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The Promise of Microbotanical Research in California: A Case Study from CA-SBA-53, a Middle Holocene Archaeological Site along Goleta Slough

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Ancient starch research is a burgeoning field in archaeology, and is growing in popularity in California. This study looks at starch granules extracted from groundstone tools found at CA-SBA-53, a large middle Holocene site on the Goleta Slough. The middle Holocene is one of the least understood time periods in the Santa Barbara Channel region; little in particular is known about subsistence practices, and even less about plant usage. Understanding subsistence can shed light on other questions relating to settlement patterns, seasonality, and even social organization during this period. This study's findings suggest that acorns were part of the middle Holocene diet 5,500 years ago, and made up 15% of the starch assemblage. However, more research is needed to contextualize these findings, both in relationship to other taxa consumed, and to other time periods in prehistory.

The story of California prehistory is incomplete without acorns. Acorns served as a staple food source for many groups across the cultural province, particularly during later periods in prehistory. The mainland Santa Barbara coast is no exception; acorns were, by some estimations, the "most important single food source" for contact period peoples (Grant 1978:516), helping to support one of the densest populations of hunter-gatherers ever documented, with an uncommonly high degree of sociopolitical complexity (Gamble 2008). However, as currently understood, acorns (*Quercus* spp.) are not believed to have been a primary food source for the ancestral Chumash until about 4,000 B.P. at the earliest, and likely somewhat later—this date remains an "open question" in the Channel region (Glassow 1996:21). This is interesting, because the earliest mortars and pestles, a technology traditionally associated with acorn processing (e.g., Basgall 1987), first arrive in the Channel more than 1,500 years before that. Thus, the central question guiding the project reported here is this: what were the earliest mortars and pestles used for in the Chumash region? Were they used to grind acorns, a costly, time-consuming task, or used for other foods, possibly some combination of roots, tubers, and corms? If acorns were in fact a critical dietary staple at this time, it would require a rethinking of our current understanding of settlement, subsistence, and even social organization during the middle Holocene (defined here as 6,650–3,350 B.P. [King 1990]), on the mainland central coast.

Excavations of key archaeological sites before the development of modern plant macrofossil recovery techniques, as well as poor preservation, has limited the quantity of macroremains recovered from mainland middle Holocene contexts. But novel microbotanical techniques, including (as here) the extraction and analysis of ancient starch grains from groundstone tools, allow a new way forward to addressing lingering subsistence questions. This paper examines starch grains extracted from groundstone tools from a single middle Holocene site, CA-SBA-53, with the goal of understanding what role, if any, acorns had in the subsistence regime during this time. The main question addressed here focuses on the timing of the addition of the acorn to the diet, the relationship between that food source and the technology traditionally associated with its processing, and the implications of those results for understanding changes in Chumash culture over time. Additionally, during the course of this project, a heretofore unencountered

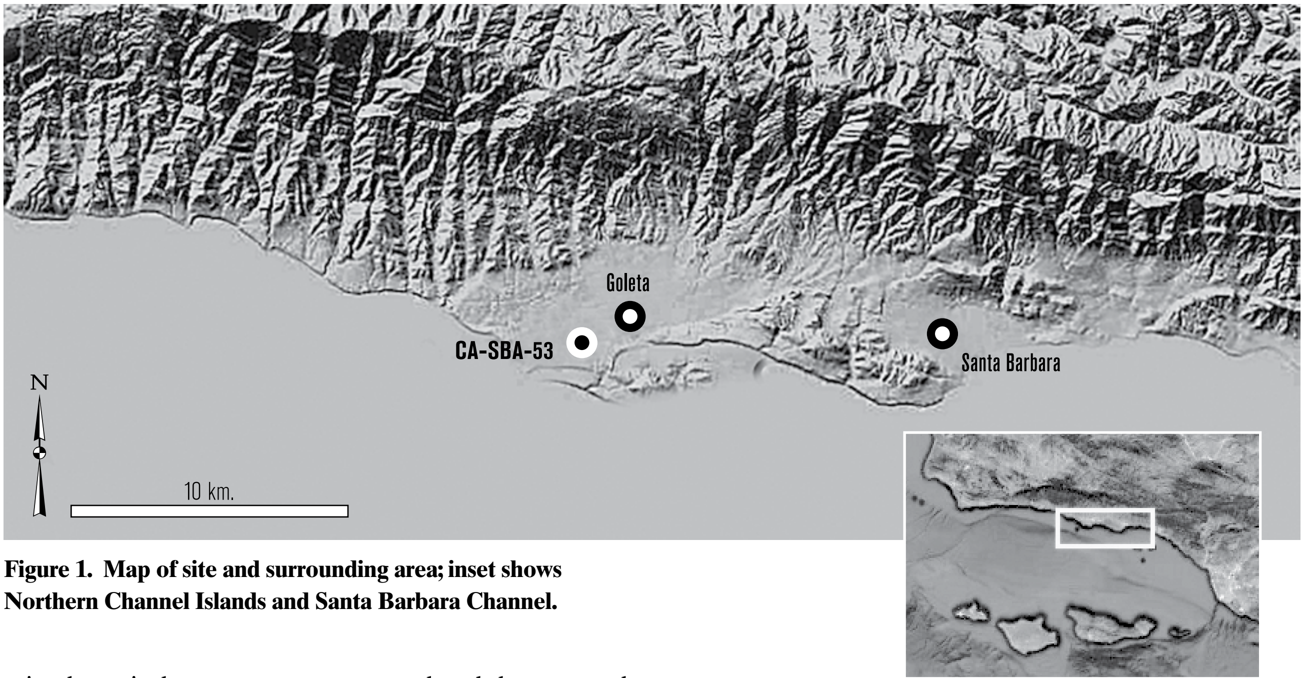

Figure 1. Map of site and surrounding area; inset shows Northern Channel Islands and Santa Barbara Channel.

microbotanical structure was extracted and documented in addition to the starch grains; these structures, axial tracheids, are cellulose structures found in the woody parts of gymnosperms, and they provide an intriguing suggestion as to the ways in which the groundstone tools were used by the inhabitants of SBA-53.

This study examines one middle Holocene site, CA-SBA-53, dating to ~5,000 years ago, with particular attention being paid to the groundstone assemblage. Specifically, this paper reports and considers ancient starch granules found on these tools. The project aims to understand the circumstances under which a novel tool type appeared in the archaeological record, one typically associated with a specific resource (and a costly one, at that), but well before that resource became a significant dietary staple. Acorns require significant amounts of processing in order to be made edible; traditionally, it is thought that rising population numbers created a need for an intensified diet, which made the previously unappealing acorn worth the effort (Basgall 1987; Bettinger et al. 1997). Was the earliest form of this groundstone technology (mortars and pestles) associated with acorns, as has been suggested elsewhere in the archaeological literature (Basgall 1987; King 1990)? And does the inclusion of a costly resource like acorns co-occur with other hallmarks of complexity that appeared around the time when this new technology began to flourish?

The middle Holocene is one of the least understood periods in Channel prehistory (Erlandson 1997:2); situated as it is between the earliest occupation of North America and the development of the dynamic, complex chiefdoms of the late Holocene, the events that occurred in this period laid the foundation for what was witnessed by the early Spanish explorers. Thus, a secondary goal of this project is to further illuminate this crucial but under-investigated period in Channel prehistory as it played out at SBA-53, especially since no macrobotanical samples were recovered from the site during its original excavation.

BACKGROUND

The Santa Barbara Channel region is renowned for its mild, Mediterranean climate, with warm summers and wet winters. People living on the mainland and the offshore Channel Islands would have had access to the Channel's productive fishery, the result of warm southern ocean currents mixing with colder currents from the north. Sea levels fluctuated during the late Pleistocene and early Holocene; by 6,000 B.P., sea levels were rising, but slowly, on the way to stability (Colten 1989:209; Inman 1983:11). Residents of CA-SBA-53 (Fig. 1), on the Goleta Slough estuary some two kilometers from the ocean, could have exploited a variety of productive coastal ecological zones, including estuarine, riparian, sandy shore, brackish, and near- and mid-shore ocean habitats. Terrestrial resources, from plant habitats including open oak woodland and chaparral sage scrubland, would likely have been readily available within less than 500 meters (USGS GAP Land Cover Survey 2011). A proposed climatic fluctuation preceding 5,500 B.P. (Kennett et al. 2007) has been posited as an explanation for a perceived population decrease in the region prior to the later middle Holocene; evidence from SBA-53 could support the suggestion that warming was underway by around 5,200 B.P. (Glassow 1997; Glassow et al. 2012; Kennett et al. 2007).

SBA-53 was excavated numerous times during the twentieth century. SBA-53, with an equal proportion of mortar/pestles and mano/metates and only side-notched projectile points present, was the type site for Roger's Hunting Culture (Rogers 1929:356). Harrison's 1956–1957 excavations (Harrison 1964; Harrison and Harrison 1966) expanded the collection greatly and recovered the groundstone artifacts evaluated in this study. Harrison also took several radiocarbon samples for dating, employing what was still a relatively novel technology at the time (Harrison and Harrison 1966:34); those dates, when calibrated, suggest a site occupation between 5,530–5,050 B.P.[1] (Rick and Glassow 1999:237). The most recent excavations, carried out by Glassow in 1985, evaluated a small remnant portion of the site, and generated a collection consisting mostly of flaked stone and shellfish.

SBA-53 is unique among middle Holocene sites in the Channel region, with a dense and diverse artifact assemblage and a "black" midden that suggest that it was a significant residential base (Harrison and Harrison 1966:14). SBA-53 was also one of the largest sites in the region, covering several acres and with several loci, with recorded dimensions of 280 m. by 180 m. (Harrison and Harrison 1966).

The material components that make SBA-53 unique include the introduction of novel (as of 5,500 B.P.) projectile point and groundstone forms. SBA-53 represents the first appearance of distinctive side-notched projectile points around the Goleta Slough (Fig. 2), suggesting an increase in terrestrial animal hunting at this time. SBA-53 has a groundstone assemblage evenly split between mortar/pestles and mano/metates; while these artifacts are not absolutely the oldest mortars and pestles found on the Channel coast (SBA-88 holds that distinction at present; see Erlandson 1997), they are the oldest found around the Goleta Slough, and are significant both in number and context. A total of 126 out of a reported collection of 250 pieces of groundstone represent mortar/pestles, with the rest being manos or metates (Glassow 1996; Harrison and Harrison 1966:24). The nearly even ratio of the two groundstone types is significant and is found nowhere else in the region; mortars and pestles tend to be rare during this period, and their presence and high abundance at SBA-53 is notable, suggesting an expansion in technology and subsequently in diet, as opposed to a replacement in either dimension.

Figure 2. Side-notched projectile points from SBA-53.

Glassow (1997; Glassow et al. 2007; Rick and Glassow 1999) has proposed that SBA-53 is also significant as an indicator of middle Holocene settlement patterns. Based on composite lithic data from contemporaneous sites elsewhere in Santa Barbara County, Glassow has suggested that SBA-53 may have been a coastal residential base camp (Otte 2001) that formed a significant element in a logistical foraging strategy in which mobile groups followed a seasonal round from the coast into the mountains (Glassow 1997:81), and with individuals bringing finished stone forms from the inland Santa Ynez Valley (Glassow et al. 2011; Hosale 2010) and elsewhere to coastal habitation sites like SBA-53.

Seasonality studies based on fish remains (Rick and Glassow 1999) and shellfish (Colten 1989) suggest that SBA-53 was occupied year-round, but with the highest intensity of occupation during the summer; identifying plant taxa recovered from the microbotanical samples I have taken can augment seasonality data and perhaps contribute to our further understanding of middle Holocene settlement patterns.

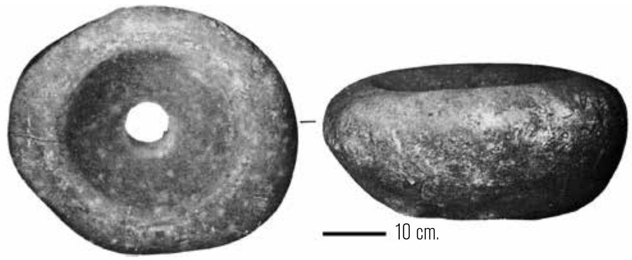

Figure 3. Early cobble mortars from CA-SBA-53. (Photo: Harrison and Harrison 1966).

GROUNDSTONE TECHNOLOGICAL SHIFTS AND TOOL FUNCTIONS

Mortars and pestles arrived in different parts of California at different times. Additionally, various forms of this technology, including forms such as hopper mortars and bedrock mortars, also arrived sometime after the initial introduction of mortars and pestles. On the central coast, millingstone technology is the earliest groundstone form noted, dating as a far back as 8,300 B.P. (Jones et al. 2002), and possibly earlier. Traditionally, millingstone technology (i.e., manos and metates) has been closely associated with processing hard seeds, and mortars and pestles with processing acorns and other fleshy roots and nuts; however, this assertion has recently been challenged (Rosenthal and McGuire 2004; Wohlgemuth 1996). Cobble mortars and pestles occur as early as 5,800 B.P. (Erlandson 1997:106), but did not become widespread until ca. 4,500 B.P. (Glassow 1996). These early specimens (Fig. 3) were large (some were over 50 cm. across) and unwieldy, suggesting perhaps a long-term occupation of a site or a role for the tools as "site furniture" (Binford 1979), which might indicate that the site was repeatedly occupied over time. The pestles themselves were made of sandstone and were pecked at the ends but otherwise unshaped, in contrast to pestle iterations later in prehistory. Even so, manos and metates continued to outnumber mortar/pestles in assemblages until ca. 3,500 B.P. (Erlandson 1997:106). The earliest hopper mortars appeared around 4,000 B.P. (although Rogers [1929] noted one in his earliest SBA-53 assemblage). Hopper mortars were traditionally associated with extensive acorn processing, according to ethnographic reports (Hudson and Blackburn 1983; Fig. 4). Millingstone technology (such as manos and metates) persisted through the middle Holocene, but its use significantly declined by ca. 2,200 B.P. (Glassow 1996).

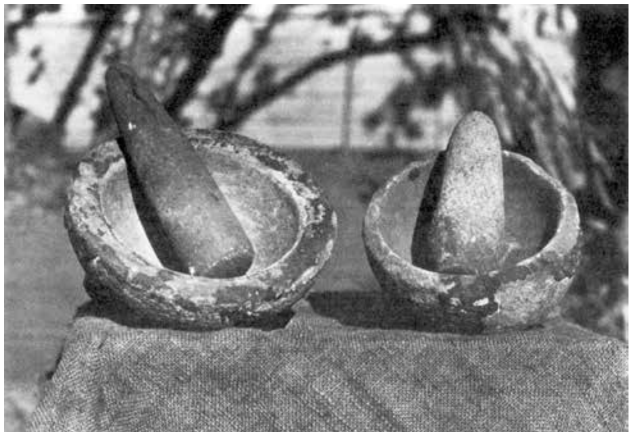

Figure 4. Hopper mortars with asphaltum ring and shaped pestles (Photo: Hudson and Blackburn 1983).

As stated previously, both the early dates and the size of the SBA-53 mortar and pestle assemblage contribute to the site's significance as a middle Holocene residential locale. This project targeted pestles and mortar fragments for two main reasons. First, the initial goal of the project was to determine at what point acorns became a dietary staple, and—as mentioned—mortars and pestles are traditionally associated with acorn processing. Second, the SBA-53 specimens are somewhat fragmented, and pestles were the most readily available for analysis.

Our current understanding of the function(s) of the earliest mortars and pestles is limited. Glassow (1996) proposed that they were used to process roots, bulbs, or other underground storage organs (USOs), which prior to 5,500 B.P. were (possibly) not a significant part of the diet. He based this hypothesis on ethnographic observations of both California and Columbia Plateau groups using mortar/pestles to grind bulrush roots (*Schoenoplectus* spp.) and even animal products such as meat. The goal of the study reported here is to better understand the use of the earliest mortars and pestles, using starch grain analysis. Understanding middle Holocene foodways more broadly can also help us understand technology, settlement patterns, and possibly even social organization, if enough lines of evidence converge. The introduction of mortars and pestles into the assemblage indicates an expansion in diet breadth occurred during this time. Why did this expansion happen? And to be clear, the large amount of milling equipment found does suggest a dietary expansion instead of a replacement. If acorns were not present in significant numbers, understanding the nature of the postulated diet breadth expansion would provide a framework for better understanding whether the earliest mortars and pestles were used for acorns, or—as proposed by Glassow—for roots, tubers, and other underground storage organs.

ANCIENT STARCH RESEARCH IN ARCHAEOLOGY

The basis of microbotanical research is the fact that plant foods, when processed using tools, leave microscopic residues (both starch granules and silicate phytoliths) on those tools. Extracted starches can then be compared to a reference collection, and an identification using key diagnostic features can be made. Starch grains preserve remarkably well on tools, can survive fairly extreme depositional conditions, and can be recovered from museum artifacts obtained from excavations that occurred long ago, when sampling for botanical remains was not standard procedure.[2] However, the use of museum artifacts can add complications, because these artifacts are usually washed prior to accession. There are additional issues as well—starch extraction and identification requires specialized lab equipment, and only a portion of starch granules contain diagnostic characteristics that allow them to be identified (Torrence and Barton 2006).

Food scientists have studied dietary starch since the early twentieth century (Reichert 1913), but it was not until the 1980s that the value of preserved starches to archaeology was realized. Pioneering studies by Ugent (Ugent et al. 1982; Ugent and Verdun 1983) focusing on tuber use in South America led to work in Oceania (Fullagar 1992) and the Neotropics (Piperno and Holst 1998; Piperno et al. 2000). Starch grains preserved in the dental calculus of Neanderthals suggest that starches can be preserved for up 50,000 years under some conditions (Henry et al. 2011). Early starch work was initially undertaken in response to poor preservation, but its value as a method of study has spread. In North America, interest in starch research has grown over the past decade. Messner's (Messner 2008, 2011; Messner et al. 2008) foundational studies of plant use along the eastern seaboard was a leap forward for North American starch research; Zarrillo and Kooyman's (2006) investigations of berry and maize using starches in the Canadian Plain also drew attention to starches in North America. However, in California and the Great Basin, starch research is still in its nascent stage. Scholze's (2011) investigation of northeastern Californian plant use in late prehistory remains the most comprehensive study undertaken in the state, and Herzog's (2014) study of Modoc Plateau plant use also warrants mention.

Starch grains share a suite of forms and attributes that aid in their identification (Fig. 5), both as starch grains in general and as elements diagnostic of specific plant genera (or even species) in particular. They are small, averaging around 20 micrometers in size; they also tend to be round in form, but can also be rectangular. Their specific attributes of shape are useful for identification; sizes are typically measured, but are less helpful, as starch size can vary depending on environmental conditions (Gott et al. 2006:42). Starches are three-dimensional structures, so when photographing them it is necessary to gently press on the mounted slide containing them so that they move around and alternate angles and attributes can be viewed. Starch granules have a center point, a hilum, from which growth rings accumulate; these rings, when visible, are called lamellae (Gott el al. 2006:40). Starches also contain features that are only visible under cross-polarized light; the most significant of these, the so-called "extinction cross," is a bright X-shaped structure that centers on the hilum. The features and measurements of the cross are other attributes that aid in starch identification.

METHODS

To create a relevant comparative collection, eleven different plant taxa were analyzed (Table 1), including three oaks (*Quercus*); seven of these eleven taxa yielded

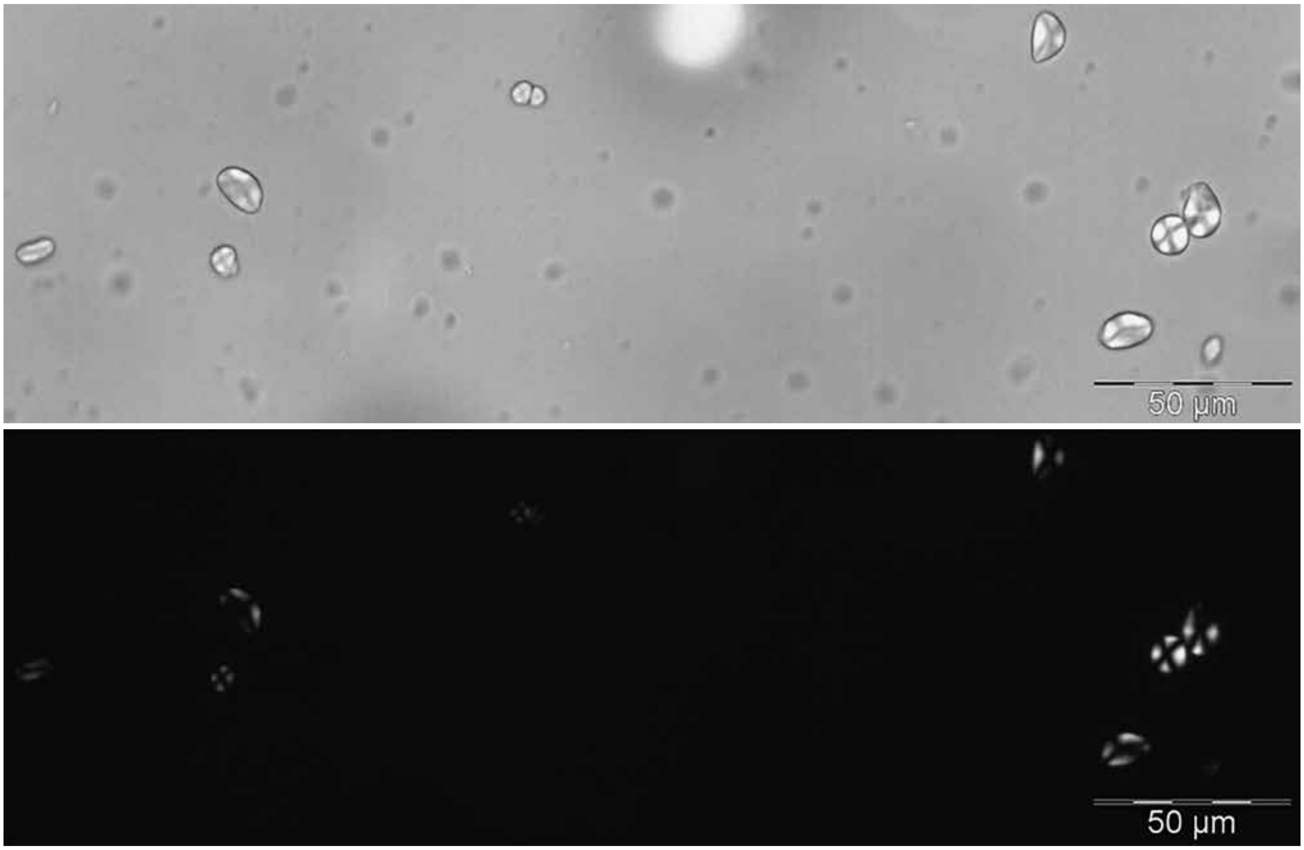

Figure 5. ***Quercus lobata*** **starch grains; one of three species sampled for this project. The bottom image is shown under full cross-polarized light; the extinction cross is readily visible. The top image is partially polarized; this better enables documentation of the 3D shape of each starch granule.**

Table 1

COMPARATIVE PLANT TAXA FROM WHICH STARCHES WERE EXTRACTED

Taxonomic Name	Common Name	Starch Recovered?
Typha angustifolia	Cattail	Y
Prunus ilicifolia – seed	Holly leaf cherry	Y
Dichelostemma capitatum	Blue dicks	Y
Aesculus californica	Buckeye	Y
Schoenoplectus acutus	Tule	N
Salvia clevelandii	Sage	N
Chlorogalum pomeridianum	Soaproot	N
Arctostaphylus glauca – berry	Bigberry manzanita	N
A. glauca – seed	Bigberry manzanita	N
Quercus kelloggii	Black oak	Y
Q. agrifolia	Coast live oak	Y
Q. lobata	Valley oak	Y

sufficient starch for analysis. All taxa, except *Q. kelloggii* and *Aesculus californica* (Buckeye), likely occurred within biotic zones no more than a kilometer from the site of SBA-53. All samples were processed with a mortar and pestle after maceration in distilled water, as per UCSB Integrated Subsistence Laboratory (ISL) protocol (www.anth.ucsb.edu/vanderwarkerlab/- "Forms and Protocols"). Particulate matter was strained out using fine mesh; a single droplet of the resulting solution was then mounted on a glass slide in a glycerol solution. I primarily selected taxa described by Timbrook (1990, 2007)—with one exception, all were plant foodstuffs noted in Chumash ethnohistoric accounts. The exception was *Chlorogalum pomeridianum* or soap plant, which traditionally was crushed and then used for cleansing (Timbrook 1990).

For the present study, I extracted starches from eleven groundstone tools from the CA-SBA-53 assemblage: seven pestles, three mortar fragments, and one mano. These were processed according to the UCSB ISL Starch Extraction Protocol,[3] with some notable exceptions. As these artifacts had been processed, washed, and cataloged many years ago, very little visible sediment remained on the tools. Thus, instead of using a toothbrush and collecting two different sediment samples (as is standard), the tools were only sonicated a single time, creating a single sample each. Additionally, for the first batch of artifacts processed (specimens 105, 638, 925, and 939), the solution used for heavy liquid flotation had a specific gravity of 1.8 rather than 1.2. This appears to have enabled the recovery of a greater number of starch grains, but the slides had so much residual sediment that getting usable images of granules from those artifacts was difficult. However, using a multi-step heavy liquid flotation process does seem to recover more starches, so it will be the method of choice for future work.

Starch Extraction Method (Abbreviated)

1. After photographing artifact, place in sonicating bath with distilled water, using sound waves to dislodge starches from nooks and crannies. Sonicate for 10 minutes.
2. Gradually reduce the subsequent solution by centrifuging and pouring liquid off.
3. Eventually, reduce it so greatly that it fits into a 15 ml. tube.
4. Float substrate in a heavy liquid with specific gravity of 1.2, which will cause starch grains (SG 1.4) in solution to sink.
5. After centrifuging away heavy liquid, place starch samples in oven at 100°F for 12 hours, or until dry.
6. Mix dry starch solution with a predetermined amount and percentage of glycerol; mount one drop on a slide, cover with coverslip, and seal with nail polish.

RESULTS

Some 367 starch grains were recovered from the eleven artifacts processed, of which 110 were identifiable. Seventeen of these 110 were identified as acorn, or 15.4% of the total assemblage (Table 2).

However, while in the process of finding and photographing starch grains from the archaeological samples, a multitude (188) of other structures were encountered that—owing to their birefringent properties with extinction cross—were initially identified as starch grains. Consultation with Rob Cuthrell resulted in their identification as axial tracheids from gymnosperms, or "bordered pit" concentric cellulose structures from the woody part of conifers. The only woody conifers native to Santa Barbara County that would have bordered pits of this particular size are pines. The structures were present in large numbers (186) on six out of seven pestles, and a few of them (2) were found on one of the three mortars. They are not found in pine nut shells, or in pinecones; they are present only in the wood itself, and thus are not likely to be related to dietary components.

Table 2

TABLE OF RESULTS

Artifact Number	Artifact Type	Total # Starch Granules Found	Total # Identifiable Starch Granules Found	Total # *Quercas* Granules Found	Total # Tracheids Found
105	Mano	100	10	2	0
638	Mortar (fragment)	82	31	5	2
939	Mortar (fragment)	68	24	6	0
925	Mortar (fragment)	70	13	1	0
1004	Pestle	25	4	0	16
1005	Pestle	10	7	2	4
1838	Pestle	11	2	1	14
159	Pestle	1	1	0	0
2190	Pestle	0	0	0	66
1007	Pestle	0	0	0	25
1020	Pestle	1	0	0	61
ASSEMBLAGE TOTALS:		**367**	**110**	**17**	**188**

DISCUSSION

The finding that acorns were a part of the diet of the inhabitants of SBA-53 augments site faunal studies and helps contextualize subsistence debris from SBA-53. Rick and Glassow (1999:248) determined that 90% of SBA-53 fish remains were likely taken during the summer or spring months (with 10% representing taxa that could be exploited year-round), probably from the nearby Goleta Slough estuary or just offshore (80%);

only 20% of the fish identified in the assemblage came from mid-water or kelp habitats, with the majority of that 20% likely coming from kelp beds (Rick and Glassow 1999:247). The authors noted that the fish assemblage at SBA-53 more closely resembled Early Holocene fishing assemblages than it did Late Period assemblages, primarily due to a distinct lack of pelagic, open-ocean-dwelling taxa. In this respect, the starch grain assemblage at SBA-53 is reminiscent of pelagic fish: while some *Quercus* starches were present, they are relatively low in number, especially compared to what we might expect of starch assemblages from later in prehistory. Like pelagic fish, acorns represented a small but significant portion of the diet at SBA-53, with both increasing in abundance and significance in later prehistory. While it is difficult to contextualize the presence and amount of acorn starch present at SBA-53, the relatively low amount (15% of the starch assemblage), combined with the minimal presence of pelagic fish, suggests a more extensive foraging strategy than has been documented later in prehistory in this region. If the population during this time period was relatively small and not constricted territorially, as is hypothesized, there would have been no need to heavily exploit resources that require considerable labor to be made edible, such as acorn (Basgall 1987); instead, plant foods that require less processing, such as roots and tubers, would be predicted to have been the primary source of dietary carbohydrates. The inclusion of high-cost foods—in terms of energy investments towards pursuit and processing versus overall caloric output—is characteristic of intensified subsistence economies, much like those of the late Holocene in the Santa Barbara Channel region (Glassow et al. 2007:203); a preponderance of pelagic fish and acorn, both requiring a significant energy input, is the kind of dietary emphasis that would be expected in such subsistence regimes. Large quantities of pelagic fish, in particular, are a hallmark of Middle and Late Period coastal sites (Glenn 1990; Rick and Glassow 1999:251). More research (both micro- and macrobotanical) is needed to better understand the plant foodways during these periods. Colten's (1989) analysis of shellfish remains from several Goleta Slough sites dating throughout prehistory also supports the idea that the residents of SBA-53 relied more heavily on taxa found in the estuarine/bay environment directly adjacent to their immediate locale than they did on marine taxa. These three lines of evidence allow us to characterize the occupation at SBA-53. With the fish assemblage suggesting a spring and primarily summer occupation, the presence of acorn starches suggests at least a minimal fall seasonal occupation, as well as a generalized exploitation of the oak woodlands that would have bordered the Goleta Slough (see calflora.org). Inhabitants of SBA-53 also relied on the bay/estuarine environment adjacent to their home, and hunted (using their side-notched projectile points) and foraged in chaparral sagelands and oak woodlands surrounding the Slough.

The presence and abundance of coniferous axial tracheids encountered during the starch grain analysis requires further discussion, particularly considering the fact that they are disproportionately found on pestles relative to the other tool types. There are several possibilities that could account for the recovery of these tracheids. First, some form of decomposed pine may have been present in the soil as a modern contaminant. SBA-53 is a lowland estuarine coastal site, and the closest pine stand would have been a minimum of fifteen kilometers away, in the mountains. There is no reason to suspect that pine would have been found naturally on site. Second, these axial tracheids may represent evidence of wooden mortar use—perhaps these pestles were used on wooden mortars. Hudson and Blackburn (1983:118) noted the ethnohistoric use of wooden mortars, but simply stated that "wooden pestles were no doubt used with wooden mortars," without citing any examples; while wooden pestles are often used with wooden mortars, stone pestle/wood mortar combinations also have been documented archaeologically in the Southwest (Windmiller 1973), opening the possibility that mixed material mortar/pestle combinations could have been used on the Channel coast as well. The wood mortar shown in Hudson and Blackburn (1983; Fig. 6) was made of oak, which is much harder than pine, and would seemingly make a superior mortar. However, redwood (*Sequoia sempervirens*) driftwood used to make *tomol* plank canoes during the Middle and Late periods was surely also available during the middle Holocene as well; perhaps redwood mortars were made from it. The fact that the tracheid structures were (primarily) present on pestles directly supports this hypothesis. A final possibility is that the ancient inhabitants of SBA-53 mashed pine pulp for resin onsite. This is not how pitch

Figure 6. Oak mortar. (Photo: Hudson and Blackburn 1983).

was extracted ethnographically (Hudson and Blackburn 1983:165); it was usually taken opportunistically when individuals were up in the pine stands. Additionally, with asphaltum so plentiful in nearby natural tar seeps, it does not seem likely that the inhabitants of the site brought fresh pine wood down from the mountains to mash on site for resin.

I suggest that the most likely explanation involves the use of a wooden mortar. This hypothesis raises questions about food preferences and choices that lie beyond what we might consider basic subsistence; it is worth considering the idea that foods prepared using a weather-proof, salt-cured redwood mortar might taste better than the same foods prepared on a gritty sandstone mortar. Recent research emphasizing food preferences and cuisine directs us to look at food as more than a means of meeting a baseline level of caloric intake, and instead as being a reflection of choices made by individuals within particular social, cultural, and political contexts (Eusebio and Jordan 2015; Smith 2006; Twiss 2012). Taste preferences, in addition to dietary needs, are worth considering, even if our ability to bring evidence to bear on the question is limited, as it is in this particular case. Experimental studies comparing the taste of acorn flour prepared using both groundstone tools and salt-cured wood mortars could be one way of testing this hypothesis.

CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

Acorns were part of the diet of middle Holocene groups living at CA-SBA-53 between 5,500 and 5,100 years ago. This research represents the first definitive evidence of mid-Holocene acorn use on the Santa Barbara Coast. A total of 15.4% of the identifiable starch extracted from stone artifacts that would have been used to process plants belongs to the oak genus, *Quercus*. However, without any baseline for comparison with either other starch assemblages or other time periods, it is difficult to say exactly what that number means. I suspect that acorn may have represented a secondary (or tertiary) resource, but further research is needed. Ideally, mortars/pestles from later in prehistory, post-4,000 B.P. (when acorn supposedly became a staple), could be analyzed for comparison, as well as hopper mortars, whose starch assemblages we would predict should include higher incidences of acorn. Future research directions for this phase of the project include expanding the comparative collection to broaden our knowledge of the middle Holocene Chumash diet beyond the acorn. Expanding the comparative collection is necessary, as is taking a closer a look at roots and tubers, including reevaluations of both *Typha* and *Schoenoplectus*, and adding taxa such as *Calochortus*. Additionally, if several of the pestles were used on a wooden mortar, we might expect some use-wear evidence of this, so investigating that possibility is a subsequent step to take.

In closing, novel microbotanical techniques like starch grain analysis are giving us access to data we once thought were lost or that we never knew existed. With microbotanical data, we can reopen the book on sites where preservation was poor or which were excavated long ago, before it was a common practice to take flotation and column samples in order to recover plant macro-remains. Additionally, these analyses give new life to old collections, and allow the extraction and identification of organic materials—like the axial tracheids—that had not previously been recovered or even sought. Without microbotanical analysis, we would never suspect the possibility that wooden mortars were in use 5,000 years ago; now we have some tantalizing clues. These analyses are in their nascent stage in California archaeology, but the future is bright. As this paper and the other papers in these two special issues of the *Journal* show, microbotanical research is already yielding dividends, and will keep doing so, especially as these methods continue to grow in popularity.

NOTES

1 Uncorrected radiocarbon date. All other dates presented here are calibrated, unless otherwise noted. Rick and Glassow (1999) obtained six dates from SBA-53 material, all dating between 5,530–5,050 B.P.; all material dated was Pismo clam or red abalone shell.

2 Prior investigations at SBA-53 did not sample for macrofloral remains, even though Harrison removed a total of fifteen 4" × 4" × 6" column samples from a variety of locations across the site. As of 1969, those samples could not be located in the UCSB Repository (M. Glassow, personal communication).

3 "Microbotanical Laboratory Procedures 2013", available via anth.ucsb.edu/vanderwarkerlab>.

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