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Macrobotanical food remains from a trans-Holocene sequence at Daisy Cave (CA-SMI-261), San Miguel Island, California

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ABSTRACT

Carbonized macrobotanical remains from a trans-Holocene archaeological and paleontological sequence at Daisy Cave provide important insights into the use of food plants by Paleo-coastal people as well as later groups on California's Northern Channel Islands. Small seeds are rare among the macrobotanical remains recovered in the cultural strata at Daisy Cave, which are dominated by charcoal from woody plants used as fuel. The recovery of *Brodiaea*-type corms from the Early and Late Holocene strata suggests, however, that geophytes were an important source of carbohydrates and calories for Channel Islanders throughout the Holocene. The proposed importance of geophytes is consistent with the abundance of *Brodiaea* in island vegetation communities recovering from more than a century of over-grazing, as well as the large numbers of digging stick weights found in island sites.

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1. Introduction

Since the 16th century AD, when Europeans first explored the California Coast and described the Island Chumash as relatively poor and dependent almost solely on fishing (Paez, 1968:14), the Northern Channel Islands have often been viewed as relatively marginal human habitat when compared to the adjacent mainland coast. This supposed marginality, usually attributed to the dearth of endemic terrestrial mammals and the comparatively limited diversity of plants available on the islands, is at odds with the Terminal Pleistocene settlement of the islands by humans (Erlandson et al., 2011; Jones et al., 2002; Orr, 1968), the large number and extensive nature of island archaeological sites, and the rich technological and artistic traditions of the Island Chumash (see Arnold, 2001; Kennett, 2005; Rick, 2007).

Plant foods were a crucial component of Native American economies along the southern California Coast, including the early Milling Stone complex that existed along the mainland coast of the Santa Barbara Channel between roughly 9000 and 5000 years ago (Erlandson, 1991, 1994; Glassow et al., 1988). Humans occupied the Northern Channel Islands throughout this period of time, but Milling Stone sites that typically contain an abundance of manos

and metates have not been found on the islands, probably because of the dearth of prolific seed-producing plants. The lack of such island sites led some early archaeologists to mistakenly conclude that the Channel Islands were settled relatively late (i.e., Olson, 1930; Rogers, 1929:339).

A substantial amount is now known about human settlement of the northern islands by Paleo-coastal peoples between about 12,000 and 9000 years ago, including their technologies and faunal exploitation patterns (Connolly et al., 1995; Erlandson and Braje, 2008; Rick et al., 2001, 2005). The available data demonstrate that Paleo-coastal peoples were fully maritime and harvested a variety of marine shellfish, fish, sea mammals, sea birds, and waterfowl (Erlandson et al., 2011). Little is known about Paleo-coastal use of terrestrial plants, in contrast, and paleo-ethnobotanical data from archaeological sites are limited even for later occupations of Channel Islanders (see Erlandson et al., 1999:259; Martin, 2009; Orr, 1968:210; Reddy, 2000a, 2000b; Thomas, 1995). Ethnographic accounts provide some insight into the use of plant foods by the Island Chumash (e.g., King, 1971; Timbrook, 2007), but these come primarily from oral histories collected in the early 20th century that are fragmentary and have limited time depth.

Given the dearth of data on terrestrial plant exploitation strategies on the islands, our study establishes a sequence of plant food use at Daisy Cave across the Holocene, and particularly for the Early Holocene, that provides a baseline for early human settlement on the Channel Islands and coastal California. Carbonized plant

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remains have rarely been recovered from stratified Early Holocene archaeological sites in these areas. As a result discussions of the role of plants in the diet of California's early coastal populations have remained largely conjectural.

We present macrobotanical data from flotation samples collected from a deeply stratified sequence at Daisy Cave (CA-SMI-261) on San Miguel Island. The samples come from a series of discrete occupation strata dated between about 11 600 and 3000 years ago (Erlandson, 2007; Erlandson et al., 1996), as well as several non-cultural strata that provide valuable data on natural sources of burned macrobotanical remains in the site vicinity. Our focus is on edible plant tissues from archaeological and paleontological strata dated to the Terminal Pleistocene, Early Holocene, Middle Holocene, and Late Holocene. The results provide new insights into the nature of plant foods utilized by the Island Chumash and their ancestors, including Paleocoastal peoples who occupied the cave between about 10 000 and 8600 years ago.

2. Setting, stratigraphy, and chronology of Daisy Cave

Located 42 km off the Santa Barbara Coast, San Miguel Island, is the westernmost and second smallest (37 km²) of the Northern Channel Island (Fig. 1). Prior to about 10 000 years ago, San Miguel was connected to the other islands as the western end of a significantly larger island known as Santarosae (Orr, 1968:18). Since the Last Glacial Maximum, the Northern Channel Islands are estimated to have lost between 75% and 80% of their land area to rising seas and coastal erosion (Kennett et al., 2008:2530), progressively reducing the productivity of terrestrial plants through time.

There have been numerous botanical surveys on the Northern Channel Islands (see Junak et al., 1997), but only well after island

vegetation had been severely affected by the grazing of sheep, cattle, pigs, horses, deer, elk, and other land mammals introduced by ranchers since the 1850s. Overgrazing was especially devastating on San Miguel Island, causing rapid devegetation, serious soil erosion, and widespread dune destabilization that led many early visitors to characterize the island as a wasteland of blowing sand. Since the 1960s, sheep and other livestock have been removed from the island and the native vegetation and hydrology has slowly recovered.

Given the dramatic environmental changes that have taken place on the Northern Channel Islands since the Late Pleistocene, botanical data from island archaeological and paleontological sites can provide important information about the nature of island plant communities prior to European contact and Native American uses of plants for food, fuel, medicinal, and technological purposes through the Holocene.

One of the longest and best-preserved archaeological sequences on the Channel Islands comes from Daisy Cave (CA-SMI-261), a cave and rock shelter complex located on the northeast shore of San Miguel. The site was occupied on numerous occasions between about 11 600 and 700 years ago, with relatively intensive occupations dating to the Early Holocene and Late Holocene (Erlandson, 2007; Erlandson et al., 1996). The site has been the scene of multiple excavations, beginning with local ranchers in the 1870s, Ralph Glidden in the early 1900s (Heye, 1921), Charles Rozaire in the 1960s, Pandora Snethkamp and Daniel Guthrie in the 1980s, and more recent work directed by Erlandson since 1991.

The interior of Daisy Cave was heavily disturbed by early looters and antiquarians, but the interior of the rock shelter was largely intact until it was almost completely excavated by Rozaire's team in the 1960s. These excavations produced extensive artifact and faunal

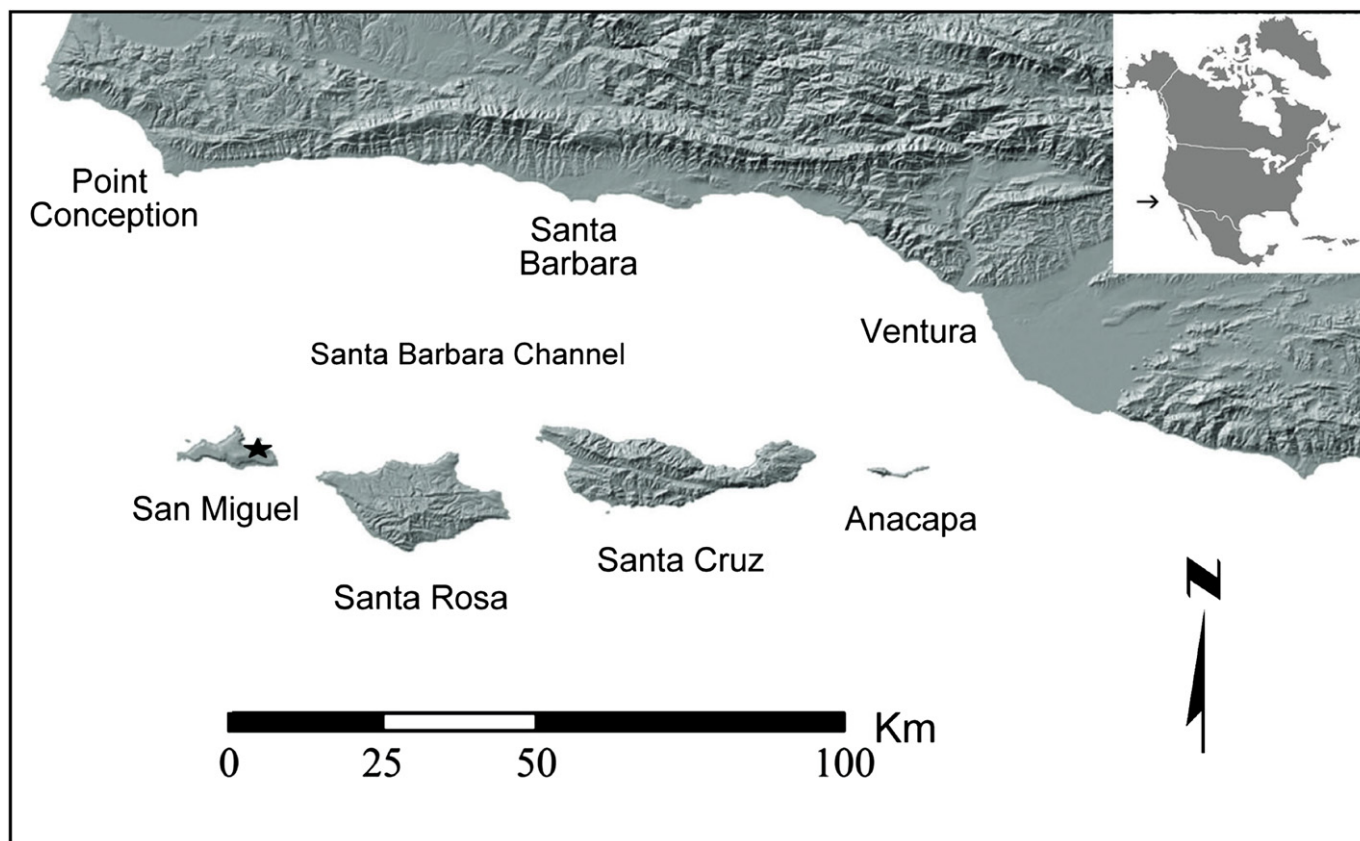


Fig. 1. The Santa Barbara Channel region, showing the location of San Miguel Island and Daisy Cave (black star).

collections attributed by Rozaire (1978) to the past 3000 years or so. Although relatively crude by modern standards, the excavations collected a large assemblage of artifacts made from wood and other plant remains, including planks made from redwood (*Sequoia sempervirens*) drift logs and hundreds of woven artifacts (cordage, etc.) made of sea grass (*Phyllospadix* spp.) and tule reeds (*Scirpus* spp.).

Returning to the site in the mid-1980s, Guthrie, Snethkamp, and Morris observed the remains of an extinct giant deer mouse (*Peromyscus nesodytes*) in archaeological strata exposed in Rozaire's trench walls, obtained the first ^{14}C dates for the site, and documented the great antiquity of the archaeological sequence. Their work was limited in scope but highly significant, including the collection of the first high-resolution samples, including stratigraphically-controlled column samples, sizeable sediment samples for macrobotanical analysis, and the retention of fine-screen residuals for micro-constituent studies. Column E6 (initially labeled as D5), the subject of the current macrobotanical analysis, was collected from along the dripline of the rock shelter at this time (Fig. 2).

Erlandson's work in the 1990s focused on completing the analysis of Snethkamp and Guthrie's samples and limited but careful excavation of the finely-stratified sediments along the dripline of the rock shelter. In the process a much larger sample of artifacts, faunal and floral remains, and ^{14}C dates was collected from the archaeological and paleontological strata at Daisy Cave. A suite of nearly 60 ^{14}C dates on a variety of organic materials (marine shell, charcoal, wood, bone) now anchors the site chronology, providing a relatively detailed framework for interpreting the archaeological and paleontological assemblages.

A variety of plant remains have been identified at Daisy Cave, including hundreds of pieces of cordage and other woven artifacts made from sea grass (*Phyllospadix* spp.) found in the Early Holocene strata (10 000–8600 cal BP; see Connolly et al., 1995; Norris, 1997). Although pollen preservation was relatively poor, West and

Erlandson (1994) and Erlandson et al. (1996) also published a summary of pollen remains identified from the major strata reported on below. The pollen sequence suggests that pines were relatively abundant in the area until about 13,000 years ago, after which the local vegetation took on an increasingly modern character (Erlandson et al., 1996:369). Pollen data from the well-dated strata at Daisy Cave reveal a changing environment, with a pine forest habitat prior to 12 000 to 13 000 cal BP (when sea levels were lower), followed by a dramatic decrease in pine pollen (Erlandson et al., 1996:370). With the post-glacial warming around 10 000 cal BP, the pine forests were replaced rapidly by oaks and plants belonging to the sunflower and rose families. By the Late Holocene, plant communities in the Daisy Cave area were similar to those present today.

3. Macrobotanical methods

Column E6 was excavated in 1986, following natural stratigraphic levels, with some of the thicker cultural strata (e.g., A, E, F) subdivided into arbitrary substrata. Caldwell (1986:25) described Column E6 as 20 × 60 cm wide and ~130 cm deep, with a total volume estimated at approximately 117 L. The field notes and profile drawings suggest that the size and volume of each column sample varied from stratum to stratum (see Table 1) and only general estimates for individual samples can now be made. Each of the column samples was bagged in the field and removed in its entirety to the archaeological laboratories in the Department of Anthropology at the University of California, Santa Barbara (UCSB). At UCSB, the light fractions were recovered from each individual sediment (column) sample via flotation using a 0.635 mm (1/40-inch) mesh. During excavation, transitional samples 1–2 cm thick were taken at major stratigraphic boundaries to avoid mixing between the major components. These transitional layers were not included in the current macrobotanical analysis due to their uncertain stratigraphic association.

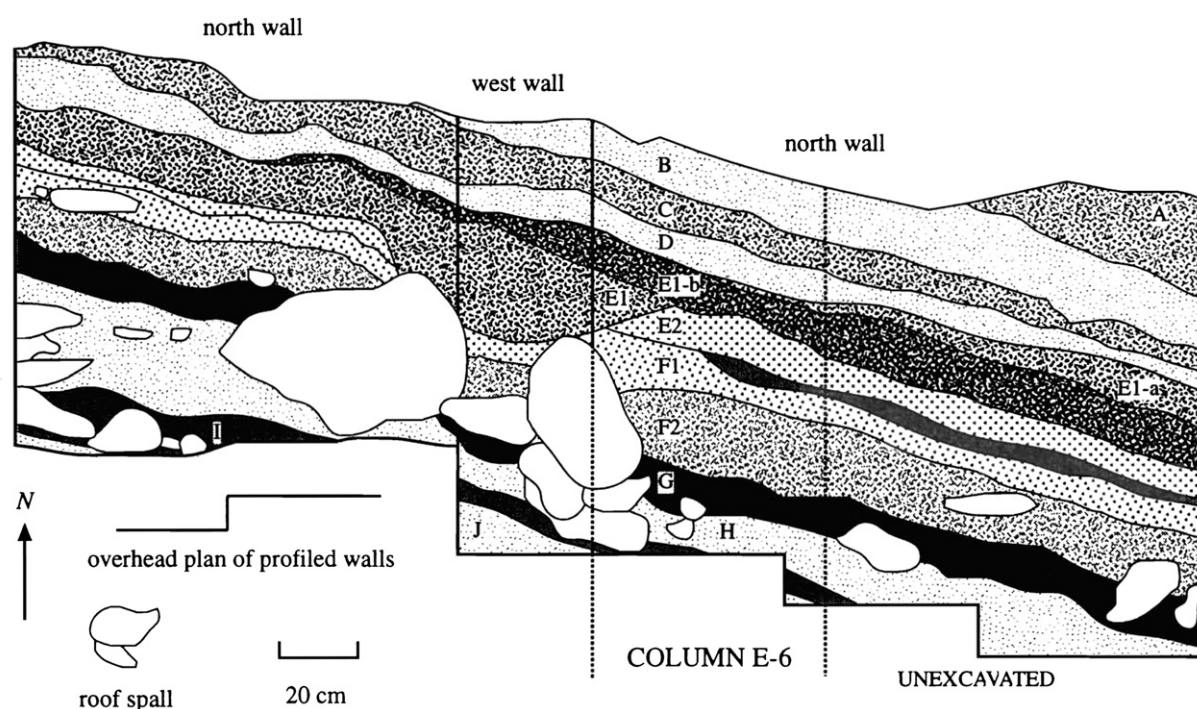


Fig. 2. Stratigraphy along dripline of Daisy Cave rock shelter, showing column from which flotation samples are derived (Stratum A partially lost to erosion; adapted from Erlandson et al., 1996).

Table 1
Carbonized macrobotanical remains from flotation samples, Column E6 at Daisy Cave.

Stratum	Age (cal BP)	Era	Description	Sample Volume (L)	Charcoal		Seeds		Corm fragments ^a		
					g	g/L	n	n/L	n	g	g/L
A1	~3000–3300	Late Holocene	Dense shell midden	5.1	58.9	11.5	1	0.2	9	0.6	0.12
A2	~3000–3300	Late Holocene	Dense shell midden	4	31.28	8.5	–	–	11	0.2	0.05
A3	~3000–3300	Late Holocene	Dense shell midden	8	43.71	5.5	–	–	2	0.05	0.01
B	~3300–6500	Middle Holocene	Nearly sterile	4	4.75	1.2	–	–	–	–	–
C	~6600	Middle Holocene	Shell midden	10	17.82	1.8	–	–	12	0.22	0.02
D	~6600–8500	Middle Holocene	Culturally sterile	5	2.38	0.5	–	–	–	–	–
E1	~8500	Early Holocene	Dense shell midden	10	92.9	9.3	–	–	4	0.13	0.01
E2	~8600	Early Holocene	Dense shell midden	10	96.1	9.6	–	–	25	1.3	0.13
E4	~8800	Early Holocene	Dense shell midden	6	76.14	12.7	–	–	10	0.6	0.10
F1	~9000	Early Holocene	Shell midden	16	17.41	1.1	6	0.4	26	0.4	0.03
F2	~9500	Early Holocene	Shell midden	10	20.44	2.0	1	0.1	1	0.01	0.001
F3	~10 000	Early Holocene	Shell midden	4	8.28	2.1	–	–	2	0.2	0.05
G	~11 500	Terminal Pleistocene	Low-density midden	3	8.43	2.8	–	–	–	–	–
H1	~11 800–12 400	Terminal Pleistocene	Culturally sterile	8	3.78	0.5	–	–	–	–	–
H2	~12 400–12 800	Terminal Pleistocene	Culturally sterile	8	28.0	3.5	–	–	–	–	–
J	~13 000–14 000	Terminal Pleistocene	Culturally sterile	5	4.92	1.0	3	0.6	7	0.01	0.002
Totals				116.1	515.24	4.4	11	0.1	109	3.72	0.03
All Sterile Strata				30	43.83	1.5	3	0.1	7	0.01	<0.01
All Cultural Strata				86.1	471.41	5.5	8	0.1	102	3.71	0.04
Late Holocene Cultural Strata				17.1	133.89	7.8	1	0.06	22	0.85	0.05
Middle Holocene Cultural Strata				10	17.82	1.8	–	–	12	0.22	0.02
Early Holocene Cultural Strata				56	311.27	5.6	7	0.13	68	2.64	0.05
Terminal Pleistocene Cultural Strata				3	8.43	2.8	–	–	–	–	–

^a Including *Brodiaea*-type.

After the UCSB collection was transferred to the University of Oregon, 16 light fraction samples from Column E6 were submitted to the senior author for macrobotanical analysis. These came from several archaeological strata (A, C, E, F, and G) or substrata ranging in age from ~11 600–3000 cal BP (Erlandson et al., 1996), as well as several non-cultural strata (B, D, H, J) that contained little or no evidence for human occupation. The site stratigraphy and ¹⁴C dating suggest that the relatively thick, organic-rich cultural strata accumulated much more rapidly (on annual or decadal scales) than the non-cultural strata, which represent from 1000 to 3000 years of natural accumulation (Table 1). The Early Holocene strata (E & F) contain the remnants of multiple finely-stratified human occupations over a roughly 1400 year period.

In the macrobotanical lab, all 16 light fraction samples were sorted using similar methods. First, each sample was screened over three nested geological sieves with mesh sizes of 4.75 mm (Sieve A), 2.0 mm (Sieve B) and 1.0 mm (Sieve C). Such presorting is an effective way to remove modern rootlets, leaves, and isolated flakes, bones, and shell. Each of these size fractions then was sorted under a binocular microscope with magnifications ranging between 5× and 15×. Charcoal, carbonized seeds, and other plant remains were collected from all sieve samples and stored in vials. When all sorting was completed, the charcoal and other materials were weighed. Identification of the carbonized seeds was done through comparison with comparative materials, identification manuals (Martin and Barkley, 1973; Musil, 1963), and consultation with botanists at the Seed Herbarium in Sacramento (California Department of Agriculture).

Although Daisy Cave contains a finely-stratified sequence of natural and cultural strata, strong winds often buffet the site and can contaminate sediment samples during excavation with airborne plant and other light-weight matter of modern origin. To understand the origins and integrity of the recovered remains, post-depositional disturbance was measured through a qualitative-categorical method. Organic materials sometimes associated with disturbance, including rodent fecal matter, insect parts, worms, and land snails, were noted when present. Only three samples had possible indicators of disturbance (in low frequencies), all in the

form of carbonized rodent droppings (less than 2 mm): Strata H1, H2 and J, which all appear to pre-date human occupation of the site. Although Daisy Cave is currently located immediately above the coast, in the Terminal Pleistocene the site was bounded on the north by a low coastal plain several hundred meters wide. Thus, the carbonized rodent droppings and other charcoal fragments found in Stratum H and J are most likely to be the result of natural wildfires periodically burning the Daisy Cave area.

4. Macrobotanical results

The 16 flotation samples yielded 11 carbonized seeds, 109 fragments of corms and related carbonized remains, and 43 small fragments of manroot (cf. *Marah* sp.) from 116.1 L of sediment (Tables 1 and 2). Four of the five culturally sterile strata (B, D, H1 and H2) and the low density shell midden level (G) did not yield any carbonized seeds or corm fragments, and also had low charcoal densities (see Table 1). In terms of post-depositional indicators, less than 10 very small (<1 mm in size) rodent droppings were recovered from the Strata H1, H2 and J samples. Interestingly, none of the other strata had carbonized rodent droppings in the light fractions. Except for Stratum J, the carbonized seeds and corm fragments were recovered only from the cultural strata, especially those associated with relatively dense shell midden deposits. Stratum J yielded three carbonized seeds, 7 small corm fragments (0.01 g) and 10 small fragments (0.01 g) of cf. *Marah* sp. Other than charcoal, the strata immediately above Stratum J (G, H1 and H2) yielded no macrobotanical remains. On strictly botanical grounds, comparing the results to the cultural assemblages from strata A, E, and F, the recovery of the seeds, and the corm and *Marah* fragments from Stratum J might suggest the potential for the presence of a low density cultural deposit. Considering that a charred twig from Stratum J was dated to 11700 ± 70 RYBP (~11570–11820 BC), however, additional corroborating evidence of a cultural occupation would be required. Charcoal densities reflect varying preservation contexts at the site, and also the intensity of activities involving plants and fire. Charcoal densities of the 16 levels at the site generally decrease with depth (Fig. 3), with the uppermost

Table 2
Plant taxa recovered from flotation samples, Column E 6 at Daisy Cave.

Stratum ^a	Total Seeds		Galium sp. Seeds		cf. Chenopodium sp. Seeds		Unidentified Seed A		Unidentified Seed Frags		Brodiaea-type Corm Fragments		Unknown Tuber/Corm Fragments		cf. Marah sp. Fragments		
	n	n/L	n	n/L	n	n/L	n	n/L	n	n/L	n	g	g/L	n	g	g/L	
A1	1	0.2	1	0.2	—	—	—	—	—	—	9	0.6	0.1	—	—	—	—
A2	—	—	—	—	—	—	—	—	—	—	11	0.2	0.1	—	—	—	—
A3	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0.05	0.01	—
C	—	—	—	—	—	—	—	—	—	—	—	—	—	12	0.2	0.02	—
D	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
E1	—	—	—	—	—	—	—	—	—	—	4	0.13	0.01	—	—	—	0.020
E2	—	—	—	—	—	—	—	—	—	—	7	0.5	0.05	18	0.8	0.1	0.001
E4	—	—	—	—	—	—	—	—	—	—	4	0.1	0.02	6	0.4	0.1	0.001
F1	6	0.4	1	0.1	—	0.06	—	—	4	0.3	26	0.4	0.03	—	—	16	0.3
F2	1	0.1	—	—	—	—	0.07	—	—	—	1	0.01	0.001	—	—	—	—
F3	—	—	—	—	—	—	—	—	—	—	—	—	—	2	0.2	0.1	—
J	3	0.6	—	—	—	—	0.07	—	2	0.4	7	0.01	0.002	—	—	10	0.01
Total	11	0.1	2	0.02	1	0.01	0.13	0.1	6	0.1	69	2	0.02	40	2	0.01	0.004

^a No macrobotanical food remains were found in strata B, G, H1 and H2.

Stratum A having higher values relative to the lowest strata. There are two spikes in charcoal densities, however, one in the Early Holocene Stratum E (E1, E2 and E4) and a second in the Late Holocene midden Stratum A (A1, A2 and A3). The Early Holocene midden Stratum F (F1, F2 and F3) has much lower charcoal densities compared to those in the overlying Stratum E. This suggests that different types of activities associated with plants and fire occurred in these portions of the midden area during the Early Holocene. Also Stratum H2 (Terminal Pleistocene -Non-cultural) had a higher charcoal density compared to Stratum G (an ephemeral Terminal Pleistocene shell midden). This may be due to the accumulation of charcoal from occasional wildfires.

Small fragments of vertebrate remains were noted in all the light fractions, except for culturally sterile Strata H1, H2, and J. The samples from Strata E1, E2, E4, F1, F2, and F3 contained numerous uncarbonized fragments of dried sea grass recovered in the 2 mm–1 mm sieve fraction. These same strata yielded large numbers of woven sea grass artifacts as well as clumps of unmodified sea grass (Connolly et al., 1995; Norris, 1997), so these tiny fragments of sea grass are almost certainly cultural in origin. The preservation of these remains appears to result from the fact that these strata, where they are found inside the rock shelter dripline, are laced with sea bird guano (Connolly et al., 1995).

The 11 carbonized seeds include *Galium* sp. ($n = 2$), cf. *Chenopodium* sp. ($n = 1$), Unidentifiable Seed A ($n = 2$), and unidentified seed fragments ($n = 6$) (Table 2). The low seed density (0.1 seeds per liter of sediment) is consistent with the limited diversity and relatively low productivity of prolific seed-producing plants and the dearth of manos and metates at Daisy Cave and Northern Channel Island sites in general. *Galium californicum* ssp. *miguelense* (San Miguel Island bedstraw) is endemic to the island (Junak et al., 1997:32). Several species of *Chenopodium* are also present on the island (Junak et al., 1997:18). The unidentifiable seed fragments are too small to provide adequate identification information (<2 mm in size). Both *Galium* sp. and *Chenopodium* sp. could have been food resources in the past. Two seeds were recovered which have not retained the finer morphological characteristics to facilitate an identification (Unidentifiable Seed A). They may be related to seeds of *Phyllospadix* sp. (surf grass). Stratigraphically, the 11 carbonized seeds from the site were recovered from only four strata: A1, F1, F2 and J. The two *Galium* sp. seeds were recovered from A1 and F1, while the single *Chenopodium* was from Stratum F1. The Unidentifiable Seed A specimens were recovered from the F2 and J strata.

The 43 carbonized fragments (0.4 g) of cf. *Marah* sp. were recovered from strata A1, D, E1, E2, F1, and J. Their presence in the non-cultural strata D and J suggest that some or all of these could be of natural origin. *Marah macrocarpus* v. *major* (wild-cucumber) occurs naturally on San Miguel Island (Junak et al., 1997:20), however, and *M. macrocarpus* is ubiquitously recovered from prehistoric sites in coastal southern California. Its recovery from cultural contexts suggests prehistoric use, but the recovered parts are typically toxic (Martin, 2009) and *Marah* use may have been primarily ritualistic and medicinal, rather than for food. It is conceivable, therefore, that the possible *Marah* remains from the cultural strata at Daisy Cave are anthropogenic in origin.

Among the carbonized plant remains recovered at Daisy Cave, 69 fragments (2 g) of *Brodiaea*-type corm remains were also identified. They are the remains of *Dichelostemma capitatum* (blue dicks), *Triteleia laxa* (Ithuriel's spear), and/or *Brodiaea terrestris* (cluster lilies), all of which occur naturally on San Miguel Island. These three species are closely related and have been variously lumped or split by taxonomists over the last 50–60 years. Therefore, the corm fragments recovered from Daisy Cave are referred to as the *Brodiaea*-type group. In the spring of 2008, Erlandson found that flowering blue dicks were abundant on the flats above Daisy

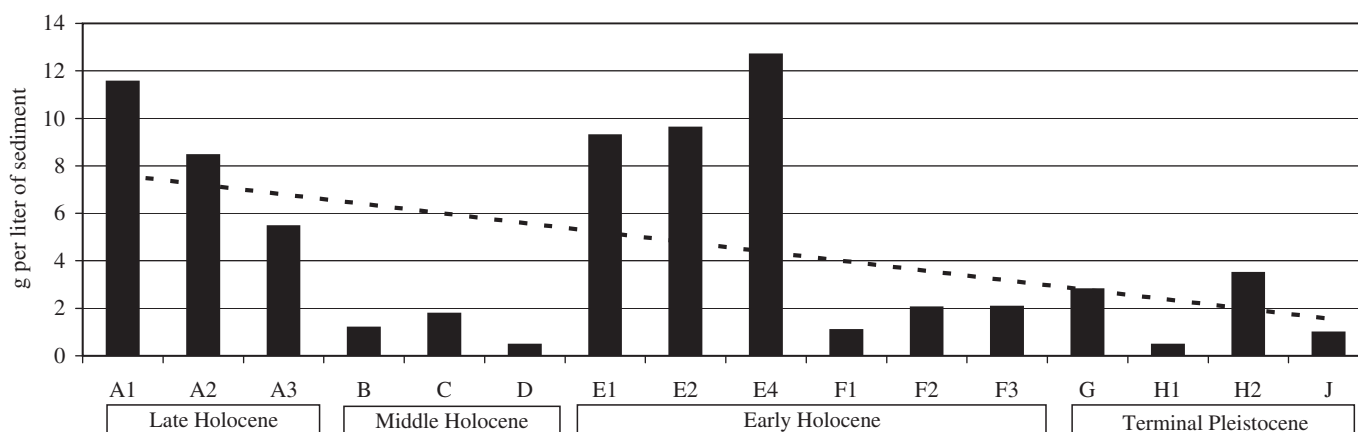


Fig. 3. Charcoal Density (g/L) by Stratum, Daisy Dave.

Cave and large quantities have also been observed more recently on Santa Rosa Island. *Brodiaea*-type corms are rich in carbohydrates and calories (Gilliland, 1985) and are known to have been cooked and eaten by the Island Chumash (Sutton, 2010; Timbrook, 2007:75–77). Therefore, the *Brodiaea*-type corm remains from Daisy Cave seem likely to have been used as food by the prehistoric cave occupants. Although these soft plant tissue remains were recovered in low densities overall at Daisy Cave (0.02 g per liter of sediment), their densities were higher in the Late and Early Holocene strata (Fig. 4).

Brodiaea-type corms may be up to 3–4 cm in diameter, and the mature corms have small cormlets at their base. These cormlets are important for plant propagation. According to Anderson (2005), ethnohistorically California Indians intentionally knocked these off the parent corms during harvest so that the plants propagated for the next season. The *Brodiaea*-type corms bloom in the spring and would be ideal for harvest in summer. Many of the geophytes (root foods) are fire followers, and their growth was promoted by fire (Anderson, 2005). *Brodiaea*-type corms could be eaten raw, but were most likely either baked, roasted, steamed or parched before consumption. On Santa Cruz Island, these geophytes were an important food source that was baked in large earth ovens in ethnohistoric times (Sutton, 2011:5; Timbrook, 2007; Wagner, 1929:162). Once these corms are roasted, parched or baked they

can be stored for winters. Trammel et al. (2008) conducted ethnographic and experimental research on the mainland, and argued that terrestrial roots should be considered the highest ranked plant foods, given returns of 2000–4000 kcal/h for some root foods dependent on abundance and processing requirements.

In addition to the *Brodiaea*-type corm fragments, 40 fragments of what appears to be carbonized soft plant tissue were recovered that are too small for identification. Based on the gross anatomy of the fragments—which are rounded in nature with a spherical structure of cells and cavities visible on some fractured margins—they are identified as the soft tissue of roots, tubers, rhizomes, or corms. These could also be small fragments of *Brodiaea*-type corms, but could not be definitively identified as such.

Although pine forests appear to have been present on San Miguel Island during the Terminal Pleistocene (Erlandson et al., 1996; West and Erlandson 1994)—and pines and oaks still exist on Santa Rosa and Santa Cruz islands today—no nuts or nutshell remains were recovered from the Daisy Cave samples.

5. Discussion

The macrobotanical samples from Daisy Cave yielded relatively small quantities and low densities of potentially edible plant remains, but the results are significant for both their antiquity and

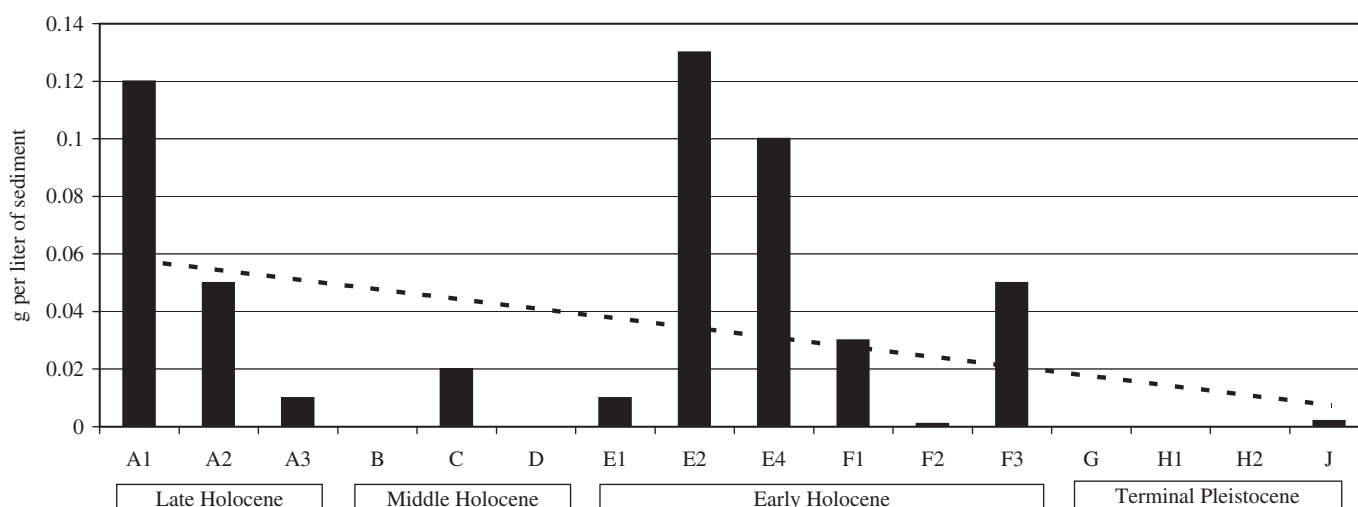


Fig. 4. Distribution of *Brodiaea*-type corm fragments (g/L) by Stratum, Daisy Cave.

the nature of the identified remains. Except for a very small assemblage from a 9300 year old Santa Rosa Island shell midden (Erlandson et al., 1999:259), these are the first paleoethnobotanical samples containing edible plant remains from a Paleocoastal site on the Northern Channel Islands. The remains are comprised mostly of carbonized soft tissues from geophyte corms or tubers—the identifiable remains all coming from *Brodiaea*-type corms—along with a few small seeds. The small assemblage recovered cannot provide a comprehensive view into the dietary or medicinal uses of plants by the occupants of Daisy Cave, but it hints at both long-term continuity in the use of geophytes on San Miguel Island and significant differences between plant food use patterns along the mainland coast vs. the Northern Channel Islands. The significance of the Daisy Cave macrobotanical remains also lies in the dearth of similar data from Channel Islands archaeological sites, including control samples from non-cultural or paleontological contexts. Unfortunately, the dearth of comparative data from other island sites limits our ability to evaluate the data within a regional context.

Significantly, all the macrobotanical remains identified from Daisy Cave—dated between about 11,600 and 3000 cal BP—could have been collected locally on San Miguel or western Santarosae Island. In contrast, Martin (2010) and Martin and Popper (2001) analyzed macrobotanical remains from five Late Holocene Chumash village sites on Santa Cruz Island spanning the Middle, Late, Transitional, and Historic periods. Among the remains they identified, a primary plant food resource found primarily on the mainland, Western sea purslane (*Sesuvium verrucosum*), was imported from the mainland and first appears during the Transitional period (~AD 1150–1300) which was characterized by periodic droughts (Arnold, 2001; Kennett, 2005; Raab and Larson, 1997). Martin (2010) suggested that the Chumash intensified cross-channel trade to supplement their subsistence economy during times of resource stress. The need for such supplemental plant foods from the mainland may have become increasingly important during the Late Holocene, after post-glacial sea level rise had reduced the size of the Northern Channel Islands significantly (Kennett et al., 2008) and Island Chumash populations appear to have increased significantly (Erlandson et al., 2001; Glassow, 1999). The combination of expanding human populations, a gradual reduction in island size and terrestrial plant productivity, and declining shellfish yields (Erlandson and Braje, 2008, 2011) may have fueled the growth of cross-channel trade and the importation of mainland plant foods.

On the more arid Southern Channel Islands, the limited data available suggest that small seeds were a more important source of plant foods than on the northern islands. Thomas (1995) summarized the limited macrobotanical remains reported from San Nicolas Island archaeological sites, for instance, which include a small assemblage from CA-SNI-351, dated to ~5950 cal BP, that yielded 16 seeds (*Marah* sp., *Calandrinia* sp., *Arctostaphylos* sp., *Vaccinium* sp.) and one bulblet fragment of *Brodiaea*-type corm. Reddy (2000a, 2000b, 2003) reported on slightly richer and more diverse assemblages of macrobotanical remains from more than 20 Late Holocene sites on San Clemente Island. These Late Holocene assemblages were dominated by *Calandrinia* sp. (redmaids) (51.5 percent) and grasses (27 percent) (Reddy, 2003). Note, however, that 95 percent of the *Calandrinia* seeds were recovered from two sites (Lemon Tank and Ledge site) (McNulty and Audrey, n.d., Eisentraut, 1990). Some of the grasses represented in the macrobotanical assemblage from the island include *Hordeum* sp. (wild barley), *Stipa* sp. (needlegrass), and *Eriogonum* sp. (native buckwheat). Other common small seeded plants represented include *Chenopodium* sp. (goose-foot), *Galium* sp. (tarweed), *Atriplex* sp. (saltbush) and *Hemizonia* sp. (tarweed). Spatially, there is an emerging pattern in the distribution of seeds between inland sites (along the central spine of the island)

and coastal sites with significantly higher seed densities in the inland sites (Reddy, 2003).

6. Summary and conclusions

Flotation of bulk soil samples from a deep and well-stratified archaeological and paleontological sequence at Daisy Cave yielded carbonized macrobotanical remains from both cultural and non-cultural strata. The analysis of the plant remains from the archaeological strata—informed by comparison to those found in non-cultural strata—allowed us to compare patterns of natural and cultural accumulation of burned plant remains from a high-resolution sequence ranging in age from ~14 000–3000 cal BP. Macrobotanical remains from the Early, Middle, and Late Holocene archaeological strata consist primarily of unidentified charcoal resulting from the use of plant fuels, along with uncarbonized remains of sea grass (*Phyllospadix* spp.) in the Early Holocene strata that are mostly the byproduct of the production and maintenance of cordage and other woven materials.

Among the potentially edible plant remains identified in the Daisy Cave sequence, small seeds were rare but fragments of *Brodiaea*-type corms were comparatively abundant in both the Early Holocene (Paleocoastal) and Late Holocene (Island Chumash) strata. Geophyte remains were relatively common in the dense cultural deposits represented by Strata A, E, and F, where they are associated with diverse artifact and faunal assemblages, but largely absent in the non-cultural strata. This suggests that the geophyte remains were of cultural origin and one of the primary plant foods consumed by the occupants of Daisy Cave in the Early and Late Holocene. Their high carbohydrate and caloric content, their abundance in island vegetation communities recovering from over a century of overgrazing by introduced livestock, and the large number of digging stick weights (a.k.a., “donut-stones”) on the Northern Channel Islands (Sutton, 2011), all support the hypothesis that geophytes were important plant foods for the occupants of the Northern Channel Islands for at least 10,000 years.

Although many ethnographic and archaeological accounts suggest that the Island Chumash imported most of their plant foods from the adjacent mainland, the productivity of geophytes and other edible plants on the islands may have been sufficient to feed local populations for much of the Holocene. The appearance of significant amounts of imported mainland plant food supplies during the past 1500 years (Martin, 2010), as well as ethnohistoric accounts of extensive trade of mainland plant foods to the Northern Channel Islands (e.g., King 1971)—both facilitated by the development of the large ocean-going plank toml—may reflect a late imbalance between growing island populations, a shrinking terrestrial resource base, and severe droughts and climatic instability associated with the Medieval Climatic Anomaly.

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References

- Anderson, K., 2005. *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*. University of California Press.
- Arnold, J.E. (Ed.), 2001. *The Origins of a Pacific Coast Chiefdom: the Chumash of the Channel Islands*. University of Utah Press, Salt Lake City.
- Caldwell, M.E., 1986. Analysis of Shellfish Remains in the Daisy Cave Midden, San Miguel Island, Senior Thesis in Biology. Joint Science Department, Claremont Colleges.
- Connolly, T.J., Erlandson, J.M., Norris, S.E., 1995. Early Holocene basketry and cordage from Daisy, cave, San Miguel island, California. *American Antiquity* 60, 309–318.
- Eisentraut, P.J., 1990. Investigations of prehistoric seed caches from site CA-SCLI-1542, San Clemente. *Pacific Coast Archaeological Society Quarterly* 26 (3), 93–113.
- Erlandson, J.M., 1994. *Early Hunter-Gatherers of the California Coast*. Plenum Press, New York.
- Erlandson, J.M., 2007. Sea change: the paleocoastal occupations of Daisy Cave. In: Neusius, S.W., Gross, G.T. (Eds.), *Seeking Our Past: An Introduction to North American Archaeology*. Oxford University Press, Oxford, pp. 135–143.
- Erlandson, J.M., Braje, T.J., 2008. Tracking Technologies: Contributions to Understanding Technological Change on California's Channel Islands. *Pacific Coast Archaeological Society Quarterly* 40 (1).
- Erlandson, J.M., Rick, T.C., Vellanoweth, R.L., Kennett, D.J., 1999. Maritime subsistence at a 9300 year old shell midden on Santa Rosa Island, California. *Journal of Field Archaeology* 26, 255–265.
- Erlandson, J.M., Rick, T.C., Kennett, D.J., Walker, P.L., 2001. Dates, demography, and disease: cultural contacts and possible evidence for old world epidemics among the island Chumash. *Pacific Coast Archaeological Society Quarterly* 37 (3), 11–26.
- Erlandson, J.M., Kennett, D.J., Ingram, B.L., Guthrie, D.A., Morris, D.P., Tveskov, M.A., West, G.J., Walker, P.L., 1996. An archaeological and paleontological chronology for Daisy Cave (CA-SMI-261), San Miguel island, California. *Radiocarbon* 38 (2), 355–373.
- Erlandson, J.M., Rick, T.C., Braje, T.J., Casperson, M., Culleton, B., Fulfrost, B., Garcia, T., Guthrie, D., Jew, N., Kennett, D.J., Moss, M.L., Reeder, L.A., Skinner, C., Watts, J., Willis, L., 2011. Paleoindian seafaring, maritime technologies, and coastal foraging on California's Channel Islands. *Science* 441, 1181–1185.
- Gilliland, L.E., 1985. Proximate Analysis and Mineral Composition of Traditional California Native American Foods. M.S. thesis, University of California, Davis.
- Glassow, M.A., 1999. Measurement of population growth and decline during California prehistory. *Journal of California and Great Basin Anthropology* 21, 45–66.
- Glassow, M.A., Wilcoxon, L.R., Erlandson, J.M., 1988. Cultural and environmental change during the Early period of Santa Barbara Channel prehistory. In: Bailey, G.N., Parkington, J.E. (Eds.), *The archaeology of prehistoric coastlines*. Cambridge University Press, Cambridge, pp. 64–77.
- Heye, G.G., 1921. Certain Artifacts from San Miguel Island, California. *Indian Notes and Monographs* 7(4). Museum of the American Indian, Heye Foundation, New York.
- Jones, T.L., Fitzgerald, R.T., Kennett, D.J., Micsicek, C., Fagan, J., Sharp, J., Erlandson, J.M., 2002. The Cross Creek site (CA-SLO-1797) and its implications for new world colonization. *American Antiquity* 67, 213–230.
- Junak, S., Philbrick, R., Chaney, S., Clark, R., 1997. *A Checklist of Vascular Plants of Channel Islands National Park Includes San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands*, second ed. Southwest Parks and Monuments Association, Tucson, AZ.
- Kennett, D.K., 2005. *The Island Chumash: Behavioral Ecology of a Maritime Society*. University of California Press, Berkeley.
- Kennett, D.J., Kennett, J.P., West, J., Erlandson, J.M., Johnson, J.R., Hendy, I.L., West, A., Jones, T.L., 2008. Wildfire and abrupt ecosystem disruption on California's northern Channel Islands at the Allerød-Younger Dryas boundary (13.0–12.9 ka). *Quaternary Science Reviews* 27, 2530–2545.
- King, C.D., 1971. Chumash inter-village exchange. *The Indian Historian* 4 (1), 30–43.
- Martin, L.S., 2010. *Reconstructing Paleoenvironmental Instability and Plant Resource Availability on Santa Cruz Island using Macrobotanical Analysis*, Masters thesis. Department of Anthropology, University of California, Los Angeles.
- Martin, S.L., 2009. The use of *Marah macrocarpus* by the prehistoric Indians of coastal southern California. *Journal of Ethnobiology* 29 (1), 77–93.
- Martin, A., Barkley, W., 1973. *Seed Identification Manual*. The Blackburn Press.
- Martin, S., Popper, V., 2001. Paleoethnobotanical Investigations of archaeological sites on Santa Cruz Island, California. In: Arnold, J.E. (Ed.), *Origins of a Pacific Coast Chiefdom*. University of Utah Press, Salt Lake City, pp. 245–260.
- McNulty, Audrey, n.d. *The Seed Caches at Ledge, San Clemente Island*. Manuscript on file the Natural Resources Office, Naval Region SW, Naval Air Station, North Island, San Diego, CA.
- Musil, A., 1963. Identification of crop and weed seeds. *Agriculture Handbook No. 219*. U.S. Department of Agriculture, Washington, D.C.
- Norris, S.E., 1997. *Early Holocene Cordage and Perishable Artifacts from the Daisy Cave Site (CA-SMI-261)*, San Miguel Island, California, Masters paper. Department of Anthropology, University of Oregon.
- Olson, R., 1930. *Chumash Prehistory*. In: *University of California Publications in American Archaeology and Ethnography*, 28. University of California Press, Berkeley and Los Angeles, pp. 1–21. 1.
- Orr, P.C., 1968. *Prehistoric of Santa Rosa Island*. Santa Barbara Museum of Natural History, Santa Barbara.
- Paez, J., 1968. 2/3. In: *Cabrillo's Log 1542–1543: A Voyage of Discovery*. The Western Explorer, vol. 5. Cabrillo Historical Association, San Diego.
- Raab, L.M., Larson, D.O., 1997. Medieval Climatic Anomaly and punctuated cultural evolution in coastal southern California. *American Antiquity* 62, 319–336.
- Reddy, S.N., 2000a. Paleoethnobotanical study of carbonized plant remains from SCLI-1239, SCLI-1249, and PL-100. In: Byrd, B.F. (Ed.), *Archaeological Testing of Three Sites along the LVT Road, North-Central San Clemente Island, California*. Technical report on file, Natural Resources Office, Naval Region SW, Naval Air Station, North Island, San Diego, CA.
- Reddy, S.N., 2000b. Paleoethnobotany on San Clemente island: plant remains from SCLI-154, LVTA-9 and LVTA/SE46. In: Byrd, B. (Ed.), *Archaeological Testing of Four Sites Near West Cover, Northern San Clemente Island, California*. Technical report on file, Natural Resources Office, Naval Region SW, Naval Air Station, North Island, San Diego, CA.
- Reddy, S.N., 2003. Prehistoric plant usage at four highland sites in the vicinity of Lemon tank on San Clemente Island, California. In: Brian Byrd, F., Andrews, Sherri (Eds.), *Archaeological Testing of Four Sites in the Lemon Tank Area, Central San Clemente Island, California*. On file. Technical Report prepared for the Natural Resources Office, Naval Region SW, Naval Air Station, North Island, San Diego, CA.
- Rick, T.C., 2007. *The Archaeology and Historical Ecology of Late Holocene San Miguel Island, California*. Cotsen Institute of Archaeology, University of California, Los Angeles.
- Rick, T.C., Erlandson, J.M., Vellanoweth, R., 2001. Paleocoastal marine fishing on the Pacific coast of the Americas: perspectives from Daisy Cave, California. *American Antiquity* 66, 595–614.
- Sutton, E.A., 2011. *An analysis of perforated stones from the Santa Barbara Channel region*. Unpublished Manuscript on file. Department of Anthropology, University of California, Santa Barbara, Repository for archaeological and ethnographic collections.
- Thomas, L., 1995. Archaeobotanical research on San Nicolas Island: current directions. *Pacific Coast Archaeological Society Quarterly* 31 (4), 23–32.
- Timbrook, J., 2007. *Chumash Ethnobotany: Plant Knowledge among the Chumash People of Southern California*. Santa Barbara Museum of Natural History and Heyday Books, Berkeley, CA.
- Trammell, J., J.O. Connell, S. Bush, C. Parker, P. Borghi, L. Hunsaker, and D. Bird, 2008. Exploring geophyte use in the northern Great Basin: nutrient content, handling costs, effects of fire and tillage, and archaeological implications. Paper presented at the Great Basin Anthropology Association Conference, Portland, OR.
- Wagner, H.R., 1929. *Spanish Voyages to the Northwest Coast of America in the sixteenth century*, vol. 4. California Historical Society Special Publications, San Francisco.
- West, G.J., Erlandson, J.M., 1994. A late Pleistocene pollen record from San Miguel Island, California: preliminary results. *American Quaternary Association Program and Abstracts* 13, 256.