweed (*Polygonum lapathifolium*)				X	X	X	X	X	X	X		

Interpretation of low density plant remains

The low density of plant remains at each of the three study sites does not support the idea that these sites were occupied primarily to exploit terrestrial resources. As discussed in Chapter 1, the low density of seeds in Middle Holocene deposits could indicate that: (1) plants were not important to the diet, (2) there was overall poor preservation of seeds due to time and/or soil conditions, or (3) that plants were being consumed, but were not being prepared in ways that would favor preservation (i.e., they were not being cooked/carbonized). I believe the starch granule evidence (discussed further in the following section) shows that plants were indeed important to the diet; however, it remains unclear whether the lack of macrobotanical remains is due to taphonomic effects, prehistoric processing techniques, or both.

Plant remains may preserve in the archaeological record in several different ways,

including through waterlogging, by desiccation in dry and protected environments, as impressions or inclusions in other material, or most commonly through carbonization (Miksicek 1987). Wooden artifacts and building materials have been recovered from Late Holocene and Historic sites on Santa Cruz Island (Timbrook 1980). At Cueva Escondida, a Late Holocene sea cave on Santa Cruz Island, organic materials including wooden harpoon shafts, cordage, and feathers have remarkable preservation, seemingly due to a process of "pickling" from the accumulation of salt from sea spray (Michael Glassow, personal communication 2017). At Daisy Cave (CA-SMI-261) on San Miguel Island, two fragments of basketry and hundreds of pieces of cordage made from sea grass were recovered from Early Holocene strata (Connolly et al. 1995:309); basketry and cordage impressions have also preserved in asphaltum at open air sites (Braje et al. 2005). Carbonized corms have been recovered in high densities from Early Holocene deposits at Daisy Cave (Reddy and Erlandson 2012) on San Miguel Island, and Diablo Valdez (SCRI 619/620) on Santa Cruz Island (Gill 2013). Nonetheless, as discussed in Chapter 1, Paleocoastal and Early Period plant food densities are significantly lower than during other time periods (Gill and Hoppa 2016).

The seemingly simple process of converting organic plant material into charcoal can drastically bias certain types of plants, even when they are exposed to the same heating or cooking process. Van der Veen (2007:977) notes that in assemblages where there are both desiccated and carbonized remains (both at waterlogged and at dry, protected sites), carbonized remains make up less than 20% of the plant remains discarded, and that, "fruits, condiments, vegetables and oil-rich seeds are much less likely to become charred." Even those items that are charred may completely incinerate if they are exposed to high enough

heat for a long enough time. Braadbaart and Poole (2008:2444) note that the charcoal we find in domestic contexts at archaeological sites is often the fuel added toward the end of the fire, as everything else will have already incinerated. Additionally, when plant charcoal is produced at temperatures below 310 C, it can contain original wood or plant constituents, which attract destructive microorganisms (Braadbaart et al. 2009:1676). The size and density of charred plants, and even their oil content, can affect which plant remains will be recovered. As Wohlgemuth (1996:85) notes, "whereas large seed residue is the robust, fragmented refuse of taxa often processed with fire (such as gray pine [*Pinus sabiniana*] or bay nut [*Umbellularia californica*], small seed remains are more delicate, and often represent whole items accidentally lost during cleaning or parching." Wright (2003) has shown that tissue density is even more important than surface area for determining whether a seed or rind will survive carbonization in a recognizable form. She notes that while wet specimens generally fare better than dry ones, some seeds, such as sunflower, may incinerate faster due to the oils they contain (Wright 2003).

There are several generalizations we can make about preservation of archaeological deposits on Santa Cruz Island, particularly regarding soil conditions. The high level of calcium carbonate in shell middens creates highly alkaline soil conditions, which can help to preserve shell and bone but can damage plant remains. Calcareous soils generally have a pH value between 6.88 and 7.25 (Jackson 1958; Sawbridge and Bell 1972), and because calcium carbonate leeches out of shells and into the soil over time, alkalinity increases over time. Similarly, hearths, a discrete area in which we can expect carbonized plant remains to have existed prehistorically, generally have highly alkaline soils, creating further challenges. Braadbaart et al. (2009) note that in alkaline soils, such as shell middens, charcoal (and

carbonized plant remains) can fragment into small pieces, and thus are less likely to preserve in the archaeological record. Wood charcoal tends to be highly fragmented (but ubiquitous) in Santa Cruz Island shell middens; fragmentation may be the result of the midden settling and becoming more compact, rather than the soil chemistry (Michael Glassow, personal communication 2017). Like carbonized plant remains, silica phytoliths can also be destroyed by alkaline soil conditions or by the roots of living plants; however, they still generally survive well in archaeological sites, particularly on the surface of artifacts (Cabanes et al. 2011:2480).

Unlike carbonized seeds and phytoliths, starch granules have an advantage in alkaline soil, as there tend to be fewer destructive enzymes than in acidic soil; however, starch granules still fare poorly in any soil, as they can break down quickly. Smaller, transitory starches (found in leaves) tend to degrade faster than larger storage starches (found in seeds, roots, tubers, corms, fruits and rhizomes); however, both can preserve for extremely long periods of time when protected on the surface of an artifact (Haslam 2004). Starches are also much more likely to preserve if they are raw than if they are cooked, as heat can damage starch granules by causing them to gelatinize (Henry et al. 2009). Filice et al. (2012) demonstrated that acorn starch granules look substantially different after different processing steps, including boiling and pounding. Nonetheless, these starches can be identifiable through much of the process, excluding full gelatinization that occurs with high temperatures.

In addition to soil conditions, early sites may face further unique taphonomic problems. Unlike substantial village sites of the Late Holocene, earlier sites on Santa Cruz Island tend to be fairly ephemeral, suggesting higher levels of mobility and periodic occupation. Indeed,

the impact of weathering may be more severe at sites with brief episodes of occupation:

> On Santa Cruz Island, most of the Early Period site components appear to be seasonal camps, since they appear to contain dense shellfish remains, few artifacts, and little stratigraphic differentiation. These conditions would most likely result from repeated short-term occupations for the purpose of shellfish collection. In the absence of pedoturbation, the high degree of fragmentation of the shellfish remains in many of these sites is assumed to be the result of mechanical weathering between brief episodes of occupation [Glassow et al. 1988:68].

If population densities are relatively low, then refuse likely accumulated slowly, meaning discarded materials were more often exposed to the elements than quickly buried. Given the fragility of charred seeds in comparison to marine shell, it would seem that weathering results could be even more severe for these plant remains.

Beyond preservation issues that may disproportionately affect carbonized plant remains in older or more ephemeral sites, there are many plants that may not end up carbonized at all. Most carbonized plant remains reflect the mistaken carbonization of edible food (e.g., cooking accidents) or the purposeful carbonization of fuel or discarded material (e.g., pine cones [Barlow and Metcalfe 1996]) (Minnis 1981). Wild cucumber (*Marah macrocarpus*), an inedible plant which is commonly found in archaeobotanical assemblages on the northern Channel Islands, may have been used as a fire starter due to the high oil content of the seeds (Gill 2015:241; Martin 2009:82).

Many roots and tubers are unlikely to become carbonized or to survive post-depositional processes, yet these resources were ethnographically important for the Chumash. Cattail (*Typha* spp.) roots were pulverized and baked into bread (Timbrook 2007:219), whereas other geophytes (e.g., blue dicks) were roasted whole. As a result, the former are far less likely to be recovered in carbonized form. Several nuts and seeds ethnographically documented as important food sources for the Chumash (e.g., acorn [*Quercus* spp.], pine

[*Pinus muricata*], cherry [*Prunus illicifolia*], manzanita [*Arctostaphylos* spp.], red maids [*Calandrinia* spp.], tarweed [*Hemizonia fasciculata*], and chia [*Salvia columbariae*]) were ground into flour before they were cooked or eaten raw (Timbrook 1990, 1993, 2007). Datura (*Datura wrightii*) and tobacco (*Nicotiana* spp.), which have medicinal and ceremonial uses, were also ground in small mortars during preparation (Timbrook 1990, 2007). While these foods can (and have) been recovered in macrobotanical contexts, they may also be likely to preserve as groundstone residue.

Starch Granule Evidence from Middle Holocene Groundstone

In addition to the groundstone artifacts collected from the surface of SCRI-393, I tested four other pieces of groundstone from contemporary interior sites (Figure 33, Table 23). These additional sites are similar to the three study sites in their size, depth, and homogenous fill, and were all occupied during the Middle Holocene. SCRI-649 is located on the isthmus, near SCRI-393, while SCRI-751 is another high elevation site located just over the Montañon, to the east. SCRI-724 is on a coastal bluff above Scorpion Anchorage. A bowl mortar fragment and a mano fragment were collected from SCRI-649 and SCRI-751 respectively, during the course of Perry's (2003) survey and testing project on eastern Santa Cruz Island; a pestle and a mano fragment were excavated from SCRI-724 by Perry in 2007 (Perry and Hoppa 2012). Even this relatively small sample size resulted in more than 80 individually keyed starch granules.

Table 23. Starches recovered from sediment 1 (wet brush) and sediment 2 (sonicated) samples from groundstone artifacts.

Site	Provenience	Depth	Artifact	Material	Starches		
					S1	S2	Totals
SCRI-649	Surface		Mortar Fragment	Volcanic			**0**
SCRI-724	2.5S/5.5W	0-10	Pestle Fragment	Volcanic	9	14	**23**
SCRI-724	2.5S/5.5W	10-20	Mano Fragment	Volcanic	3	30	**33**
SCRI-751	Surface		Mano Fragment	Basalt	5	20	**25**

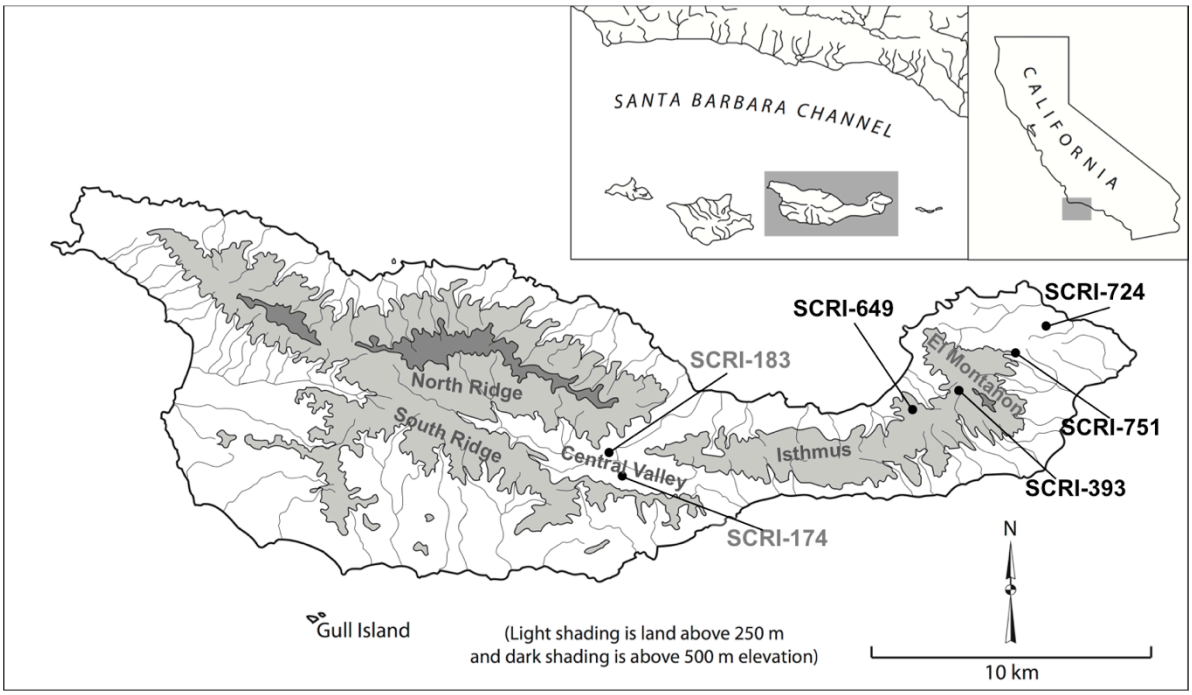


Figure 33. Map showing interior sites with groundstone artifacts included in this study.

The volcanic mortar fragment from SCRI-649 had no starches. It is unclear whether this artifact was washed after collection or whether other taphonomic reasons are to blame. I recovered a total of 81 starch granules from the other three artifacts, including 23 from a pestle fragment (Figures 34, 35, 36; Tables 24, 25) excavated from the 0-10 cm level at SCRI 724; 33 from a basalt mano fragment excavated from the 10-20 cm level of SCRI-724 (Figures 37, 38, 39; Tables 26, 27); and 25 from a basalt mano fragment from the surface of SCRI-649 (Figures 40, 41, 42; Tables 28, 29). For each artifact, the starches listed came

from a single slide, which I estimate to be roughly 20% of the material recovered. As discussed in Chapter 3, our comparative starch collection is not exhaustive. I have measured and described each of the 81 starches reported here with the hope that those that remain unidentified (and any that are misidentified) may be identified in the future using this information. The four artifacts and associated starch assemblages presented here are those for which I have complete confidence in the processing technique and in the photographed assemblage. Based on earlier attempts, I can qualitatively say that starch grains and phytoliths commonly occur on both *in situ* and curated Middle Holocene groundstone. I also suggest that the complete lack of starches recovered from the surface of the volcanic mortar at SCRI-649 is an anomaly. The following figures and tables include scaled photographs of all measured and described starch grains alongside descriptive tables (defined in Chapter 3).

Figure 34. Volcanic pestle fragment from the 0-10 level of SCRI-724.

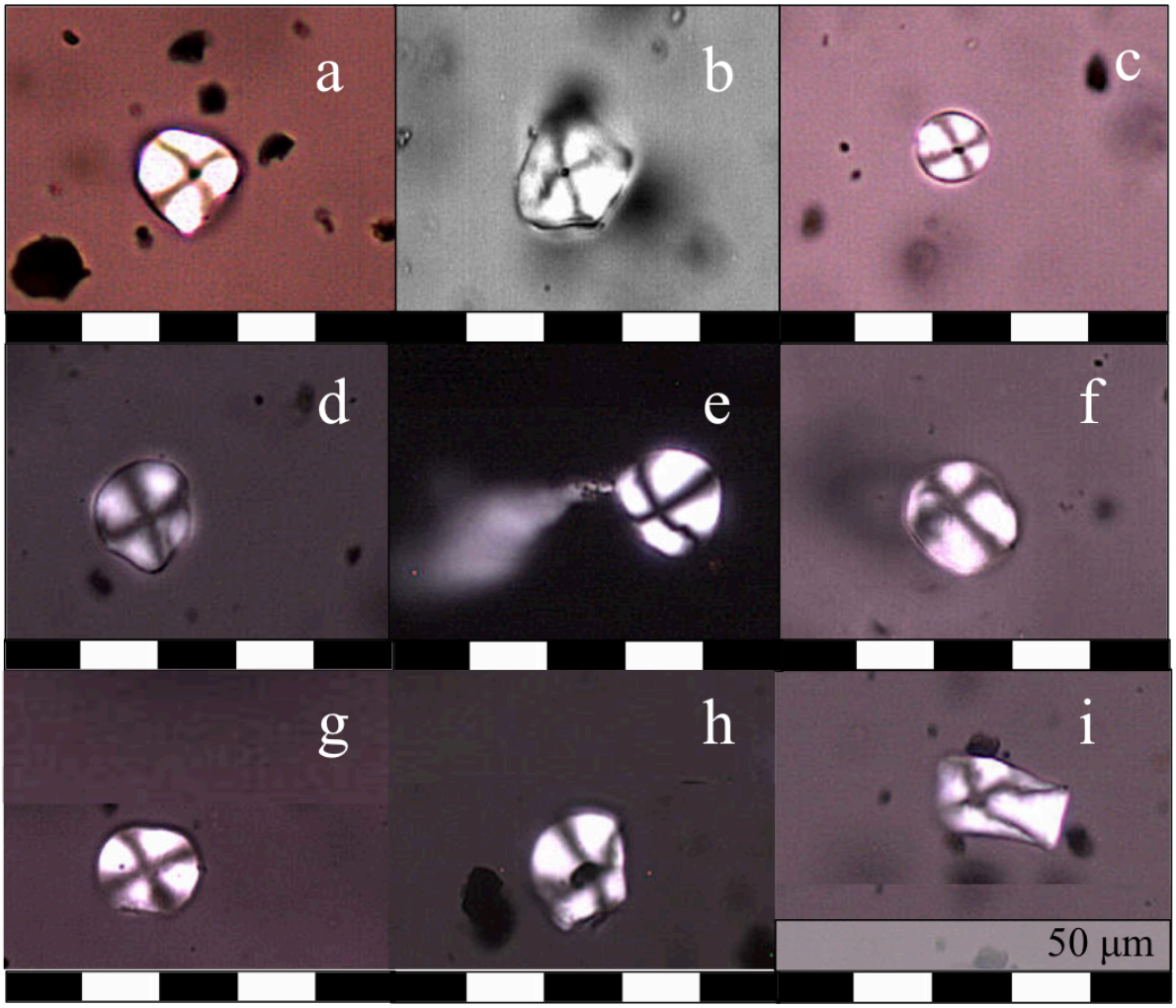


Figure 35. Starch granules from volcanic pestle fragment, sediment 1 (Table 24).

Table 24. Starch granules from volcanic pestle fragment, sediment 1.

	Possible ID	Hilum	Shape	Extinction Cross	Size	Length	Width
a	Acorn	Centric	Pear	2 curves	Medium	11.89	11.22
b		Eccentric	Semi-ovate	Wavy	Large	17.52	12.84
c	Pine	Centric	Circular	Straight	Small	9.96	9.13
d		Centric	Diamond	Straight	Large	15.19	13.84
e	Lily	Eccentric	Pear	Curved	Large	15.45	14.4
f		Eccentric	Diamond	Curved	Large	15.44	14.76
g		Centric	Ovoid	Straight	Large	15.44	14.76
h		Eccentric	Semi-ovate	Wavy	Medium	14.48	14.44
i		Eccentric	Irregular	Wavy	Medium	12.73	12.45

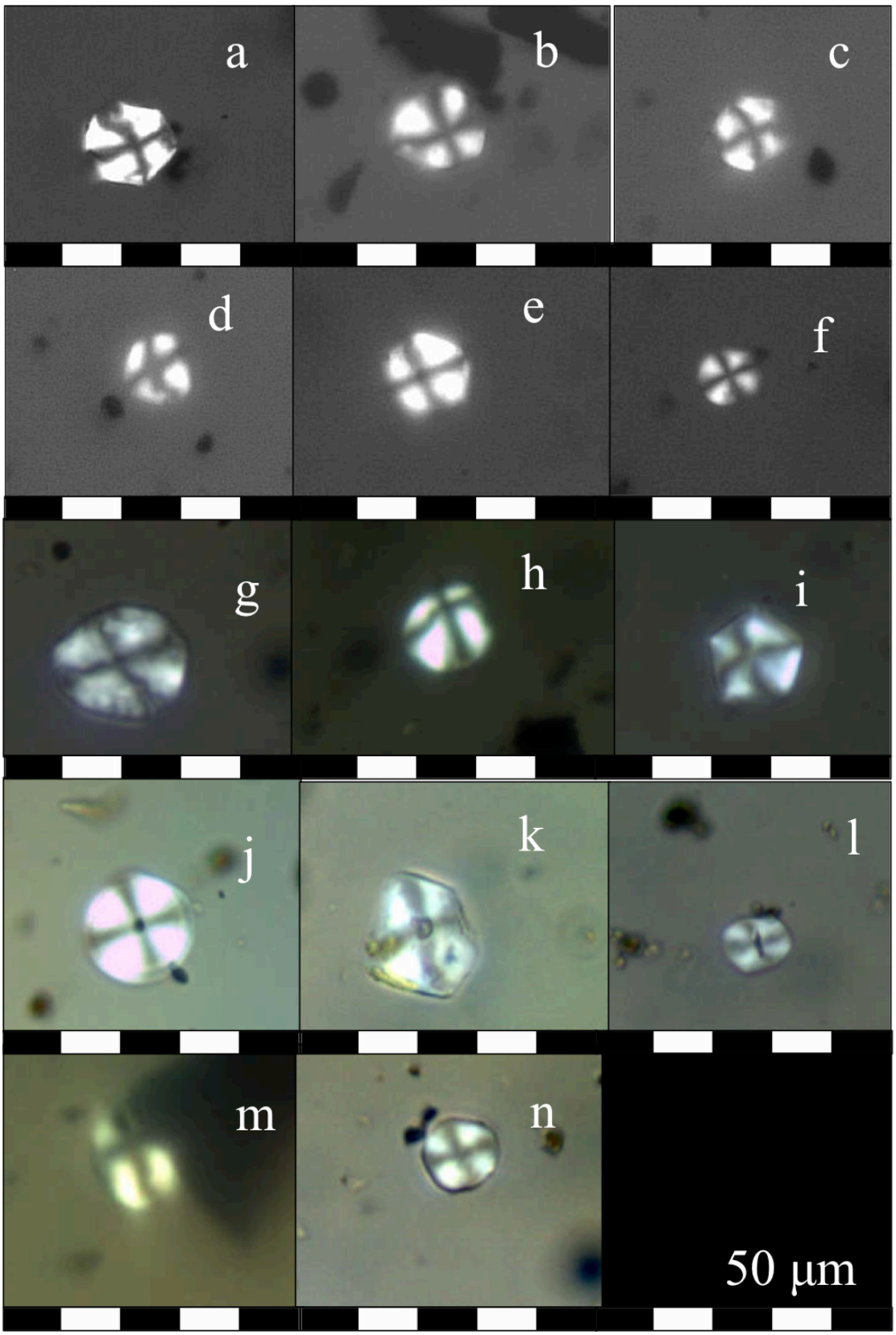


Figure 36. Starch granules from volcanic pestle fragment, sediment 2 (Table 25).

Table 25. Starch granules from volcanic pestle fragment, sediment 2.

	Possible ID	Hilum	Shape	Extinction Cross	Size	Length	Width
a		Eccentric	Diamond	Wavy	Large	17.19	16.66
b		Eccentric	Diamond	Straight	Large	15.78	14.74
c		Eccentric	Diamond	Curved	Medium	12.28	11.18
d		Centric	Reniform	Curved	Medium	13.92	13.73
e		Centric	Circular	Straight	Medium	13.94	13.29
f		Centric	Diamond	Straight	Medium	10.33	9.88
g	Acorn	Eccentric	Diamond	Straight	Xlarge	20.77	20.33
h	Lily	Eccentric	Pear	Wavy	Medium	13.9	13.68
i	Acorn	Centric	Semi-ovate	Curved	Large	15.05	14.22
j		Centric	Circular	Straight	Large	19.64	19.11
k		Centric	Semi-ovate	Wavy	Xlarge	21.84	17
l		Centric	Ovoid	Curved	Medium	10.57	7.96
m	Lily	Eccentric	Pear	Wavy	Medium	12.1	8.67
n	Pine	Centric	Circular	Curved	Medium	12.67	12.46

Figure 37. Volcanic mano fragment from the surface of SCRI-751.

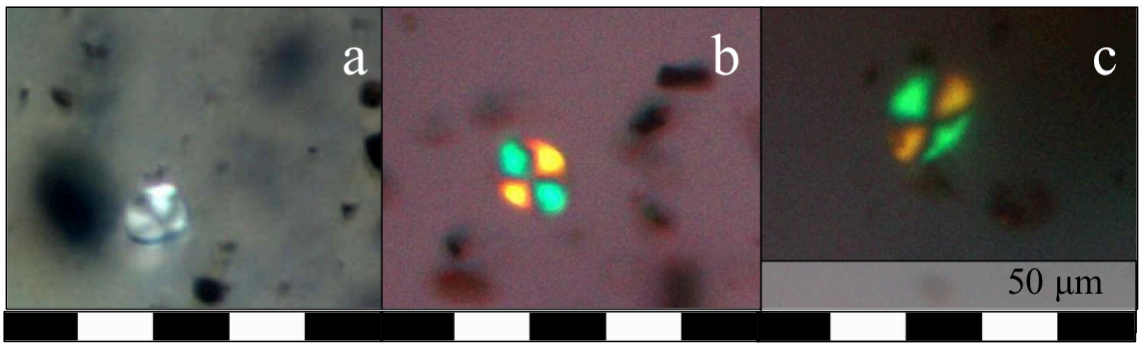


Figure 38. Starch granules from volcanic mano fragment, sediment 1 (Table 26).

Table 26. Starch granules from volcanic mano fragment, sediment 1.

	Possible ID	Hilum	Shape	Extinction Cross	Size	Length	Width
a	Cherry	Centric	Semi-ovate	Straight	Small	9.58	8.77
b		Centric	Pear	2 curves	Medium	11.74	8.85
c		Centric	Circular	Straight	Medium	13.04	10.18

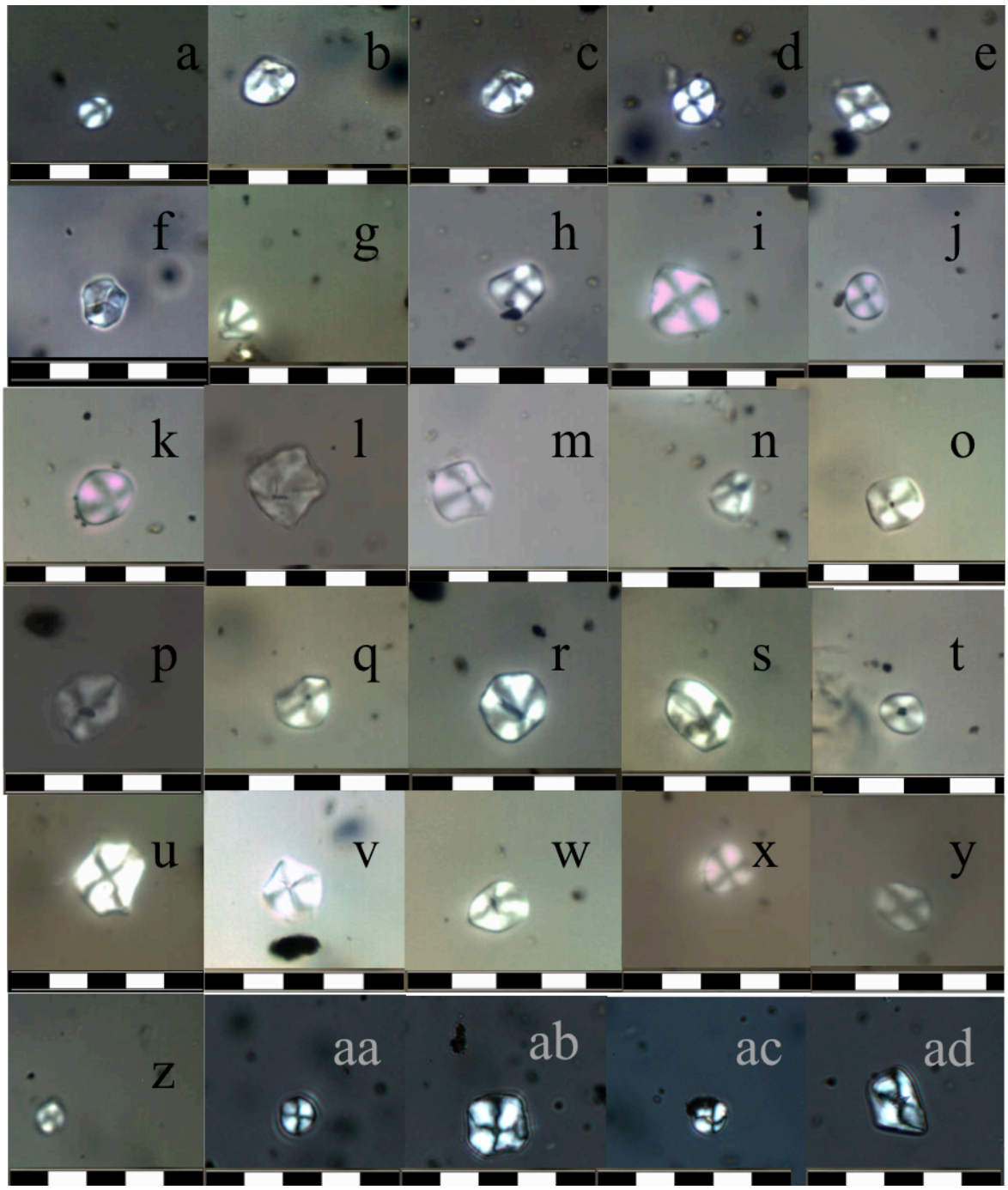


Figure 39. Starch granules from volcanic mano fragment, sediment 2 (Table 27).

Table 27. Starch granules from volcanic mano fragment, sediment 2.

	Possible ID	Hilum	Shape	Extinction Cross	Size	Length	Width
a		Eccentric	Circular	Curved	Small	9.61	9.28
b		Eccentric	Diamond	Curved	Medium	13.75	13.13
c			Reniform	Wavy	Medium	13.63	12.46
d	Lily	Eccentric	Pear	2 curves	Medium	11.92	11.82
e			Diamond	Curved	Medium	14.59	11.39
f	Cherry	Centric	Semi-ovate	Curved	Medium	12.25	11.54
g	Lily	Eccentric	Pear	Wavy	Medium	11.54	10.87
h		Irregular	Diamond	Curved	Medium	12.54	10.69
i		Irregular	Pear	Straight	Xlarge	20.59	18.76
j		Centric	Circular	Straight	Medium	11.62	11.05
k		Eccentric	Semi-ovate	Curved	Large	15.35	13.94
l		Eccentric	Semi-ovate	Wavy	Large	18.86	18.85
m	Lily	Eccentric	Pear	Curved	Medium	14.31	13.65
n		Eccentric	Reniform	Curved	Medium	12.08	11.43
o		Eccentric	Diamond	Curved	Medium	12.48	12.18
p	Lily	Eccentric	Pear	Wavy	Large	18.85	15.56
q		Eccentric	Reniform	Wavy	Medium	14.02	12.58
r		Eccentric	Semi-ovate	Wavy	Large	16.66	16.55
s	Lily	Eccentric	Ovoid	Wavy	Large	19.01	12.3
t		Eccentric	Diamond	Curved	Medium	10.47	9.23
u		Centric	Semi-ovate	Wavy	Large	19.75	19.2
v		Eccentric	Semi-ovate	Straight	Large	16.08	14.94
w		Eccentric	Reniform	Wavy	Medium	14.58	11.15
x		Eccentric	Reniform	Curved	Medium	12.7	12.18
y	Lily	Eccentric	Ovoid	Curved	Medium	14.16	11.71
z	Pine	Centric	Diamond	2 curves	Small	8.03	7.96
aa	Pine	Centric	Circular	2 curves	Small	8.87	8.88
ab		Centric	Diamond	Wavy	Large	19.48	16.65
ac	Pine	Centric	Circular	Swirling	Small	9.98	9.95
ad		Eccentric	Diamond	Wavy	Xlarge	21.16	17.43

Figure 40. Basalt mano fragment from the 10-20 cm level of SCRI-751.

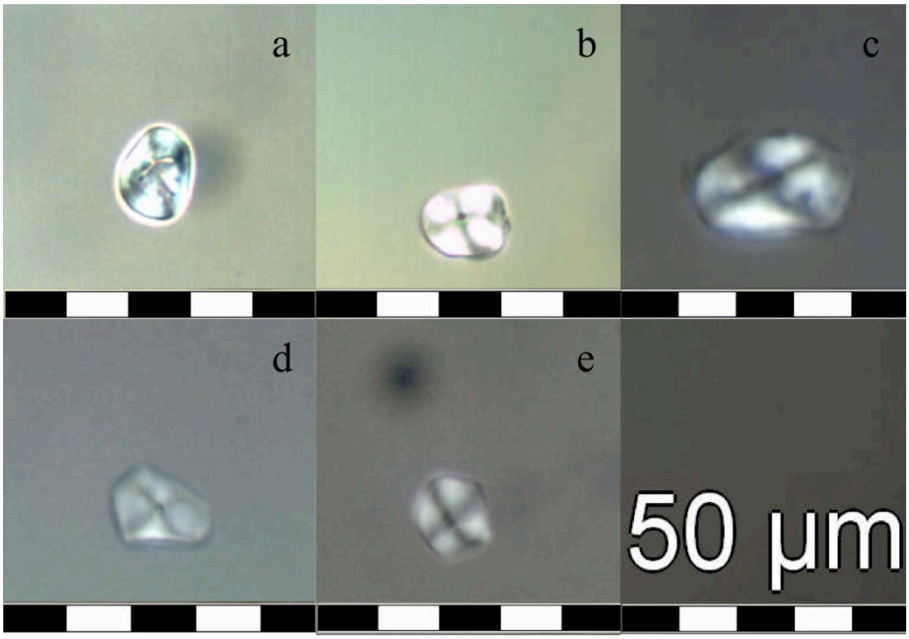


Figure 41. Starch granules from basalt mano fragment, sediment 1 (Table 28).

Table 28. Starch granules from basalt mano fragment, sediment 1.

	Possible ID	Hilum	Shape	Extinction Cross	Size	Length	Width
a	Cherry	Centric	Circular	Straight	Large	15.45	13.28
b		Centric	Ovoid	2 curves	Medium	13.75	12.02
c		Centric	Ovoid	Wavy	Xlarge	26.57	19.1
d	Lily	Eccentric	Pear	Wavy	Medium	12.84	12.58
e	Acorn	Eccentric	Diamond	Straight	Medium	12.52	11.05

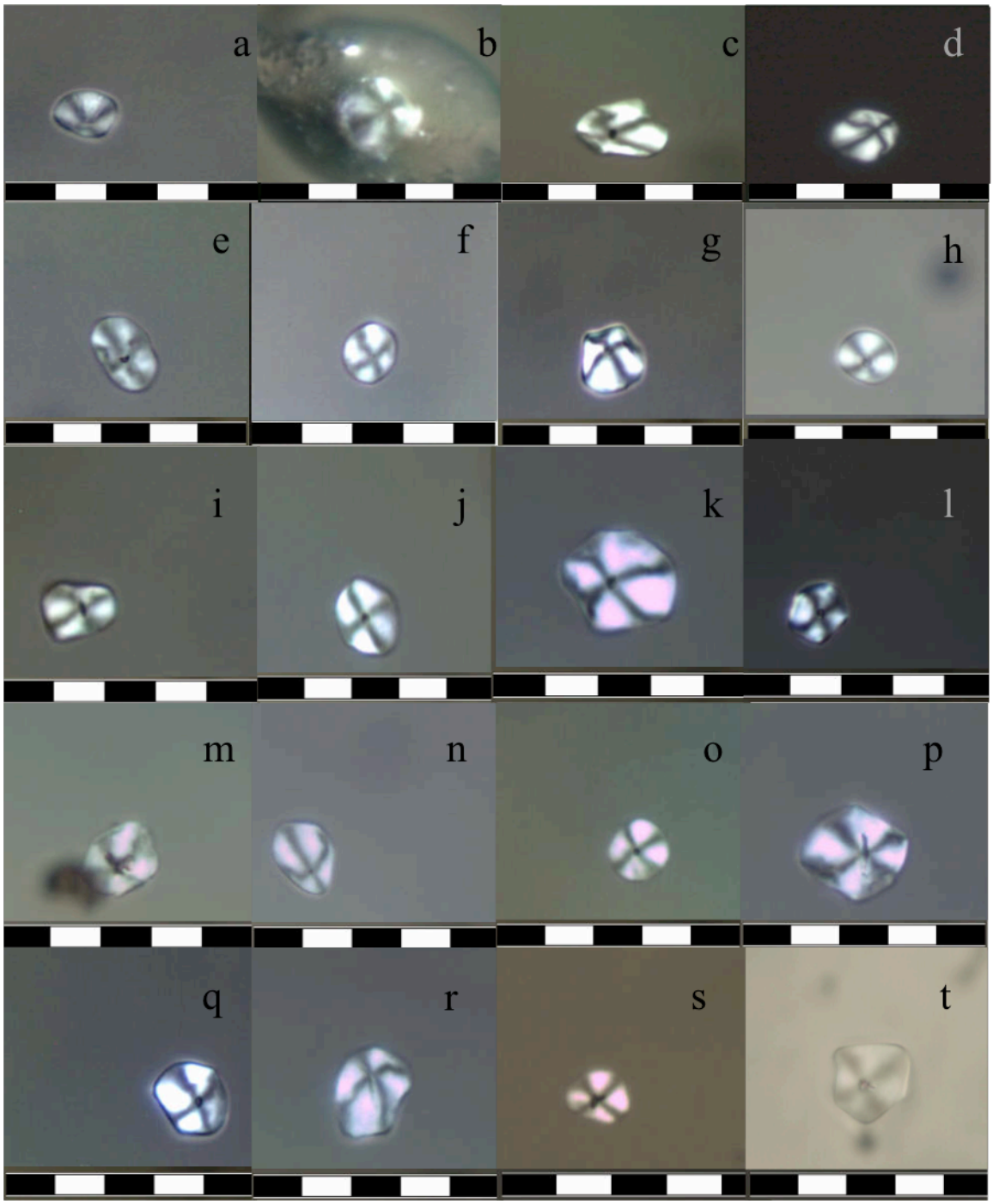


Figure 42. Starch granules from basalt mano fragment, sediment 2 (Table 29).

Table 29. Starch granules from basalt mano fragment, sediment 2.

	Possible ID	Hilum	Shape	Extinction Cross	Size	Length	Width
a	Lily	Eccentric	Pear	Curved	Medium	12.26	11.55
b		Eccentric	Diamond	Wavy	Large	19.22	16.48
c		Eccentric	Reniform	Wavy	Large	15.43	14.02
d		Eccentric	Diamond	Curved	Medium	14.75	14.49
e		Centric	Ovoid	Wavy	Large	17.1	11.78
f		Centric	Diamond	Curved	Medium	11.28	10.7
g	Lily	Eccentric	Pear	2 curves	Medium	14.72	13.75
h	Blue Dicks	Centric	Diamond	2 curves	Medium	13.36	12.28
i		Eccentric	Reniform	Curved	Medium	14.66	13.29
j		Centric	Ovoid	Straight	Large	16.83	13.61
k		Eccentric	Semi-ovate	2 curves	Xlarge	22.43	19.96
l		Eccentric	Semi-ovate	Curved	Medium	12.17	11.34
m	Acorn	Centric	Diamond	Wavy	Large	15.52	12.7
n	Lily	Eccentric	Ovoid	Curved	Large	17.27	11.96
o		Centric	Diamond	Straight	Medium	12.79	12.18
p	Cattail	Centric	Diamond	2 curves	Xlarge	21.95	19.96
q		Eccentric	Reniform	Curved	Large	16.07	13.62
r		Eccentric	Reniform	Wavy	Large	17.55	17.05
s		Eccentric	Diamond	Straight	Medium	11.38	10.65
t	Lily	Eccentric	Pear	Straight	Large	18.48	16.66

While there are many unidentified starch granules, those that can be identified provide a wealth of information. With the exception of pine, none of these other plants (acorn, blue dicks, cattail, cherry, or lily) were identified in the macrobotanical record. Furthermore, the range of starch granule types demonstrates that groundstone was used to process many different materials. It seems intuitive that groundstone would not be restricted to a single purpose; yet archaeologists often correlate specific groundstone with specific plants (e.g., pestles with acorn and manos with small seeds, respectively). My data indicate that these assumptions need to be critically evaluated, and tested with direct evidence. Particularly on the islands, it seems that mortars and pestles were multipurpose and key to the comparatively more mobile lifestyle of the Middle Holocene (as highlighted by their presence on Santa Barbara Island [Jennifer Perry, personal communication 2017]).

This study demonstrates that both starch granules and phytoliths can be recovered from Middle Holocene groundstone, including artifacts that have been exposed on the surface of sites, or sitting in museum collections. Because I was unable to identify phytoliths to a genus or species level, this line of evidence was not fruitful; however, it is certainly possible that future studies will pave the way for phytolith research in this region. Starch granules are more readily identifiable and are significantly less expensive to recover, as they do not require chemical digestion.

Conclusions

While faunal analysis is standard in almost any subsistence study, macrobotanical, and certainly microbotanical, analyses are often considered more specialized. VanDerwarker and Peres (2010:2) challenge the perception of plant and animal foodways as distinct, arguing "the separation of the analysis of archaeological plant and animal remains sets up a false dichotomy between these portions of the diet." Each of these data sets has its own challenges in terms of taphonomy and recovery; however, each has the potential to reveal unique, and often obscured, aspects of past foodways. Dense shell middens throughout the northern Channel Islands attest to the importance of marine resources. A perceived lack of ethnographically important plant foods on the islands, combined with ethnohistoric accounts of islanders purchasing plant foods from the mainland (Arnold 2012; Timbrook 1990, 1993, 2007) led some researchers to conclude that local terrestrial resources were not important (e.g., Arnold 2001; Arnold and Martin 2014; Munns and Arnold 2002). Indeed, early macrobotanical studies (e.g., Martin and Popper 1999, 2001; Popper 2003) found few to no seeds in island deposits. Recent macrobotanical studies (e.g., Gill 2015; Reddy and Erlandson 2012; Thakar 2014) have challenged the perception that plants were not important

on the northern Channel Islands. Plants, particularly geophytes, appear to have been important food resources since the earliest occupations, providing crucial carbohydrates to a diet rich in lean protein from fish and shellfish (Gill 2015; Gill and Hoppa 2016). The question remains why seeds were not recovered from these earlier studies. One important factor is sample size; early studies often used bulk samples of less than 20 liters. Preservation rates also seem to be lower at older sites, possibly due to weathering related to slow accumulation at more ephemeral occupations. The low density of macrobotanical remains recovered at the three sites included in this study provide little evidence of plant processing, even with samples of more than 100 liters. However, starch granules recovered from Middle Holocene groundstone provide direct evidence for the processing of plant foods at interior sites. The majority of identified taxa were not present in macrobotanical assemblages, highlighting the important of an integrated approach.

Overall, the findings from this study contribute to our understanding of Middle Holocene subsistence and settlement decisions by providing direct evidence for the use of groundstone tools, and highlighting preservation bias in the macrobotanical record. As other scholars have suggested (e.g., Erlandson 1997; Glassow 1996, 1997a; Schroth 1996), mortars and pestles were used to process more than just acorn. Indeed, the starch assemblages on mortar and pestle fragments tested for this study are not even dominated by acorn. Groundstone residue provides direct evidence that islanders were exploiting locally available plants at interior settlements. Furthermore, starch granules from plant taxa absent in the macrobotanical record demonstrate that a lack of macrobotanical remains should not be interpreted as evidence that terrestrial resources were not available or important on the northern Channel Islands (e.g., Fauvelle 2011). Including macrobotanical and

microbotanical analysis in future studies can provide important details of how often overlooked terrestrial resources factored into maritime hunter-gatherer decisions, and existing groundstone collections provide abundant opportunity for future research.

REFERENCES CITED

Ainis, Amira F., René L. Vellanoweth, Queeny G. Lapeña, and Carol S. Thornber.
2014 Using Non-Dietary Gastropods in Coastal Shell Middens to Infer Kelp and Seagrass Harvesting and Paleoenvironmental Conditions. *Journal of Archaeological Science* 49:343-360.

Arnold, Jeanne E.
2012 Prestige Trade in the Santa Barbara Channel Region. *California Archaeology* 4(1):145-148.

2001 Social Evolution and the Political Economy in the Northern Channel Islands. In *The Origins of a Pacific Coast Chiefdom: The Chumash of the Channel Islands*, edited by Jeanne E. Arnold, pp. 287-296. University of Utah Press, Salt Lake City.

1992 Complex Hunter-Gatherer-Fishers of Prehistoric California: Chiefs, Specialists, and Maritime Adaptations of the Channel Islands. *American Antiquity* 57:60-84.

1987 *Craft Specialization in the Prehistoric Channel Islands, California*. University of California Press, Berkeley.

1981 Archaeological Site Record for CA-SCRI-393. On file at the Central Coast Information Center, Department of Anthropology, University of California, Santa Barbara.

Baguskas, Sara A.
2014 Influences of Coastal Fog on the Physiology and Distribution of Bishop Pine on Santa Cruz Island, California. Unpublished Ph.D. dissertation, Department of Geography, University of California, Santa Barbara.

Barlow, K. Renee, and Duncan Metcalfe
1996 Plant Utility Indices: Two Great Basin Examples. *Journal of Archaeological Science* 23:351-–371.

Basgall, Mark E.
1987 Resource Intensification among Hunter-Gatherers: Acorn Economies in Prehistoric California. *Research in Economic Anthropology* 9: 21-52.

Baumhoff, Martin A.
1963 *Ecological determinants of aboriginal California populations*. University of California Press, Berkeley.

Beck, Charlotte, Amanda K. Taylor, George T. Jones, Cynthia M. Fadem, Caitlyn R. Cook, and Sara Millward.
2002 Rocks are Heavy: Transport Costs and Paleoarchaic Quarry Behavior in the Great Basin. *Journal of Anthropological Archaeology* 21: 481–507.

Bettinger, Robert L.
1987 Archaeological Approaches to Hunter-Gatherers. *Annual Review of Anthropology* 16:121–142.

Bettinger, Robert L., Ripan Malhi, and Helen McCarthy
1997 Central Place Models of Acorn and Mussel Processing. *Journal of Archaeological Science* 24:887–899.

Binford, Lewis R.
1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45(1):4–20.

Bingham, R. F.
1890 Medicinal Plants Growing Wild in Santa Barbara and Vicinity. Santa Barbara Society of Natural History Bulletin 1(3):34-37.

Biradent, Frank L.
n.d. Wild Herbs Used by the Indians and Spanish People in Santa Barbara County for Medicinal Purposes. Unpublished manuscript on file, Santa Barbara Museum of Natural History, Santa Barbara, California.

Bird, Douglas W., and Rebecca L. Bliege Bird
1997 Contemporary Shellfish Gathering Strategies among the Meriam of the Torres Straight Islands, Australia: Testing Predictions of a Central Place Foraging Model. *Journal of Archaeological Science* 24:39–63.

Braadbaart, F., and I. Poole
2008 Morphological, Chemical and Physical Changes during Charcoalification of Wood and its Relevance to Archaeological Contexts. *Journal of Archaeological Science* 35:2434-2445.

Braadbaart, F., I. Poole, and A. A. van Brussel
2009 Preservation Potential of Charcoal in Alkaline Environments: An Experimental Approach and Implications for the Archaeological Record. *Journal of Archaeological Science* 36:1672-1679.

Braje, Todd J., Jon M. Erlandson, Jan Timbrook
2005 An Asphaltum Coiled Basket Impression, Tarring Pebbles, and Middle Holocene Water Bottles from San Miguel Island, California. *Journal of California and Great Basin Anthropology* 25:207-213.

Braje, Todd J., Jon M. Erlandson, and Torben C. Rick
2013 Points in Space and Time: The Distribution of Paleocoastal Points and Crescents on the Northern Channel Islands. In *Small Island, Big Implications: The California Channel Islands and their Archaeological Contributions*, edited by Jennifer E. Perry and Christopher S. Jazwa, pp. 26-39. University of Utah Press, Salt Lake City.

Cabanes, Dan, Steve Weiner, and Ruth Shahack-Gross
2011 Stability of Phytoliths in the Archaeological Record: A Dissolution Study of Modern and Fossil Phytoliths. *Journal of Archaeological Science* 38:2480-2490.

Chandler-Ezell, K., and Deborah M. Pearsall
2003 'Piggyback' Microfossil Processing: Joint Starch and Phytolith Sampling from Stone Tools. *The Phytolitharien* 15:2–8.

Chiles, Frederic Caire
2011 *Justinian Caire and Santa Cruz Island: The Rise and Fall of a California Dynasty*. Arthur H. Clark Company, Norman, Oklahoma.

Cleveland, William S.
1994 *The Elements of Graphing Data*. AT&T Bell Laboratories, Murray Hill, New Jersey.

Connolly, Thomas J., Jon M. Erlandson, and Susan E. Norris
1995 Early Holocene Basketry and Cordage from Daisy Cave, San Miguel Island, California. *American Antiquity* 60:309-318.

Cuthrell, Rob Q.,
2011 Phytolith Sample Collection & Processing Procedure. *McCown Archaeobotany Laboratory Report* 67. University of California, Berkeley.

Cuthrell, Rob Q., and Loren V. Murch
2014 Effects of Extended Sonication and Deflocculation on Starch Recovery from Stone Tools. *McCown Archaeobotany Laboratory Report* 78. University of California, Berkeley.

Dunkle, Meryl Byron
1950 Plant Ecology of the Channel Islands of California. *Allan Hancock Pacific Expeditions* 13(3):247-386. University of Southern California Press, Los Angeles.

Ehmann, Margaret C., and John Pousson
1973 Archaeological site record for CA-SCRI-183. On file at the Central Coast Information Center, Department of Anthropology, University of California, Santa Barbara.

Erlandson, Jon M.
1994 *Early Hunter-Gatherers of the California Coast*. Plenum Press, New York.

1997a The Middle Holocene along the California Coast. In *Archaeology of the California Coast during the Middle Holocene*, edited by Jon M. Erlandson and Michael A. Glassow, pp. 1-10. Perspectives in California Archaeology, Vol. 4. Institute of Archaeology, University of California, Los Angeles.

Erlandson, Jon M., Todd J. Braje, Torben C. Rick and T. Davis
2009 Comparing Faunal Remains and Subsistence Technology at CA-SMI- 507: A 9,000-year-old Paleocoastal Shell Midden on San Miguel Island, California. *Journal of Island and Coastal Archaeology* 4:195-206.

Erlandson, Jon M., and Roger H. Colten
1991 An Archaeological Context for Early Holocene Studies on the California Coast. In *Hunter-Gatherers of Early Holocene Coastal California*, edited by Jon M. Erlandson and Roger H. Colten, pp. 1-10. Perspectives in California Archaeology, Volume 1. Cotsen Institute of Archaeology, University of California, Los Angeles.

Erlandson, Jon M., Torben C. Rick
2002 Late Holocene Cultural Developments Along the Santa Barbara Coast. In *Catalysts to Complexity: Late Holocene Societies of the California Coast*, edited by Jon M. Erlandson and Terry L. Jones, pp. 166-182.Perspectives in California Archaeology, Volume 6. Cotsen Institute of Archaeology, University of California, Los Angeles.

Erlandson, Jon M., Torben C. Rick, Todd J. Braje, Alexis Steinberg, and René L. Vellanoweth
2008 Human Impacts on Ancient Shellfish: A 10,000 Year Record from San Miguel Island, California. *Journal of Archaeological Science* 35:2144–2152.

Erlandson, Jon M., Torben C. Rick, Todd J. Braje, Molly Casperson, Brendan Culleton, Brian Fulfrost, Tracy Garcia, Daniel A. Guthrie, Nicholas Jew, Douglas J. Kennett, Madonna L. Moss, Leslie Reeder, Craig Skinner, Jack Watts, and Lauren Willis
2011 Paleoindian Seafaring, Maritime Technologies, and Coastal Foraging on California's Channel Islands. *Science* 331(6021):1181–1185.

Fauvelle, Mikael
2011 Mobile Mounds: Asymmetrical Exchange and the Role of the *Tomol* in the Development of Chumash Complexity. *California Archaeology* 3:141-158.

Filice, Ursula, Jelmer Eerkens, and Diane Beckles
2012 *An Experimental Study in Acorn Starch Grain Preservation and Identification*. Paper presented at the 46th Annual Meeting of the Society for California Archaeology, San Diego, California.

Friesen, T. Max
2004 A Tale of Two Settlement Patterns: Environmental and Cultural Determinants of Inuit and Dene Site Distributions. In *Hunters and Gatherers in Theory and Archaeology,* edited by George M. Crothers, pp.299-315. Center for Archaeological Investigations, Southern Illinois University, Carbondale.

Gamble, Lynn H.
2015 Chronology. In *First Coastal Californians*, edited by Lynn Gamble. School for Advanced Research Press, Santa Fe.

2008 *The Chumash World at European Contact: Power, Trade, and Feasting among Complex Hunter-Gatherers*. University of California Press, Berkeley.

Gamble, L.H., P.L. Walker, and G.S. Russell
2001 An Integrative Approach to Mortuary Analysis: Social and Symbolic Dimensions of Chumash Burial Practices. *American Antiquity* 66:185-212.

2002 Further Considerations on the Emergence of Chumash Chiefdoms. *American Antiquity* 67:772-777.

Gill, Kristina M.
2015 Prehistoric Plant Use Among Complex Maritime Hunter-Gatherer-Fishers, Santa Cruz Island, California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

2013 Paleoethnobotanical Investigations on the Channel Islands: Current Directions and Theoretical Considerations. In *Small Island, Big Implications: The California Channel Islands and their Archaeological Contributions*, edited by Jennifer E. Perry and Christopher S. Jazwa, pp. 113-136. University of Utah Press, Salt Lake City.

Gill, Kristina M., and Kristin M. Hoppa
2016 Evidence for an Island Chumash Geophyte-Based Subsistence Economy on the Northern Channel Islands. *Journal of California and Great Basin Anthropology* 36(1):51-71.

Glassow, Michael A.
2016 Environmental Factors Affecting Shellfish Utilization At Two Prehistoric Habitation Sites In Santa Cruz Island's Interior. Paper presented at the 9th Annual California Islands Symposium, Ventura, California.

1993a Changes in Subsistence on Marine Resources through 7,000 Years of Prehistory on Santa Cruz Island. In *Archaeology on the Northern Channel Islands of California*, edited by Michael A. Glassow, pp. 75-94. Coyote Press, Salinas, California.

1993b The Occurrence of Red Abalone Shells in Northern Channel Islands Archaeological Middens: Implications for Climactic Reconstruction. In *The Third California Islands Symposium, Recent Advances in Research on the California Islands*, edited by F.G. Hochberg, pp. 567-576. Santa Barbara Museum of Natural History.

1996 The Significance to California Prehistory of the Earliest Mortars and Pestles. *Pacific Coast Archaeological Society Quarterly* 32(4):14-26.

1997a Middle Holocene Cultural Development in the Central Santa Barbara Channel Region. In *Archaeology of the California Coast During the Middle Holocene*, edited by Jon M. Erlandson and Michael A. Glassow, pp. 73-90. Perspectives in California Archaeology, Vol. 4. Institute of Archaeology, University of California, Los Angeles.

1997b Research Issues of Importance to Coastal California Archaeology of the Middle Holocene. In *Archaeology of the California Coast During the Middle Holocene*, edited by Jon M. Erlandson and Michael A. Glassow, pp. 151-163. Perspectives in California Archaeology, Vol. 4. Institute of Archaeology, University of California, Los Angeles.

2014 Prehistoric Occupation of the Interior of Western Santa Cruz Island. In *Proceedings of the 8th California Islands Symposium*, edited by Mark C. Belk, pp. 118-128. Monographs of the Western North American Naturalist, Vol. 7.

Glassow, Michael A., Jennifer E. Perry, and Peter Paige

2008 *The Punta Arena Site: Early and Middle Holocene Development on Santa Cruz Island*. Contributions in Archaeology, no. 3, Santa Barbara Museum of Natural History, Santa Barbara, California.

Glassow, Michael A., Larry R. Wilcoxon, and Jon M. Erlandson

1988 Cultural and Environmental Change during the Early Period of Santa Barbara Channel Prehistory. In *The Archaeology of Prehistoric Coastlines*, edited by Geoff Bailey and John Parkington, pp. 64-77. Cambridge University Press.

Graesch, Anthony P., and Jeanne E. Arnold

2003 Small Scale Testing at SCRI-393: An Early Period Ridgetop Site. Submitted to Channel Islands National Park, Ventura, California.

Gusick, Amy E.

2012 Behavioral Adaptations and Mobility of Early Holocene Hunter-Gatherers, Santa Cruz Island, California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

2013 The Early Holocene Occupation of Santa Cruz Island. In *Small Island, Big Implications: The California Channel Islands and their Archaeological Contributions*, edited by Jennifer E. Perry and Christopher S. Jazwa, pp. 40-59. University of Utah Press, Salt Lake City.

Haslam, Michael
2004 The Decomposition of Starch Granules in Soils: Implications for Archaeological Residue Analyses. *Journal of Archaeological Science* 31:1715-1734.

Henry, Amanda G., Holly F. Hudson, and Dolores R. Piperno
2009 Changes in Starch Granule Morphologies from Cooking. *Journal of Archaeological Science* 36:915-922.

Henshaw, Henry W.
1955 California Indian Linguistic Records: The Mission Indian Vocabularies of H. W, Henshaw, edited by Robert F. Heizer. *Anthropological Records* 15(2). University of California Press, Berkeley.

Herzog, Nicole M.
2014 Starch Grain Analysis in California and the Great Basin. *California Archaeology* 6:171-189.

Holland, R.
1986 *Preliminary Descriptions of the Terrestrial Natural Communities of California*. California Department of Fish and Game, Sacramento.

Hollimon, Sandra E.
2001 Death, Gender, and the Chumash Peoples: Mourning Ceremonialism as an Integrative Mechanism. *Archeological Papers of the American Anthropological Association* 10(1):41–55.

1990 Division of Labor and Gender Roles in Santa Barbara Channel Area Prehistory. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

Hoppa, Kristin M.
2014 Island Interiors and Terrestrial Resources: Floral Data from Middle Holocene Sites on Santa Cruz Island. In *Proceedings of the 8th California Islands Symposium*, edited by Mark C. Belk, pp. 109-117. Monographs of the Western North American Naturalist, Vol. 7.

Hunter, Andrea A., and Brian R. Gassner
1998 Evaluation of the Flote-Tech Machine-Assisted System. *American Antiquity* 63(1):143-156.

Jackson, Marion Leroy
1958 *Soil Chemical Analysis*. Prentice Hall, Englewood Cliffs, New Jersey.

Jazwa, Christopher S., Todd J. Braje, Jon M. Erlandson, Douglas J. Kennett
2015 Central place foraging and shellfish processing on California's Northern Channel Islands. In *Journal of Anthropological Archaeology* 40:33-47.

Jazwa, Christopher S., and Jennifer E. Perry
2013 The Ecological, Environmental, and Cultural Contexts for Island Archaeology. In *Small Island, Big Implications: The California Channel Islands and their Archaeological Contributions*, edited by Jennifer E. Perry and Christopher S. Jazwa, pp. 2-25. University of Utah Press, Salt Lake City.

Johnson, John R.
2001 Ethnohistoric Reflections of Cruzeño Chumash Society. In *Origins of a Pacific Coast Chiefdom: The Chumash of the Channel Islands*, edited by Jeanne E. Arnold, pp. 53-70. University of Utah Press, Salt Lake City.

1982 An Ethnohistoric Study of the Island Chumash. Unpublished M.A. thesis, Department of Anthropology, University of California, Santa Barbara.

Johnson, John R., Thomas W. Stafford, Henry O. Ajie, and Don P. Morris
2000 Arlington Springs Revisited. In *Proceedings of the 5th California Islands Symposium*, edited by D. Browne, K. Mitchell, and H. Chaney, pp.541-545. Santa Barbara Museum of Natural History, Santa Barbara, California.

Jochim, Michael A.
2013 Island Perspectives. In *Small Island, Big Implications: The California Channel Islands and their Archaeological Contributions*, edited by Jennifer E. Perry and Christopher S. Jazwa, pp. 190-194. University of Utah Press, Salt Lake City.

1981 Strategies for Survival: Cultural Behavior in an Ecological Context. Academic Press, New York.

1976 *Hunter-Gatherer Subsistence and Settlement*. Academic Press, New York.

Jones, Terry L.
1996 Mortars, Pestles, and Division of Labor in Prehistoric California: A View from Big Sur. *American Antiquity* 61:243-264.

Junak, Steve, Denise A. Knapp, J. Robert Haller, Ralph Philbrick, Allan Schoenherr, and Tooo Keeler-Wolf
2007 The California Channel Islands. In *Terrestrial Vegetation of California*, edited by Michael Barbour, pp. 227-253. University of California Press, Berkeley.

Junak, Steve, Tina Ayers, Randy Scott, Dieter Wilken, and David Young
1995 *A Flora of Santa Cruz Island.* Santa Barbara Botanic Garden, Santa Barbara, California.

Kelly, Robert L.
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, D.C.

Kennett, Douglas J.
2005 *The Island Chumash: Behavioral Ecology of a Maritime Society*. University of California Press, Berkeley.

1998 Behavioral Ecology and the Evolution of Hunter-Gatherer Societies on the Northern Channel Islands. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

Kennett, Douglas J., and R. Clifford
2004 Flexible Strategies for Resource Defense on the Northern Channel Islands of California: An Agent-Based Model. In *The Archaeology of Insularity: Examining the Past in Island Environments*, edited by Scott Fitzpatrick, pp. 21-50. Greenwood Press, West Port, Connecticut.

Kennett, Douglas J., and Christina A. Conlee
2002 Emergence of Late Holocene Sociopolitical Complexity on Santa Rosa and San Miguel Islands. In *Catalysts to Complexity: Late Holocene Societies of the California Coast*, edited by Jon M. Erlandson and Terry L. Jones, pp.147-165. Perspectives in California Archaeology, Volume 6. Cotsen Institute of Archaeology, University of California, Los Angeles.

Kennett, D. J., J. P. Kennett, G. J. West, J. M. Erlandson, J. R. Johnson, I. L. Hendy, A. West, B. J. Culleton, T. L. Jones and T. W. Stafford Jr.
2008 Wildfire and Abrupt Ecosystem Disruption on California's Northern Channel Islands at the Ållerød-Younger Dryas boundary (13.0-12.9 ka). *Quaternary Science Reviews* 27(27-28):2530-2545.

King, Chester D.
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*. Garland Publishing, New York.

Lee, Georgia
1997 *The Chumash Cosmos: Effigies, Ornaments, Incised Stones and Rock Paintings of the Chumash Indians.* Bear Flag Books, Arroyo Grande, California.

Martin, Alexander C., and William D. Barkley
2000 *Seed Identification Manual*. Blackburn Press, Caldwell, New Jersey.

Martin, Lana S.
2010 Reconstructing Paleoenvironmental Instability and Plant Resource Availability on Santa Cruz Island using Macrobotanical Analysis. Unpublished M.A. Thesis, Department of Anthropology, University of California, Los Angeles.

Martin, Steve L.
2009 The Use of Marah Macrocarpus by the Prehistoric Indians of Coastal Southern California. *Journal of Ethnobiology* 29(1):77-93.

Martin, Steve, and Virginia Popper
2001 The Chumash in World and Regional Perspectives. In *The Origins of a Pacific Coast Chiefdom: The Chumash of the Channel Islands*, edited by Jeanne E. Arnold, pp. 1-19. University of Utah Press, Salt Lake City.

1999 Macrobotanical Analysis of Flotation Light Fractions from CA-SCRI-109 and -427, Santa Cruz Island, Santa Barbara County, California. Technical Report Submitted to Michael A. Glassow, Department of Anthropology, University of California, Santa Barbara.

McGill, Robert, John W. Tukey, and Wayne A. Larsen
1978 Variations of Box Plots. *The American Statistician* 32:12-16.

McKenzie, Dustin M.
2007 Simulated Prehistoric Fishing Methods on the Northern Channel Islands, California. Unpublished M.A. Thesis, Department of Anthropology, University of California, Santa Barbara.

Mead, George R.
2003 *Ethnobotany of the California Indians.* E-Cat Worlds, La Grande, Oregon.

Minnich, Richard A.
1980 Vegetation of Santa Cruz and Santa Catalina Islands. In *The California Islands: Proceedings of a Multidisciplinary Symposium*, edited by Dennis M. Power, pp. 123-138. Santa Barbara Museum of Natural History.

Miksicek, Charles
1987 Formation Processes of the Archaeobotanical Record. *Advances in Archaeological Method and Theory* 10:211-47.

Minnis, Paul
1981 Seeds in Archaeological Sites: Sources and Some Interpretive Problems. *American Antiquity* 46:143-152.

Moss, Madonna L., and Jon M. Erlandson
2010 Diversity in North Pacific Shellfish Assemblages: The Barnacles of Kit'n'Kaboodle Cave, Alaska. *Journal of Archaeological Science* 37:3359-3369.

Munns, Ann M., and Jeanne E. Arnold
2002 Late Holocene Santa Cruz Island: Patterns of Continuity and Change. In *Catalysts to Complexity: Late Holocene Societies of the California Coast*, edited by Jon M. Erlandson and Terry L. Jones, pp.127-146. Perspectives in California Archaeology, Volume 6. Cotsen Institute of Archaeology, University of California, Los Angeles.

Orians, Gordon H., and Nolan E. Pearson
1979 On the Theory of Central Place Foraging. In *Analysis of Ecological Systems,* edited by D. J. Horn, G. R. Stairs, and R. D. Mitchell, pp. 155–177. Ohio State University Press, Columbus.

Orr, Phil C.
1968 *Prehistory of Santa Rosa Island, Santa Barbara, California*. Santa Barbara Museum of Natural History, Santa Barbara, California.

Owen, R.W.
1980 Eddies of the California Current System: Physical and Ecological Characteristics. In *The California Islands: Proceedings of a Multidisciplinary Symposium*, edited by Dennis M. Power, pp.237-264. Santa Barbara Museum of Natural History, Santa Barbara, California.

Pearsall, Deborah M.
2010 *Paleoethnobotany: A Handbook of Procedures*. 2nd ed. Left Coast Press, Walnut, California.

Perry, Jennifer E.
2013 The Archaeology of Ritual on the Channel Islands. In *Small Island, Big Implications: The California Channel Islands and their Archaeological Contributions*, edited by Jennifer E. Perry and Christopher S. Jazwa, pp. 137-155. University of Utah Press, Salt Lake City.

2008 Catalog for Middle Holocene Sites CA-SCRI-174, -183 -724. Technical report in possession of the author.

2007 Chumash ritual and sacred geography on Santa Cruz Island, California. *Journal of California and Great Basin Anthropology* 27(2):103–124.

2004 Quarries and Microblades: Trends in Prehistoric Land and Resource Use on Eastern Santa Cruz Island. In *The Foundations of Chumash Cultural Complexity*, edited by Jeanne E. Arnold, pp. 113–131. Perspectives in California Archaeology, Volume 7. Cotsen Institute of Archaeology, University of California, Los Angeles.

2003 Prehistoric Land and Resource Use among Complex Hunter-Gatherer-Fishers on Eastern Santa Cruz Island. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

Perry, Jennifer E., and Colleen Delaney-Rivera
2011 Interactions and Interiors of the Coastal Chumash: Perspectives from Santa Cruz Island and the Oxnard Plain. *California Archaeology* 3:103-125.

Perry, Jennifer E., and Michael A. Glassow
2015 Prehistoric Settlement in Island Interiors: Evidence From California's Santa Cruz Island. *Journal of Island and Coastal Archaeology* 0:1-23.

Perry, Jennifer E., and Kristin M. Hoppa
2012 Subtidal Shellfish Exploitation on the California Channel Islands: Wavy Top (*Lithopoma undosum*) in the Middle Holocene. In *Exploring Methods of Faunal Analysis*, edited by Michael A. Glassow and Terry Joslin, pp. 65-86. Institute of Archaeology, University of California, Los Angeles.

Perry, Jennifer E., and Christopher S. Jazwa
2010 Spatial and Temporal Variability in Chert Exploitation on Santa Cruz Island, California. *American Antiquity* 75(1):177-198.

Pesendorfer, Mario B., Kathryn M. Langin, Brian Cohen, Zachary Principe, Scott A. Morrison and T. Scott Sillett
2014 Stand Structure and Acorn Production of the Island Scrub Oak (*Quercus pacifica*). In *Proceedings of the 8th California Islands Symposium*, edited by Mark C. Belk, pp. 246-259. Monographs of the Western North American Naturalist, Vol. 7.

Philbrick, Ralph N.
1978 A Botanists's View of Santa Cruz Island. *Fremontia* 6:6-10, 23.

Philbrick, Ralph N. and J. Robert Haller
1977 The Southern California Islands. In *Terrestrial Vegetation of California*, edited by Jack Major and Michael G. Barbour, pp. 893-906. Wiley, New York.

Pinney, Thomas
1994 *The Wine of Santa Cruz Island*. Santa Cruz Island Foundation, Santa Barbara, and Zamorano Club, Los Angeles, California.

Popper, Virginia
2008 Selecting Quantitative Measurements in Paleoethnobotany. In *Current Paleoethnobotany*, edited by Christine Hastorf and Virginia Popper, pp. 53-71. University of Chicago Press.

2003 *Macrobotanical Analysis of Soil Samples and Charcoal from CA-SCRI-393, Santa Cruz Island, California.* Technical report submitted to Channel Islands National Park, Ventura.

Reddy, Seetha N., and Jon M. Erlandson
2012 Macrobotanical Food Remains from a Trans-Holocene Sequence at Daisy Cave (CA-SMI-261), San Miguel Island, California. *Journal of Archaeological Science* 39:33-40.

Rick, Torben C., Jon M. Erlandson, and René L. Vellanoweth
2001 Paleocoastal Marine Fishing on the Pacific Coast of the Americas: Perspectives from Daisy Cave, California. *American Antiquity* 66:595-613.

Rodríguez-Suárez, J.A., B. Soto, R. Perez, and F. Diaz-Fierros
2011 Influence of *Eucalyptus globulus* Plantation Growth on Water Table Levels and Low Flows in a Small Catchment. *Journal of Hydrology* 396:321–326.

Rogers, David Banks
1929 Prehistoric Man of the Santa Barbara Coast. Santa Barbara Museum of Natural History, Santa Barbara, California.

Santa Cruz Island Foundation
2015 Winery SCRI. Electronic document, <http://islapedia.com/index.php?title=File:Winery_SCRI_1937%C2%A9.jpg>, accessed <June 8, 2017>.

Sawbridge, David F., and M. A. M. Bell
1972 Vegetation and Soils of Shell Middens on the Coast of British Columbia. *Ecology* 53:840-849.

Scholze, Gary J.
2011 The Application of Starch Grain Analysis to Late Prehistoric Subsistence in Northeastern California. Master's Thesis, Department of Anthropology, California State University, Sacramento.

2010 Potential Role of Starch-Grain Analysis in Determining Geophyte Use Within Northeastern California. Proceedings of the Society of California Archaeology 24:1–12.

Schroth, Adella B.
1996 An Ethnographic Review of Grinding, Pounding, Pulverizing, and Smoothing with Stones. *Pacific Coast Archaeological Society Quarterly* 32(4):55-75.

Strike, Sandra S.
1994 *Ethnobotany of the California Indians*, Vol. 2. Aboriginal Uses of California's Indigenous Plants. Koeltz Scientific Books, Champaign, Illinois.

Sutton, Elizabeth A.
2014a Digging Stick Weights and Doughnut Stones: An Analysis of Perforated Stones from the Santa Barbara Channel Region. *Journal of California and Great Basin Anthropology* 34(1):17–42.

2014b Household and Community Organization at Nimatlala, an Island Chumash Village on Limuw (Santa Cruz Island), California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

Thakar, Heather B.
2014 Food & Fertility in Prehistoric California: A Case-study of Risk-Reducing Foraging Behavior and Population Growth from Santa Cruz Island, California. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Santa Barbara.

Timbrook, Jan
2007 *Chumash Ethnobotany: Plant Knowledge Among the Chumash People of Southern California*. Santa Barbara Museum of Natural History monographs, no. 5. Santa Barbara Museum of Natural History, Santa Barbara, California.

1993 Island Chumash Ethnobotany. In *Archaeology on the Northern Channel Islands*, edited by M.A. Glassow, pp. 47-62. Coyote Press, Salinas, California.

1990 Ethnobotany of Chumash Indians, California, Based on Collections by John P. Harrington. *Economic Botany* 44:236-253.

1980 A Wooden Artifact from Santa Cruz Island. *Journal of California and Great Basin Anthropology* 2:272-279.

Van der Veen, Marijke
2007 Formation Processes of Desiccated and Carbonized Plant Remains and the Identification of Routine Practice. *Journal of Archaeological Science* 34:968-990.

VanDerwarker, Amber M

2010a Simple Measures for Integrating Plant and Animal Remains. In *Integrating Zooarchaeology and Paleoethnobotany: A Consideration of Issues, Methods, and Cases*, edited by Amber M. VanDerwarker and Tanya M. Peres, pp. 64-74. Springer, New York.

2010b Correspondence Analysis and Principal Components Analysis as Methods for Integrating Archaeological Plant and Animal Remains. In *Integrating Zooarchaeology and Paleoethnobotany: A Consideration of Issues, Methods, and Cases*, edited by Amber M. VanDerwarker and Tanya M. Peres, pp. 75-95. Springer, New York.

VanDerwarker, Amber M., and Tanya M. Peres

2010 Introduction. In *Integrating Zooarchaeology and Paleoethnobotany: A Consideration of Issues, Methods, and Cases*, edited by Amber M. VanDerwarker and Tanya M. Peres, pp. 1-14. Springer, New York.

Walker, Phillip L. and Jon Erlandson

1986 Dental Evidence for Prehistoric Dietary Change on the Northern Channel Islands. *American Antiquity* 51(2):375-83.

Weyrauch, Rita

1982 Herbal Remedies. *Solstice Journal* 1(1):1-27. Santa Barbara Indian Center, Santa Barbara, California.

Wilkinson, Leland, MaryAnn Jill, Stacey Miceli, Gregory Birkenbeuel, and Erin Vang

1992 *Systat Graphics*. SYSTAT, Evanston, Illinois.

Winterhalder, Bruce

1992 The Behavioural Ecology of Hunter Gatherers. In *Hunter Gatherers: And Interdisciplinary Perspective,* edited by Catherine Panter-Brick, Robert H. Layton, and Peter Rowley-Conway, pp. 13–38. Cambridge University Press.

Wisely, Justin

2016 Starch Grain Analysis of Bedrock Mortars in the Sierra Nevada Mountains: Experimental Studies To Determine Their Function. Unpublished M.A. Thesis, Department of Anthropology, California State University, Chico.

Wright, Patti J.

2003 Preservation or Destruction of Plant Remains by Carbonization? *Journal of Archaeological Science* 30:577-583.

Wohlgemuth, Eric

2010 Plant Resource Structure and the Prehistory of Plant Use in Central Alta California. *Journal of California Archaeology* 2:57-76.

1996 Resource Intensification in Prehistoric Central California: Evidence from Archaeobotanical Data. *Journal of California and Great Basin Anthropology* 18:81-103.

APPENDIX I

CATALOG OF SCRI-174 COLLECTIONS

Level	Fraction	Common Name	Scientific Name	Count	Weight (g)
0-10	HF	Unmodified Stone			1363
0-10	HF	Chert Debitage		20	11.09
0-10	HF	Chert Flakes		12	4.25
0-10	HF	Volcanic Debitage		1	9.48
0-10	HF	Volcanic Flakes		1	2.65
0-10	HF	Bone, undif.		2	0.2
0-10	HF	Fish vertebra		2	0.15
0-10	HF	Mammal Bone, undif.		6	1.65
0-10	HF	Abalone	*Haliotis* spp.		7.51
0-10	HF	Acorn Barnacle	*Balanus* spp.		35.68
0-10	HF	Black Abalone	*Haliotis cracherodii*		2.69
0-10	HF	CA Mussel	*Mytilus californianus*		550
0-10	HF	CA Mussel Hinges	*Mytilus californianus*	98	37.13
0-10	HF	Leaf Barnacle	*Pollicipes polymerus*		0.45
0-10	HF	Shell, undif.			15.38
0-10	HF	Turban Snail	*Tegula* spp.		0.16
0-10	HF	Urchin	*Strongylocentrotus* spp.		0.43
0-10	HF	Wavy Top	*Megastraea undosa*		22.71
0-10	HF	Wavy Top Opercula	*Megastraea undosa*	1	3.51
0-10	HF	Worm tube	Polychaeta		8.51
0-10	LF	Charcoal			<0.01
0-10	LF	Nutshell, undif.			0.07
0-10	LF	Amaranth	*Amaranthus* spp.	1	<0.01
0-10	LF	Bean Family	Fabaceae	8	<0.01
0-10	LF	c.f. Cryptantha	*Cryptantha clevelandii*	1	<0.01
0-10	LF	Catchfly	*Silene laciniata*	36	<0.01
0-10	LF	Chenopod	*Chenopodium* spp.	1	<0.01
0-10	LF	Yarrow	*Achillea millefolium*	3	<0.01
0-10	LF	Unidentifiable Seed		3	<0.01
10-20	HF	Unmodified Stone			1735
10-20	HF	Chert Debitage		19	18.65
10-20	HF	Chert Flakes		6	16.59
10-20	HF	Volcanic Debitage		5	51.91
10-20	HF	Volcanic Flakes		3	3.54
10-20	HF	Bone, undif.		5	1.13
10-20	HF	Fish Bone, undif		2	0.56
10-20	HF	Fish vertebra		1	0.09

10-20	HF	Mammal Bone, undif.			7	2.09
10-20	HF	Pinniped Bone, undif.			2	0.43
10-20	HF	Abalone	*Haliotis* spp.			3.08
10-20	HF	Acorn Barnacle	*Balanus* spp.			38.63
10-20	HF	Black Abalone	*Haliotis cracherodii*			3.78
10-20	HF	CA Mussel	*Mytilus californianus*			525.87
10-20	HF	CA Mussel Hinges	*Mytilus californianus*		106	59.47
10-20	HF	Leaf Barnacle	*Pollicipes polymerus*			0.14
10-20	HF	Limpet	*Acmaea* spp.			0.06
10-20	HF	Norris Top	*Norrisia norrisii*			29.75
10-20	HF	Shell, undif.				50.03
10-20	HF	Urchin	*Strongylocentrotus* spp.			0.11
10-20	HF	Volcano Limpet	*Fissurella volcano*			0.16
10-20	HF	Wavy Top	*Megastraea undosa*			22.39
10-20	HF	Wavy Top Opercula	*Megastraea undosa*		1	4.97
10-20	HF	Worm tube	Polychaeta			2.32
10-20	LF	Charcoal				<0.01
10-20	LF	Catchfly	*Silene laciniata*	2		<0.01
10-20	LF	Unidentifiable Plant Part		2		<0.01
10-20	LF	Unidentifiable Seed		2		<0.01

APPENDIX II

CATALOG OF SCRI-183 COLLECTIONS

Level	Fraction	Common Name	Scientific Name	Count	Weight (g)
0-10	HF	Unmodified Stone			2183
0-10	HF	Chert Debitage		16	30.23
0-10	HF	Chert Flakes		10	19.67
0-10	HF	Volcanic Debitage		7	5.71
0-10	HF	Fired Clay			0.22
0-10	HF	Bone, undif.		1	0.09
0-10	HF	Mammal Bone, undif.		7	2.87
0-10	HF	Sheephead	*Semicossyphus pulcher*		0.26
0-10	HF	Abalone	*Haliotis* spp.		16.35
0-10	HF	Acorn Barnacle	*Balanus* spp.		44.02
0-10	HF	CA Mussel	*Mytilus californianus*		388.72
0-10	HF	CA Mussel (Burnt)	*Mytilus californianus*		0.51
0-10	HF	CA Mussel Hinges	*Mytilus californianus*	65	37.06
0-10	HF	Leaf Barnacle	*Pollicipes polymerus*		1.45
0-10	HF	Limpet, undif.			0.08
0-10	HF	Norris Top	*Norrisia norrisii*		0.33
0-10	HF	Olive Shell	*Olivella biplicata*		0.17
0-10	HF	Shell, undif.			17.87
0-10	HF	Slipper Shell	*Crepidula* spp.		0.14
0-10	HF	Urchin	*Strongylocentrotus* spp.		0.32
0-10	HF	Wavy Top	*Megastraea undosa*		18.37
0-10	HF	Wavy Top Opercula	*Megastraea undosa*	1	1.09
0-10	HF	Worm tube	Polychaeta		1.31
0-10	HF	CA Mussel (Modified)	*Mytilus californianus*		0.29
0-10	HF	Olive Shell Bead	*Olivella biplicata*		0.77
0-10	LF	Charcoal			0.06
0-10	LF	Amaranth	*Amaranthus* spp.	6	<0.01
0-10	LF	Catchfly	*Silene laciniata*	6	<0.01
0-10	LF	Red Maids	*Calandrinia brewerii*	1	<0.01
10-20	HF	Unmodified Stone			1939
10-20	HF	Chert Debitage		19	9.52
10-20	HF	Chert Flakes		9	27.95
10-20	HF	Volcanic Debitage		4	20.14
10-20	HF	Volcanic Flakes		1	11.78
10-20	HF	Bone, undif.		4	0.54
10-20	HF	Mammal Bone, undif.		8	1.99

10-20	HF	Abalone	*Haliotis* spp.			12.68
10-20	HF	Acorn Barnacle	*Balanus* spp.			857.25
10-20	HF	Black Abalone	*Haliotis cracherodii*			17.6
10-20	HF	CA Mussel	*Mytilus californianus*			848
10-20	HF	CA Mussel Hinges	*Mytilus californianus*		135	67.58
10-20	HF	Leaf Barnacle	*Pollicipes polymerus*			0.94
10-20	HF	Olive Shell	*Olivella biplicata*			1.42
10-20	HF	Shell, undif.				32.33
10-20	HF	Urchin	*Strongylocentrotus* spp.			0.47
10-20	HF	Wavy Top	*Megastraea undosa*			21.17
10-20	HF	Wavy Top Opercula	*Megastraea undosa*		1	2.46
10-20	HF	Whelk, undif.				0.28
10-20	HF	Worm tube	Polychaeta			0.33
10-20	LF	Bone, undif.				<0.01
10-20	LF	Charcoal				0.02
10-20	LF	Amaranth	*Amaranthus* spp.	2		<0.01
10-20	LF	Chenopod	*Chenopodium* spp.	2		<0.01
20-30	HF	Unmodified Stone				2122
20-30	HF	Chert Debitage		17		7.9
20-30	HF	Chert Flakes			14	17.57
20-30	HF	Volcanic Debitage			6	11.92
20-30	HF	Volcanic Flakes			2	6.66
20-30	HF	Bone, undif.			2	0.16
20-30	HF	Mammal Bone, undif.			8	1.32
20-30	HF	Sheephead	*Semicossyphus pulcher*		3	1.71
20-30	HF	Abalone	*Haliotis* spp.			5.7
20-30	HF	Acorn Barnacle	*Balanus* spp.			102.93
20-30	HF	Black Abalone	*Haliotis cracherodii*			3.68
20-30	HF	CA Mussel	*Mytilus californianus*			942.13
20-30	HF	CA Mussel Hinges	*Mytilus californianus*	107		83.51
20-30	HF	Clam, undif.				0.47
20-30	HF	Leaf Barnacle	*Pollicipes polymerus*			0.79
20-30	HF	Limpet	*Acmaea* spp.			0.16
20-30	HF	Norris Top	*Norrisia norrisii*			3.86
20-30	HF	Olive Shell	*Olivella biplicata*			0.71
20-30	HF	Shell, undif.				37.09
20-30	HF	Urchin	*Strongylocentrotus* spp.			0.12
20-30	HF	Wavy Top	*Megastraea undosa*			10.74
20-30	HF	Wavy Top Opercula	*Megastraea undosa*	1		1.82
20-30	HF	Worm tube	Polychaeta			0.89
20-30	HF	Bone, undif. (Modified)		1		0.26
20-30	HF	Olive Shell Bead	*Olivella biplicata*		1	0.11
20-30	LF	Bone, undif.				0.01

20-30	LF	Charcoal				0.02
30-40	HF	Unmodified Stone				1332
30-40	HF	Chert Debitage		17		25.23
30-40	HF	Chert Flakes			5	11.44
30-40	HF	Bird Bone, undif.			1	0.13
30-40	HF	Bone, undif.			6	0.88
30-40	HF	Mammal Bone, undif.			6	1.42
30-40	HF	Abalone	*Haliotis* spp.			4.51
30-40	HF	Acorn Barnacle	*Balanus* spp.			204.01
30-40	HF	Black Abalone	*Haliotis cracherodii*			24.02
30-40	HF	CA Mussel	*Mytilus californianus*			1390.16
30-40	HF	CA Mussel Hinges	*Mytilus californianus*	234		93.38
30-40	HF	Leaf Barnacle	*Pollicipes polymerus*			1.28
30-40	HF	Misc. Gastropods				2.25
30-40	HF	Owl Limpet	*Lottia gigantea*			0.69
30-40	HF	Platform Mussel	*Mytilisepta bifurcata*			0.16
30-40	HF	Shell, undif.				47.67
30-40	HF	Urchin	*Strongylocentrotus* spp.			0.65
30-40	HF	Wavy Top	*Megastraea undosa*			10.41
30-40	HF	Wavy Top Opercula	*Megastraea undosa*	1		0.3
30-40	HF	Worm tube	Polychaeta			0.3
30-40	HF	Olive Shell Bead	*Olivella biplicata*	1		0.26
30-40	LF	Bone, undif.				<0.01
30-40	LF	Charcoal				<0.01
40-50	HF	Unmodified Stone				1746
40-50	HF	Chert Debitage		8		4.34
40-50	HF	Chert Flakes			5	18.58
40-50	HF	Volcanic Debitage			8	3.54
40-50	HF	Mammal Bone, undif.			2	0.39
40-50	HF	Sheephead	*Semicossyphus pulcher*		1	0.29
40-50	HF	Acorn Barnacle	*Balanus* spp.		69	83.12
40-50	HF	Black Abalone	*Haliotis cracherodii*			2.37
40-50	HF	CA Mussel	*Mytilus californianus*			521.29
40-50	HF	CA Mussel Hinges	*Mytilus californianus*			22.61
40-50	HF	Leaf Barnacle	*Pollicipes polymerus*			1.96
40-50	HF	Norris Top	*Norrisia norrisii*			2.44
40-50	HF	Platform Mussel	*Mytilisepta bifurcata*			0.2
40-50	HF	Shell, undif.				49.36
40-50	HF	Urchin	*Strongylocentrotus* spp.			2.32
40-50	HF	Wavy Top	*Megastraea undosa*			5.49
40-50	HF	Wavy Top Opercula	*Megastraea undosa*	1		2.44
40-50	HF	Worm tube	Polychaeta			0.44

APPENDIX III

CATALOG OF SCRI-393 COLLECTIONS

Level	Fraction	Common Name	Scientific Name	Count	Weight (g)
0-10	HF	Unmodified Stone			1023
0-10	HF	Chert Cores		2	181.47
0-10	HF	Chert Debitage		57	122.25
0-10	HF	Chert Flakes		18	33.77
0-10	HF	Volcanic Debitage		6	15.05
0-10	HF	Bird Bone, undif.		1	0.14
0-10	HF	Bone, undif.		5	0.69
0-10	HF	Mammal Bone, undif.		6	3.46
0-10	HF	Abalone	*Haliotis* spp.		0.87
0-10	HF	Acorn Barnacle	*Balanus* spp.		69.49
0-10	HF	Black Abalone	*Haliotis cracherodii*		5.14
0-10	HF	CA Mussel	*Mytilus californianus*		850.81
0-10	HF	CA Mussel Hinges	*Mytilus californianus*	211	100.13
0-10	HF	Chiton	Polyplacophora		0.33
0-10	HF	Giant Keyhole Limpet	*Megathura crenulata*		3.07
0-10	HF	Leaf Barnacle	*Pollicipes polymerus*		3.24
0-10	HF	Olive Shell	*Olivella biplicata*	1	0.25
0-10	HF	Olive Shell Bead	*Olivella biplicata*		0.15
0-10	HF	Owl Limpet	*Lottia gigantea*		0.11
0-10	HF	Shell, undif.			58.1
0-10	HF	Urchin	*Strongylocentrotus* spp.		0.17
0-10	HF	Wavy Top	*Megastraea undosa*		1.72
0-10	HF	Wavy Top Opercula	*Megastraea undosa*	1	0.13
0-10	HF	Float Rock Projectile Point		1	1.95
0-10	LF	Charcoal			0.16
0-10	LF	Bean Family	Fabaceae	1	<0.01
0-10	LF	Catchfly	*Silene laciniata*	327	<0.01
0-10	LF	Grass Family	Poaeceae	9	<0.01
0-10	LF	Peppergrass	*Lepidium* spp.	1	<0.01
0-10	LF	Unidentifiable Seed		9	<0.01
10-20	HF	Unmodified Stone			585
10-20	HF	Chert Debitage		43	19.64
10-20	HF	Chert Flakes		7	8.34
10-20	HF	Volcanic Debitage		5	11.54
10-20	HF	Bird Bone, undif.		1	0.04
10-20	HF	Bone, undif.		2	0.37

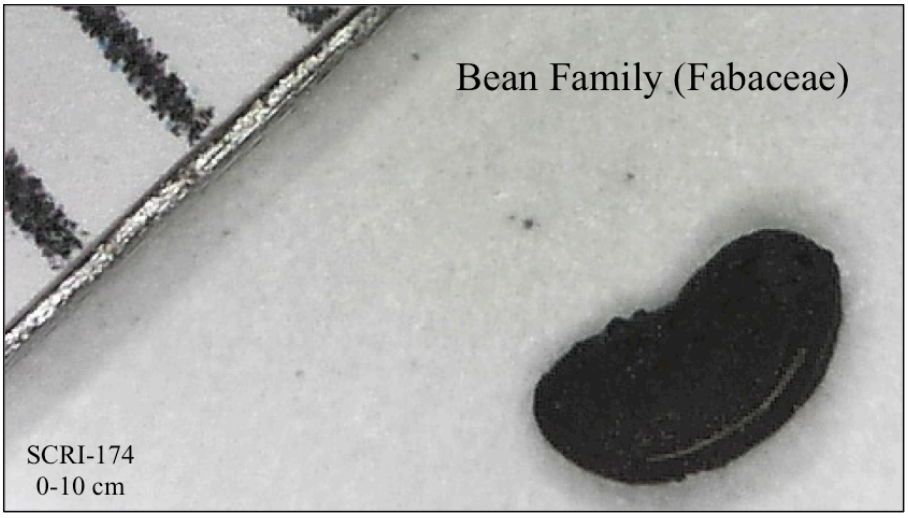
10-20	HF	Fish Otolith, undif		1	0.74
10-20	HF	Mammal Bone, undif.		3	1.04
10-20	HF	Sheephead	*Semicossyphus pulcher*	2	1.65
10-20	HF	Abalone	*Haliotis* spp.		0.09
10-20	HF	Acorn Barnacle	*Balanus* spp.		161.19
10-20	HF	Black Abalone	*Haliotis cracherodii*		8.51
10-20	HF	Black Abalone	*Haliotis cracherodii*		18
10-20	HF	CA Mussel	*Mytilus californianus*		911.63
10-20	HF	CA Mussel Hinges	*Mytilus californianus*	282	192.41
10-20	HF	Leaf Barnacle	*Pollicipes polymerus*		6.69
10-20	HF	Limpet	*Acmaea* spp.		0.07
10-20	HF	Misc. Gastropod			1.65
10-20	HF	Misc. Gastropod			0.84
10-20	HF	Olive Shell	*Olivella biplicata*		0.8
10-20	HF	Shell, undif.			54.2
10-20	HF	Urchin	*Strongylocentrotus* spp.		0.14
10-20	HF	Wavy Top	*Megastraea undosa*		8.11
10-20	HF	Worm tube	Polychaeta		0.26
10-20	LF	Bone, undif.			<0.01
10-20	LF	Charcoal			0.07
10-20	LF	Manzanita	*Arctostaphylos* spp.	2	<0.01
20-30	HF	Unmodified Stone			2915
20-30	HF	Chert Debitage		72	32.18
20-30	HF	Chert Flakes		12	36.8
20-30	HF	Volcanic Debitage		9	16.93
20-30	HF	Bone, undif.		3	0.32
20-30	HF	Bone, undif. (Worked)		1	0.09
20-30	HF	Mammal Bone, undif.		1	0.12
20-30	HF	Sheephead	*Semicossyphus pulcher*	5	7.56
20-30	HF	Abalone	*Haliotis* spp.		14.77
20-30	HF	Acorn Barnacle	*Balanus* spp.		762.04
20-30	HF	Black Abalone	*Haliotis cracherodii*		21.67
20-30	HF	CA Mussel	*Mytilus californianus*		1995.96
20-30	HF	CA Mussel Hinges	*Mytilus californianus*	767	433.07
20-30	HF	Leaf Barnacle	*Pollicipes polymerus*		42.15
20-30	HF	Limpet	*Acmaea* spp.		0.57
20-30	HF	Misc. Gastropod			0.19
20-30	HF	Owl Limpet	*Lottia gigantea*		3.08
20-30	HF	Shell, undif.			194.65
20-30	HF	Urchin	*Strongylocentrotus* spp.		0.15
20-30	HF	Wavy Top	*Megastraea undosa*		180.73
20-30	HF	Wavy Top Opercula	*Megastraea undosa*	2	15.24
20-30	HF	Worm tube	Polychaeta		2.63

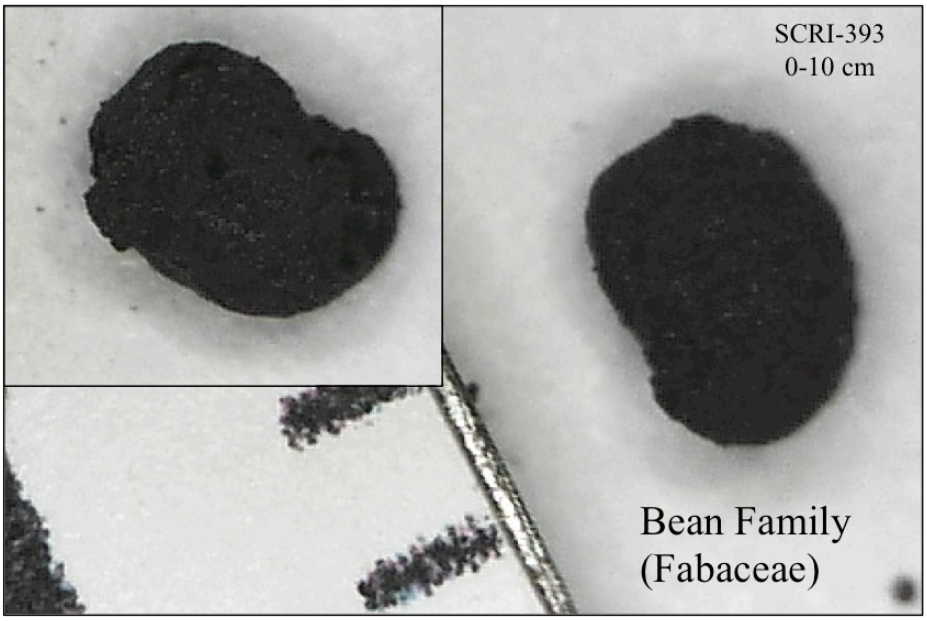
20-30	LF	Bone, undif.			0.01
20-30	LF	Charcoal			0.27
20-30	LF	Manzanita	*Arctostaphylos* spp.	1	<0.01
20-30	LF	Unidentifiable Seed		1	<0.01
30-40	HF	Unmodified Stone			2500
30-40	HF	Chert Debitage		57	47.01
30-40	HF	Chert Flakes		9	49.29
30-40	HF	Volcanic Debitage		32	8.12
30-40	HF	Volcanic Flakes			8
30-40	HF	Bird Bone, undif.		1	0.27
30-40	HF	Bone, undif.		10	1.05
30-40	HF	Mammal Bone, undif.		8	1.16
30-40	HF	Sheephead	*Semicossyphus pulcher*	3	0.53
30-40	HF	Abalone	*Haliotis* spp.		1.13
30-40	HF	Acorn Barnacle	*Balanus* spp.		618.48
30-40	HF	Black Abalone	*Haliotis cracherodii*		35.05
30-40	HF	CA Mussel	*Mytilus californianus*		1610.84
30-40	HF	CA Mussel Hinges	*Mytilus californianus*	548	361.27
30-40	HF	Leaf Barnacle	*Pollicipes polymerus*		37.05
30-40	HF	Limpet	*Acmaea* spp.		0.58
30-40	HF	Misc. Gastropod			2.56
30-40	HF	Platform Mussel	*Mytilisepta bifurcata*		0.15
30-40	HF	Red Abalone	*Haliotis rufescens*		4.1
30-40	HF	Shell, undif.			142.93
30-40	HF	Turban Snail	*Tegula* spp.		1.39
30-40	HF	Urchin	*Strongylocentrotus* spp.		1.48
30-40	HF	Wavy Top	*Megastraea undosa*		193.7
30-40	HF	Wavy Top Opercula	*Megastraea undosa*	3	26.3
30-40	HF	Worm tube	Polychaeta		3.88
30-40	HF	Charcoal		1	0.08
30-40	LF	Bone, undif.			<0.01
30-40	LF	Charcoal			0.08
30-40	LF	Bean Family	Fabaceae	1	<0.01
30-40	LF	Knotweed	*Polygonum* spp.	1	<0.01
30-40	LF	Pine	*Pinus muricata*	1	<0.01
30-40	LF	Unidentifiable Seed		7	<0.01
40-50	HF	Unmodified Stone			3325
40-50	HF	Chert Debitage		30	43.06
40-50	HF	Chert Flakes		9	15.92
40-50	HF	Volcanic Debitage		5	46.04
40-50	HF	Mammal Bone, undif.		1	0.54
40-50	HF	Abalone	*Haliotis* spp.		5.71
40-50	HF	Acorn Barnacle	*Balanus* spp.		83.62

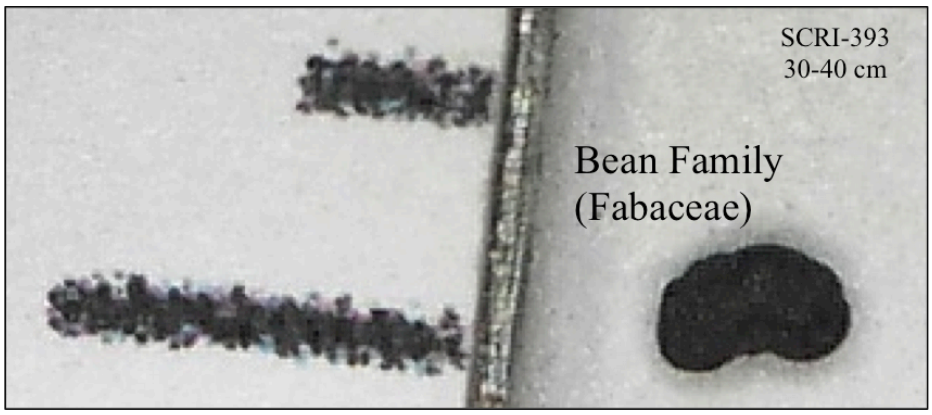
40-50	HF	Black Abalone	*Haliotis cracherodii*		29.64
40-50	HF	CA Mussel	*Mytilus californianus*		483.99
40-50	HF	CA Mussel Hinges	*Mytilus californianus*	128	74.24
40-50	HF	Leaf Barnacle	*Pollicipes polymerus*		7.18
40-50	HF	Limpet, undif.			0.1
40-50	HF	Misc. Gastropod			0.83
40-50	HF	Shell, undif.			122.06
40-50	HF	Wavy Top	*Megastraea undosa*		31.28
40-50	HF	Wavy Top Opercula	*Megastraea undosa*	2	18.9
40-50	HF	Worm tube	Polychaeta		0.48
40-50	LF	Charcoal			0.16
40-50	LF	Unidentifiable Seed		1	<0.01
50-60	HF	Unmodified Stone			2810
50-60	HF	Chert Debitage		8	12.53
50-60	HF	Chert Flakes		1	2.86
50-60	HF	Acorn Barnacle	*Balanus* spp.		8.46
50-60	HF	CA Mussel	*Mytilus californianus*		51.98
50-60	HF	CA Mussel Hinges	*Mytilus californianus*	16	8.8
50-60	HF	Leaf Barnacle	*Pollicipes polymerus*		1.01
50-60	HF	Shell, undif.			5.86
50-60	LF	Charcoal			0.01
50-60	LF	Johnny jump-up	*Viola pendunculata*	1	<0.01

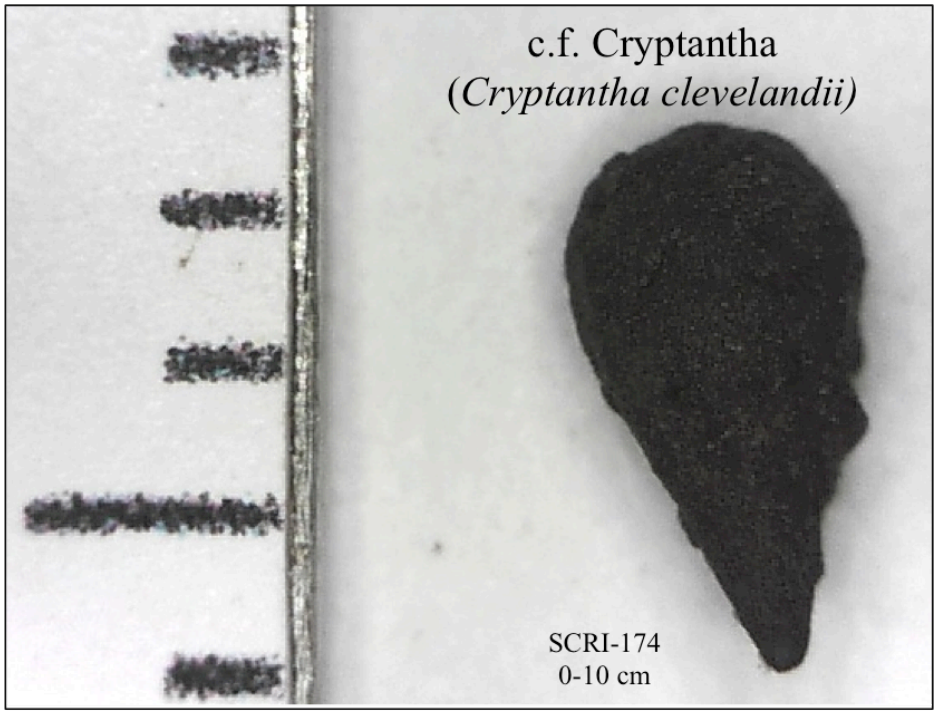
APPENDIX IV

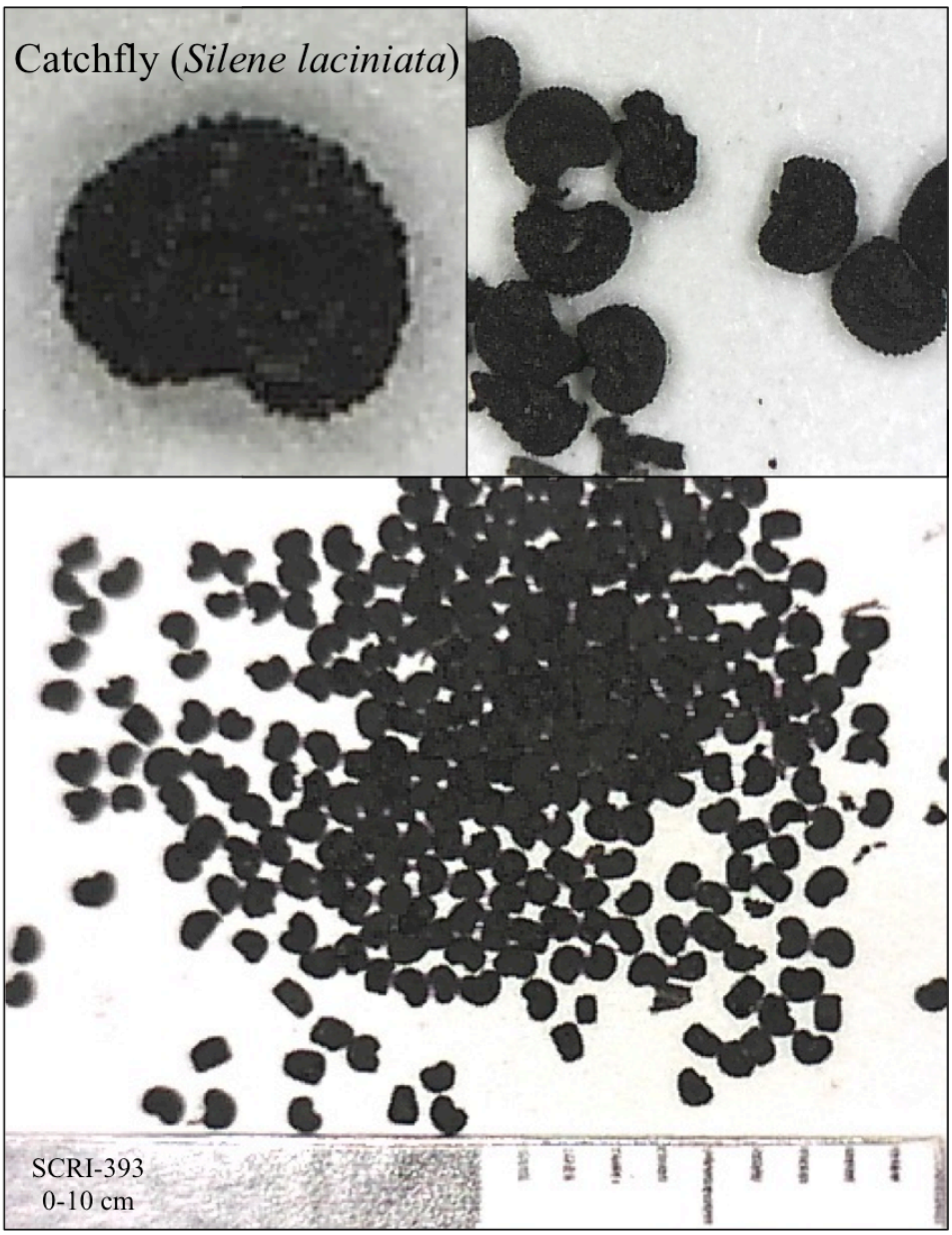
PHOTOS OF IDENTIFIED MACROBOTANICAL REMAINS



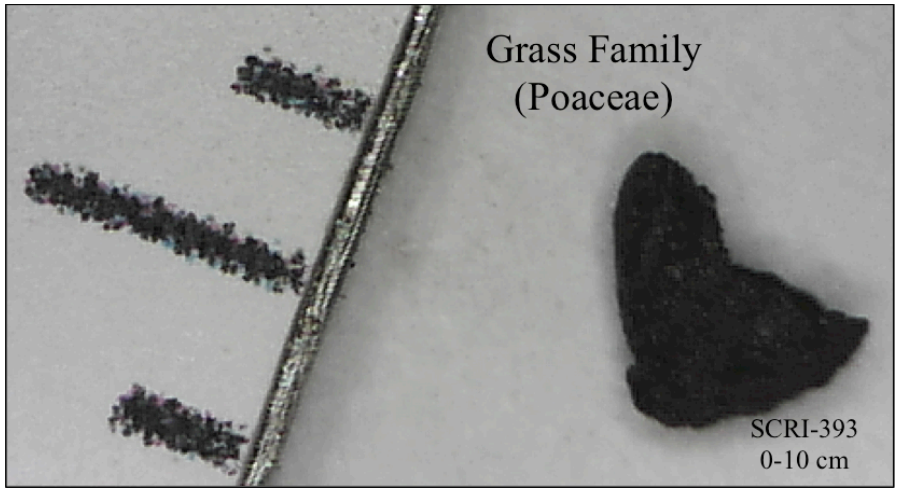


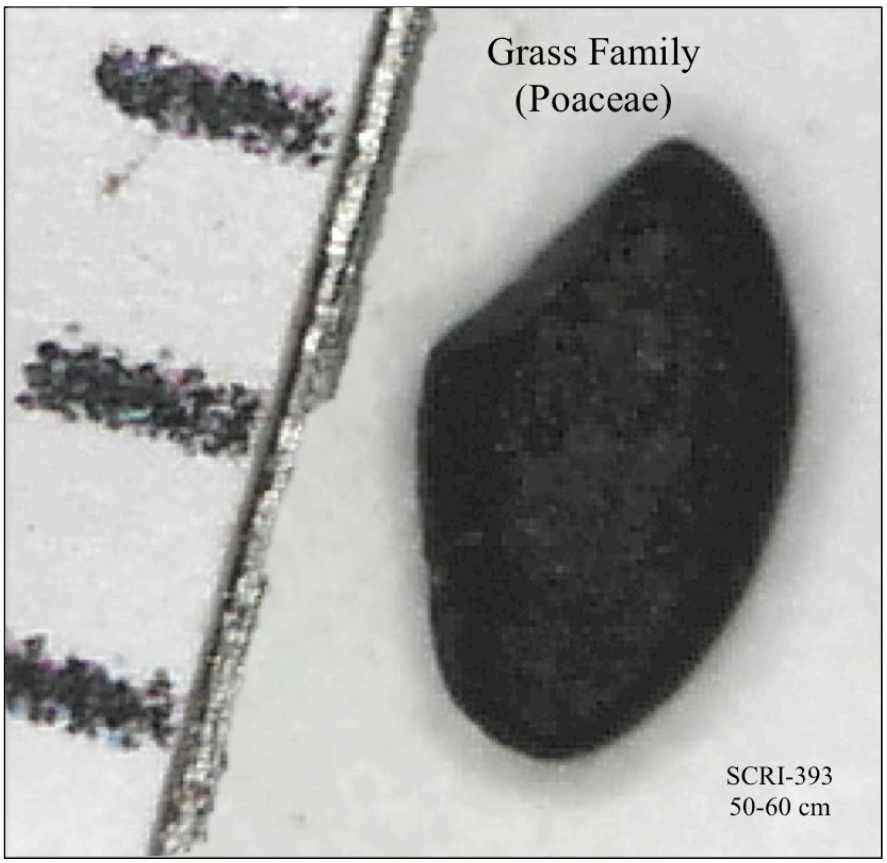

SCRI-393
30-40 cm
Bean Family
(Fabaceae)

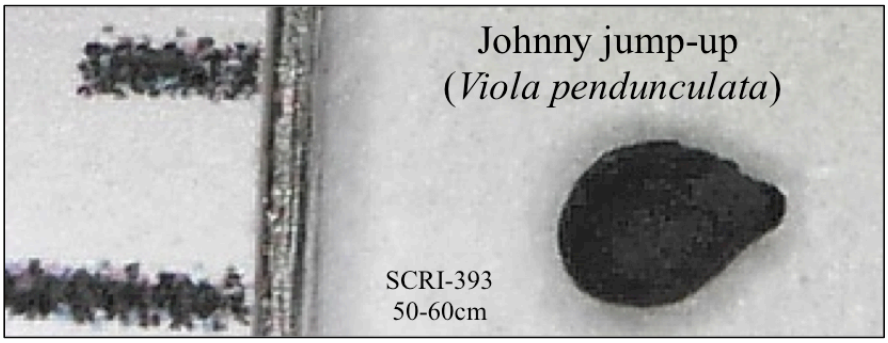

c.f. Cryptantha
(*Cryptantha clevelandii)*
SCRI-174
0-10 cm

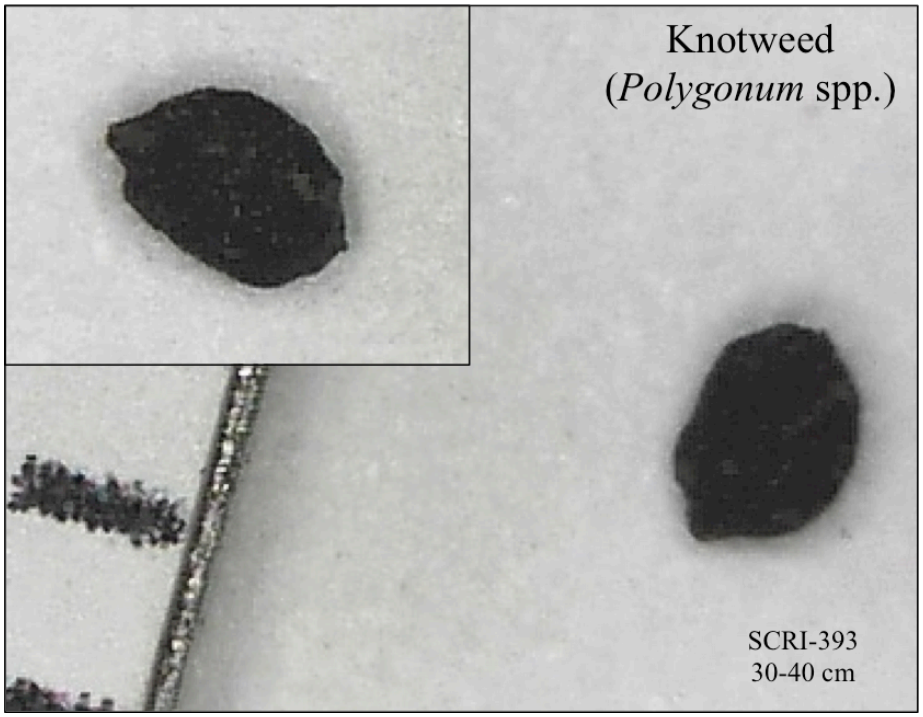

Catchfly (*Silene laciniata*)
SCRI-393
0-10 cm

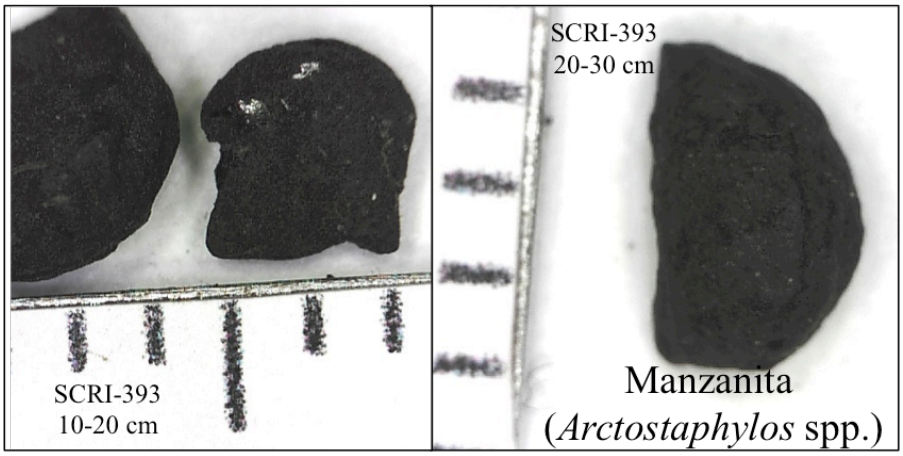

Grass Family
(Poaceae)
SCRI-393
0-10 cm

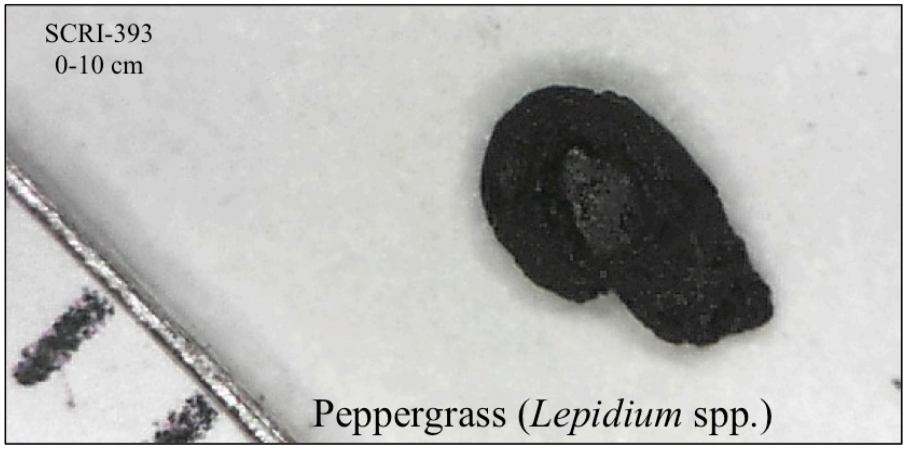

Grass Family
(Poaceae)
SCRI-393
0-10 cm

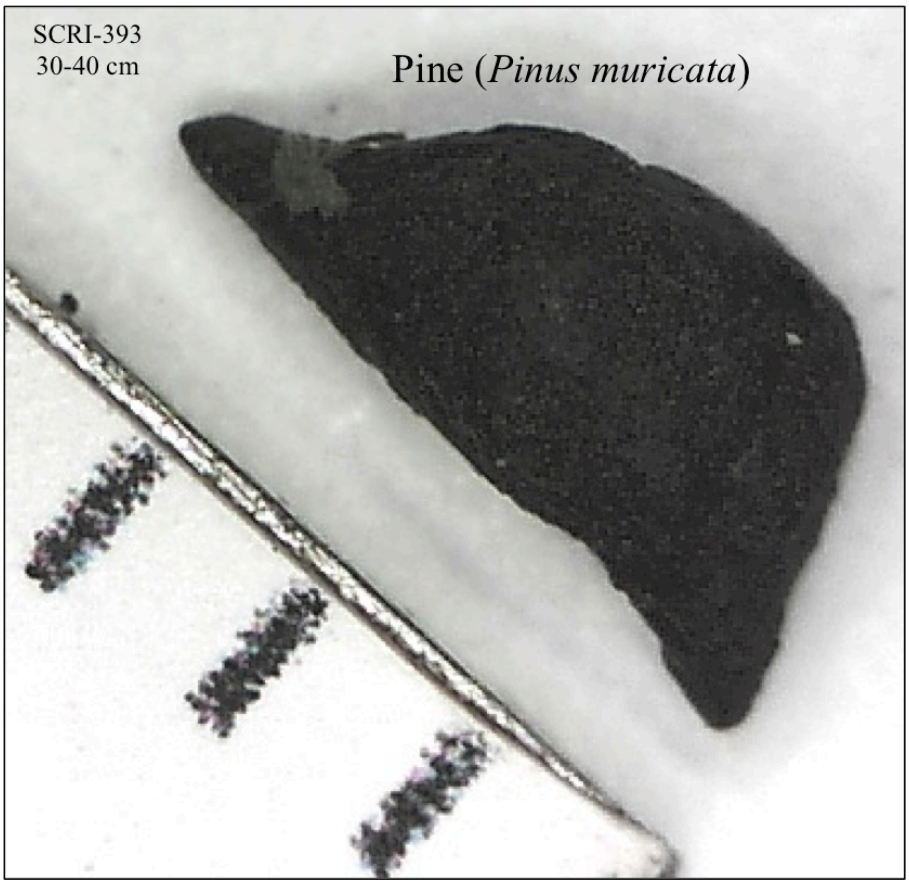

Grass Family
(Poaceae)
SCRI-393
50-60 cm

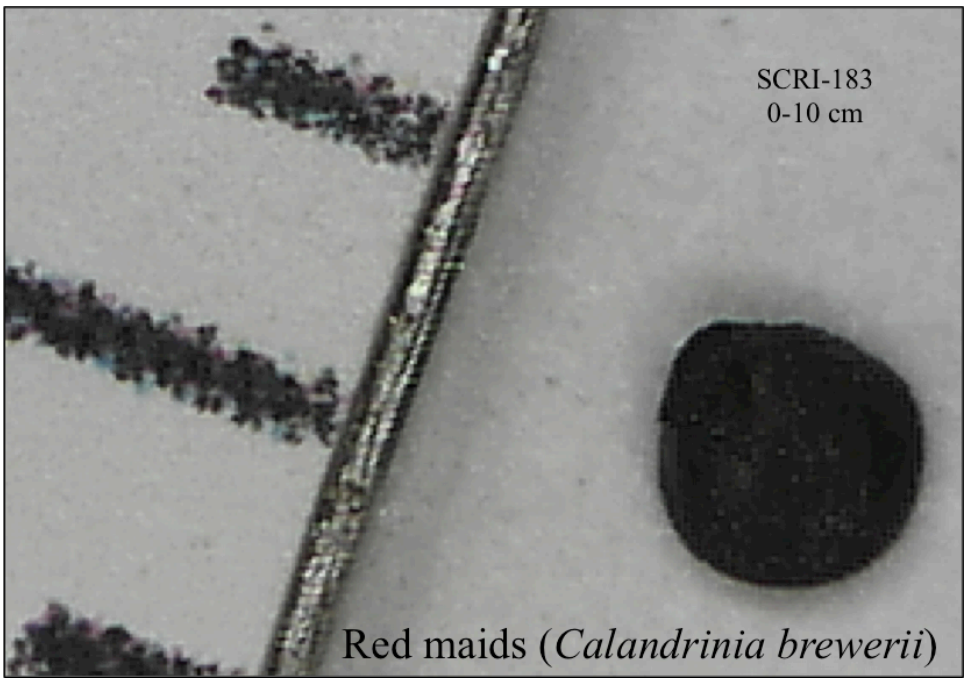

Johnny jump-up
(*Viola pendunculata*)
SCRI-393
50-60cm


Knotweed
(*Polygonum* spp.)
SCRI-393
30-40 cm


SCRI-393
10-20 cm
SCRI-393
20-30 cm
Manzanita
(*Arctostaphylos* spp.)


SCRI-393
0-10 cm
Peppergrass (*Lepidium* spp.)


SCRI-393
30-40 cm
Pine (*Pinus muricata*)


SCRI-183
0-10 cm
Red maids (*Calandrinia brewerii*)


SCRI-174
0-10 cm
Yarrow
(*Achillea millefolium*)


SCRI-174
0-10 cm
Unidentified Nutshell

APPENDIX V

MICROBOTANY LABORATORY PROTOCOL

1. Preparation. In this step, you will generate your initial laboratory sample, referred to as your *Original Sample,* from a soil sample (1a), or from an artifact (1b). Gloves (non-starched) should be worn and changed between samples to avoid contamination.

1a. Soil Preparation.

-Dry Soils.

-Sieve through 0.5 mm mesh.

-Weigh as accurately as possible. Aim for 5-10 g (more for clay soils, less for sandy soils).

-Place soils in 50 ml tubes. These will be your *Original Soil Samples.*

-Add deflocculant (e.g., 0.1% Alconox), filling vials to 20 ml.

-Put all *Original Soil Samples* on shaker for several hours*.

*After leaving vials on shaker, you can place 1 drop of the solution on a microscope slide to see whether particles are coming together. If they are, return vials to shaker.

1b. Artifact Residue Preparation.

-Create *Sediment 1* by thoroughly scrubbing artifact with a clean, wet toothbrush.

-Wash all resulting water and soil into a 50 ml tube. This will be *Original Sediment 1.*

-Create *Sediment 2* by submerging artifact in a water filled sonicator, and running for >10 minutes (artifact may be submerged in a suspended, sealed plastic bag, or placed in a glass beaker).

-*Sediment 1* and *Sediment 2* samples will likely exceed 50 ml. To fit them into 50 ml tubes, simply centrifuge, decant, and refill as necessary. Final decant should leave as little water as possible in sample.

-If you are planning to weigh your samples to calculate density, place all *Original Sediment 1* and *Original Sediment 2 Samples* in a furnace at 40˚ C (100˚ F). Once dried (24+ hours), weigh and record sample weights.

*If you are not planning to weigh your samples, you can either refill them with distilled water for Clay Removal (step 2), or transfer them to 15 ml tubes for Starch Flotation (step

3). (Clay removal is only necessary for dirty/opaque samples – most artifact residues will be translucent).

2. Clay Removal. The purpose of this step is to clean your *Original Sample* before flotation. Small particles of soil removed in this step will ultimately result in cleaner slides, which will aid in your identification of starches and phytoliths. (If your *Original Sample* is reasonably clear, particularly with artifact residues, this step may not be necessary). Gloves should be worn to avoid contamination.

-Shake/vortex vials vigorously (when turned upside down, there should be no clumped soil).

-Centrifuge vials for approximately 2 minutes at 1000 rpm.

-Using a syringe or pipette, remove the upper water column, being careful not to disturb the residue at the bottom.

-Refill vial with distilled water.

-Repeat entire process (shake, centrifuge, syringe, refill…) until your *Original Sample* is translucent (this may take 5+ times). After the final removal of the upper water column, do not refill with distilled water.

3. Starch Flotation. This step will generate a new set of samples, so that each *Original Sample* will have a paired *Starch Sample*. Gloves should be worn to prevent contamination, and to limit contact with heavy liquid (non-toxic). Remember to keep heavy liquids covered at all times (even with simple saran wrap) to avoid evaporation, as this could increase the specific gravity. *Original Samples* should be decanted before beginning this step (i.e., sample should have no excess distilled water).

-Transfer *Original Samples* from 50 ml tubes to 15 ml tubes, using a squeeze bottle of distilled water to carefully wash material from the edges of the 50 ml tube into the 15 ml tube. If the 15 ml tube fills up before you have transferred all material, simply centrifuge (2 minutes at 3000 rpm) and decant to create more space. The 15 ml vial should be labeled exactly the same as the 50 ml vial (*Original Sample* #).

-Decant all water from 15 ml tubes, leaving compact soil in the base.

-Add ~4ml of 1.6 sg heavy liquid*.

-Shake/vortex vigorously (when turned upside down, there should be no soil clumped in the bottom).

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth. DO NOT DECANT SAMPLE.

-Centrifuge for 3 minutes at 3000 rpm.

-Add another ~4ml of 1.6 sg heavy liquid.

-Shake/vortex vigorously.

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Decant *Original Sample* into a new 15 ml tube, labeled as the corresponding *Starch Sample* (including relevant sample number or notes).

-Fill *Starch Sample* with distilled water, so that the vial now contains ~8 ml of 1.6 sg heavy liquid and ~7 ml of distilled water.

-Shake/vortex *Starch Sample* vigorously.

-Centrifuge *Starch Sample* for 3 minutes at 3000 rpm.

-Decant *Starch Sample* into a container of used heavy liquid (for recycling*).

-Add another ~4 ml of 1.6 sg heavy liquid to *Original Sample.*

-Shake/vortex vigorously.

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Decant *Original Sample* into corresponding *Starch Sample.*

-Fill all *Original Sample* vials and *Starch Sample* vials with water.

-Shake/vortex vigorously.

-Centrifuge all vials for 3 minutes at 3000 rpm.

-Decant all vials into a container of used heavy liquid.

-Set aside decanted *Original Sample* vials for Chemical Digestion (step 4).

*To prepare 100 ml of 1.6 sg solution, use 31 ml of LMT (2.95 sg) and 69 ml of distilled water (1.0 sg).

*Note that by adding ~7 ml of water to ~8 ml of 1.6 sg heavy liquid, you are reducing the overall specific gravity within the vial to ~1.2 sg, meaning that the starches (~1.4 sg) are now on the bottom.

-Label a corresponding 2 ml vial for each 15 ml *Starch Sample* vial, including all relevant information.
-Weigh and record the weight of each empty 2 ml vial, including sample number. This weight will be used in Slide Mounting (step 6).
-Use small disposable pipettes to transfer *Starch Samples* from 15 ml to 2 ml vials. Remember to label and use only 1 pipette for each sample to avoid contamination. If the 2 ml vials fill up before you have transferred all material, simply centrifuge (2 minutes at 3000 rpm) and remove supernatant (with pipette) to create more space.
-Place open 2 ml vials in a furnace at 40˚ C (100˚ F) until dry (12+ hours).

4. Chemical Digestion. In this step, you will remove organics from your *Original Sample* in preparation for Phytolith Flotation (step 5). Removing organics will ultimately create cleaner slides. Because phytoliths are silica, they will withstand the harsh chemicals used in this step. However, any organic materials you wish to recover (i.e., starch or pollen) must be removed prior to this step, or they will be destroyed. Proper protection (heavy gloves, goggles, lab coats, closed shoes) should be worn throughout this step, and all chemicals should be kept under a fume hood. Remember to properly dispose of all hazardous chemicals in appropriately labeled containers.

Keep in mind that chemical digestion will not remove the amorphous silica abundant in residues removed from sandy soils or sandstone artifacts. When preparing these residues for slide mounting, it may help to use a higher concentration of mounting medium and/or a dye.

-Place a pot of water on hot plate under the fume hood and heat to ~90˚ C (194˚ F).
-Add a few ml of dilute hydrochloric acid* to *Original Sample* vials and place in hot water bath for ~10 minutes. (Remember these vials should not contain excess water).
-Slowly add strong acid* to sample. The more carbonates there are in the sample, the stronger the reaction will be. If a sample looks red/orange, it is reacting strongly; if a sample looks yellow, it is not.
-Leave vials in bath for at least 90 minutes (longer if they are reacting). A glass rod can be used to stir up contents within vial. Bubbles indicate that a reaction is still happening.

-Fill tubes with warm water and centrifuge for 2.5 minutes at 2500 rpm in order to rinse acids. Decant and repeat three times. Remember to shake/vortex vigorously between refilling/centrifuging, and remember to decant into an appropriately labeled disposal container.
-Add ~5 ml of household bleach to *Original Sample* vials. Bathe in hot water for 5 minutes only. (If samples do not look very dirty, skip this step and move onto hydrogen peroxide).
-Add ~5 ml of hydrogen peroxide (27-35% strength). Bathe in hot water (lids off) for 20-90 minutes.
-Fill *Original Sample* vials with distilled water. Centrifuge for 2.5 minutes at 2500 rpm to rinse chemicals, and decant into an appropriately labeled disposal container. Repeat twice, remembering to shake/vortex vigorously between refilling/centrifuging.

*To make dilute HCl (1M): Mix 86 ml of concentrated HCl (11.6 M) with enough distilled water to make 1 liter. Store in a wash bottle.
*To make Strong Acid: Carefully mix equal portions (50 ml per sample) of concentrated hydrochloric and nitric acid in a beaker. Make fresh for each session.

5. Phytolith Flotation. This step will generate a new set of samples, so that each *Original Sample* will have a paired *Phytolith Sample*. This step essentially mirrors Starch Flotation (step 3), except that the heavy liquid will have a higher specific gravity. Gloves should be worn to prevent contamination, and to limit contact with heavy liquid (non-toxic). Remember to keep heavy liquids covered at all times (even with simple saran wrap) to avoid evaporation, as this could increase the specific gravity.
-Add ~4ml of 2.3 sg heavy liquid* to *Original Samples* (which should have been decanted in the previous step to remove all excess water).
-Shake/vortex vigorously (when turned upside down, there should be no soil clumped in the bottom).
-Centrifuge for 1 minute at 3000 rpm.
-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.
-Centrifuge for 3 minutes at 3000 rpm.
-Add another ~4ml of 2.3 sg heavy liquid.
-Shake/vortex vigorously.

*To prepare 100 ml of 2.3 sg solution, use 67 ml of LMT (2.95 sg) and 33 ml of distilled water (1.0 sg).

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Decant *Original Sample* into a new 15 ml tube, labeled as the corresponding *Phytolith Sample* (including relevant sample number or notes).

-Fill *Phytolith Sample* with distilled water, so that the vial now contains ~8 ml of 2.3 sg heavy liquid and ~7 ml of distilled water.

-Shake/vortex *Phytolith Sample* vigorously.

-Centrifuge *Phytolith Sample* for 3 minutes at 3000 rpm.

-Decant *Phytolith Sample* into a container of used heavy liquid (for recycling*).

-Add another ~4 ml of 2.3 sg heavy liquid to *Original Sample.*

-Shake/vortex vigorously.

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Decant *Original Sample* into corresponding *Phytolith Sample.*

-Fill all *Original Sample* vials and *Phytolith Sample* vials with water.

-Shake/vortex vigorously.

-Centrifuge all vials for 3 minutes at 3000 rpm.

-Decant all vials into a container of used heavy liquid.

-Set aside decanted *Original Sample* vials.

*Note that by adding ~7 ml of water to ~8 ml of 2.3 sg heavy liquid, you are reducing the overall specific gravity within the vial to ~1.7 sg, meaning that the phytoliths (~1.9 sg) are now on the bottom.

-Label a corresponding 2 ml vial for each 15 ml *Phytolith Sample* vial, including all relevant information.

-Weigh and record the weight of each empty 2 ml vial, including sample number.

-Use small disposable pipettes to transfer *Phytolith Samples* from 15 ml to 2 ml vials. Remember to label and use only 1 pipette for each sample to avoid contamination. If the 2 ml tube fills up before you have transferred all material, simply centrifuge (2 minutes at 3000 rpm) and remove supernatant (with pipette) to create more space.

-Place open 2 ml vials in a furnace at 100˚ C (212˚ F) until dry. If any starch samples are in the furnace, keep temperature to 40 ˚ C (100˚ F).
-If desired, *Original Sample* vials (15 ml) can be similarly transferred to 2 ml vials and dried for Slide Mounting (step 6).

6. Slide Mounting. This step describes how to make a standardized mount for microscope slides. A standardized mount allows one to estimate the density of starch grains/phytoliths within a sample without mounting the entire sample. This process saves time, but also preserves some of your sample for future slides (as slides tend to dry out over time). To make a non-standardized sample, simply ignore the calculations described below. When making slides, one should wear gloves to avoid contamination. All materials are nontoxic.

6a. Mounting Starch

- Weigh each 2 ml *Starch Sample* vial and subtract the weight of the vial itself (as recorded in step 3).
-Add corn syrup to *Starch Sample* in a 0.05:1 ratio. (Assuming that 0.05 ml of corn syrup weighs 0.0695 g, you should add 0.695 of corn syrup for every mg of extract in the starch vials). Place vial on scale (secured in Styrofoam platform) and slowly add corn syrup using a syringe or pipette until desired weight is reached. This may not be exact, so be sure to record the final weight/volume added.
-Use a toothpick to thoroughly stir mixture (several minutes). You can reduce air bubbles by centrifuging samples for 3 minutes at 3000 rpm.
-Use a toothpick to spread a thin layer of your prepared standardized mount onto a glass slide, remembering to stay within the size boundaries of a cover slip.
-Apply a cover slip, slowly laying it down from left to right to avoid bubbles.
-Seal the cover slip to the slide using nail polish. Apply to corners last, to allow air bubbles to escape.

6b. Mounting Phytoliths

- Weigh each 2 ml *Phytolith Sample* vial and subtract the weight of the vial itself (as recorded in step 5).

-Add immersion oil to *Phytolith Sample* in a 0.05:1 ratio. (Assuming that 0.05 ml of immersion oil weighs 0.0462 g, you should add 0.0462 g of immersion for every mg of extract in the starch vials). Place vial on scale (secured in Styrofoam platform) and slowly add immersion oil using a syringe or pipette until desired weight is reached. This most likely will not be exact, so be sure to record the final weight/volume added.
-Use a toothpick to thoroughly stir mixture (several minutes). You can reduce air bubbles by centrifuging samples for 3 minutes at 3000 rpm.
-Use a toothpick to spread a thin layer of your prepared standardized mount onto a glass slide, remembering to stay within the size boundaries of a cover slip.
-Apply a cover slip, slowly laying it down from left to right to avoid bubbles.
-Seal the cover slip to the slide using nail polish. Apply to corners last, to allow air bubbles to escape.

This laboratory procedure is based on procedures used by Deborah Pearsall at University of Missouri, Columbia (Chandler-Ezell and Pearsall 2003), and Rob Cuthrell at University of California, Berkeley (Cuthrell 2011).