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The CA-SCR-9 Archaeofauna: Insights into Prey Choice, Seasonality, and Processing

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*Excavations of the Bonny Doon site (CA-SCR-9) in the Santa Cruz Mountains of northern Santa Cruz County, California by Hylkema in the late 1980s recovered a large and well-preserved faunal assemblage that spans the Early-Middle Period transition. With over 8,000 recorded specimens (from an estimated 12,000 total number of specimens [NSP]) and with demonstrated sampling to redundancy, the SCR-9 assemblage is one of the largest faunal samples in the region, and only the second published at this level of specificity. Analysis of the SCR-9 assemblage shows there were no changes in prey choice or handling in this part of the California central coast during the site's occupation, while the presence of northern fur seals (*Callorhinus ursinus*) suggests the site's inhabitants were connected to fur seal hunting at Año Nuevo Point. Notably, there is evidence for intensive exploitation of cervid bone nutrients, a pattern that may be typical of inland sites in this region.*

Aʀᴄʜᴀᴇᴏʟᴏɢɪsᴛs ɪɴ ɴᴏʀᴛʜᴇʀɴ and central California and the Great Basin have widely applied theoretical models drawn from the behavioral ecology of animals (cf. Krebs and Davies 2012) to human foraging strategies, using animal and plant remains from sites as proxies for foraging behavior. Early applications used Charnov's (1976) marginal value theorem to explore possible cases of resource depression in the foraging patches represented in archaeological samples. Compelling arguments for resource depression in species with indeterminate growth noted that prey sizes decrease over time, which was interpreted as evidence for intensified off-take of larger (i.e., older) individuals (e.g., Broughton 1997). Among prey types with determinate growth, such as birds and mammals,

shifts toward lower-ranked species over time and changes in age-class representation were cited as evidence for parallel processes of local resource depression (e.g., Broughton et al. 2007).

Lyman (2003) stressed that *exploitation depression*, in which encounter rates fall because local prey population numbers are reduced, is only one of several forms of resource depression outlined in behavioral ecological theory (Charnov et al. 1976). Other possible forms of resource depression are *behavioral depression*, in which encounter rates fall because prey avoid the patches their predators exploit, and *microhabitat depression*, where prey adjust by occupying habitats that are not visited by their predators. Broughton (2002) stressed that zooarchaeologists seeking to study resource depression

should understand the behavior and reproductive dynamics of each species before concluding that a specific form of resource depression accounts for patterning in archaeofaunal data. In the same vein, Whitaker (2009) argued that exploitation depression is not inevitable for all large-bodied prey. For example, modern research suggests mule deer (*Odocoileus hemionus*) were unlikely to experience exploitation depression under aboriginal population levels and technologies, while another cervid species, elk (*Cervus elaphus canadensis*), was more vulnerable to exploitation depression (Whitaker 2009).

Archaeologists have used actualistically-derived return rates (the caloric reward of an item minus the handling time or energy required to process it) in tandem with Central Place Model (CPM) foraging theory to predict human patterns of prey acquisition, processing, and transport to archaeological sites (e.g. Bettinger et al. 1997; Metcalfe and Barlow 1992). CPM approaches, combined with theoretical elaborations on trade-offs in acquisition versus storage costs, were used to explain the strong archaeological evidence for earlier practices of acorn storage over salmon storage in much of northern California, despite divergences in the immediate return rates of these resources (Tushingham and Bettinger 2013).

Behavioral ecological approaches also highlight cases where foragers do *not* meet predictions based on such models and call for other explanations. Hildebrandt et al. (2009a) noted that substantial amounts of marine shell in Laguna de Santa Rosa archaeological sites— 25 km. inland from the Sonoma County, California coast—deviate from predictions based on shellfish return rates and CPM transport models developed by Bettinger et al. (1997). They argued that these substantial marine shell deposits reflect seasonal acquisition and transport of fresh clams as status-enhancing luxury foods in feasts during a regional phase of increasingly elaborate cultural practices and internal societal differentiation. In another example, Whitaker and Byrd (2014) contended that marked increases in the abundance of very small-bodied mollusk species (e.g., *Cerithidea* snails) in some south San Francisco Bay archaeofaunas reflect politically constrained foraging in densely populated areas, rather than over-exploitation of higher-ranked species. They note that "shifts in social interaction and demography are as important or more important in driving patterns of shellfish exploitation than biological and ecological processes" (Whitaker and Byrd 2014:150).

These and other approaches to understanding forager behavior all depend upon robust archaeological data, and this is especially true of zooarchaeological data in California, where many behavioral ecological approaches depend upon faunal data as a proxy for prey choice. Fisher (2015) recently underlined this point in his reanalysis of the Coldwater Site (CA-MNO-3736) archaeofauna. This assemblage was key in arguments for and against explaining a sudden increase in artiodactyl hunting as costly signaling behavior in the Middle Archaic (Broughton and Bayham 2003; Hildebrandt and McGuire 2002). Fisher (2015) found the striking differences between the Coldwater Site archaeofauna and other White Mountain assemblages resulted from major divergences between two zooarchaeologists' sorting protocols.

Given the need for robust and clearly documented data, our intention in this article is to present a detailed analysis of vertebrate remains for which analytic decisions are well documented. Here we present data on the archaeofauna from CA-SCR-9, an Early through Middle Period residential site in the northern uplands of Santa Cruz County, California, excavated by Hylkema in the late 1980s. With over 8,000 analyzed specimens, the assemblage provides one of a few detailed zooarchaeological analyses from the coast of northern Santa Cruz and southern San Mateo counties that can shed light on patterns of prey choice and the use of coastal resources in inland contexts.

Rather than proposing and testing new hypotheses, we report these data with the hope that they will aid others in investigating Early and Middle Period foraging on the northern Santa Cruz and southern San Mateo County coast. However, we do address several hypotheses already in the literature concerning changes in foraging behavior and handling practices in the Early-Middle Period transition, connections between SCR-9 and other regional sites, and seasonality of site use (Hildebrandt et al. 2009b; Hylkema 2002). Given that Wohlgemuth's (2010) paleoethnobotanical modeling for central California indicates this stretch of the coast is remarkably low in edible plant resources, faunal evidence is of considerable importance for understanding past foraging in the region.
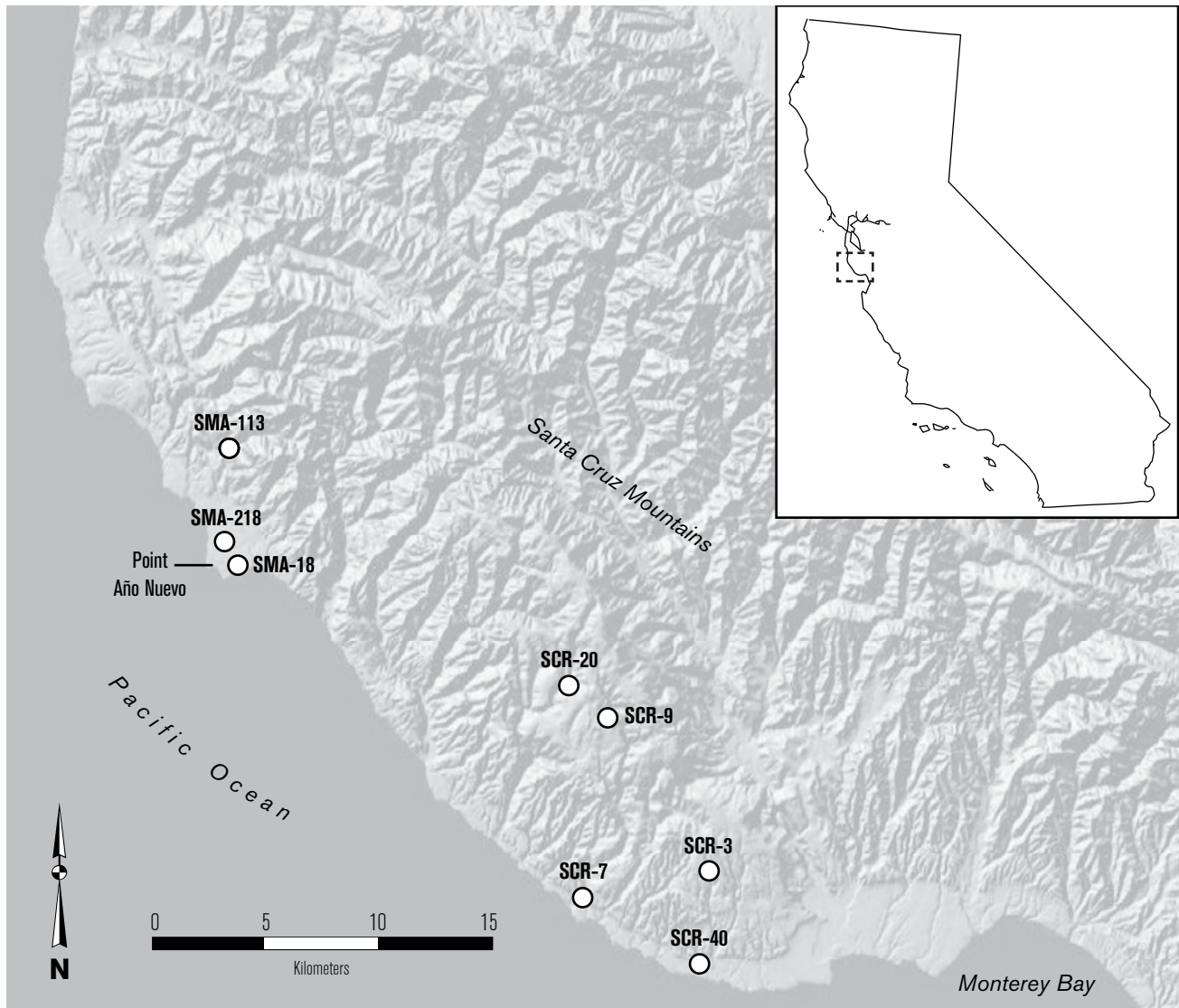
Figure 1. The California central coast showing the pertinent archaeological sites.

BACKGROUND

The Bonny Doon Site (CA-SCR-9) lies at an elevation of 395 m. (1,300 feet) above sea level on the upper, western slope of Ben Lomond Mountain, in an upland meadow habitat, surrounded by a mosaic of redwood and mixed hardwood forest. The forest encompasses the nearby headwaters of San Vicente Creek, which runs to the Pacific Ocean 6 km. to the southwest (Fig. 1). Hylkema (1991; see also Hylkema 2002) excavated SCR-9 during his Master's research at San Jose State University. He recovered limited archaeological samples for comparative data and for defining trends in regional mobility patterns and culture.

Excavations sampled 13.85 m.[3] of anthropogenic deposits, recovering 60 bone tool fragments and one complete awl. Chipped stone debitage totaled 7,980 pieces (32.5 kg.), mostly Monterey chert. Other finds included 34 temporally diagnostic projectile points, 24 point and biface fragments, 9 partial mortars, 13 pestles, 14 handstones, 2 milling slab fragments, and 4 bifacial pebble choppers, as well as large volumes of marine shell.

Site Chronology and Components

In 1990, Hylkema submitted several *Mytilus californianus* bulk samples from SCR-9 for conventional radiocarbon dating at Washington State University (Table 1). Though

Table 1

CONVENTIONAL RADIOCARBON DATES[a] ON BULK SAMPLES OF MUSSEL SHELL AND CHARCOAL FOR SCR-9 AND SMA-218

Sample	Lab Nº	Provenience	Conventional RYBP	Calibrated, marine reservoir corrected BP 2-sigma range
Mytilus californianus	WSU-3230	Unit 1 20 – 30 cm.	1,480 ± 65	907–1,191 (1,044)
Mytilus californianus	WSU-3203	Unit 4 130 –140 cm.	2,790 ± 60	2,348 – 2,696 (2,534)
Mytilus californianus	WSU-3204	Unit 5 140 –150 cm.	2,730 ± 60	2,311–2,657 (2,452)
Mytilus californianus	WSU-3170	Unit 2 200 cm.	2,940 ± 60	2,524 – 2,850 (2,719)
Charcoal	WSU-3171	Unit 2 190 –200 cm.	2,790 ± 85	2,752 – 3,080 (2,909)
SMA-218–*Mytilus*	WSU-3425	Pooled dates	2,880 ± 75	2,919 – 3,331 (3,122)

[a]All ¹⁴C dates from Hylkema (2002:Table 13.2). Calibrated with CALIB version 7.0.1 (Stuiver and Reimer 1993), 1-Sigma, 95% probability absolute date range after correction for atmospheric variation and marine reservoir effect.

bulk shell dates are stratigraphically concordant, Breschini and Haversat (2002) have stressed problems inherent in bulk shell radiocarbon dates, and SCR-9 merits further AMS radiocarbon dating of single shell samples. One 200 gm. charcoal sample from a shell-roasting pit feature at the basal 200 cm. level of Unit 2 provides a date for the earliest occupation of SCR-9 of 2,790±85 ¹⁴C B.P. (Table 1).

Projectile points from SCR-9 reflect two temporally-successive coastal traditions of the Northern Monterey Bay and the San Francisco Peninsula that have been diagnosed and dated at other sites—the Early Period Sand Hill Bluff Phase (ca. 5,500–2,800 B.P.) and the Middle Period Año Nuevo Phase (ca. 2,800–900 B.P.). Both phases are expressions of the California central coast Hunting Culture and are mainly distinguished by projectile point form combinations that are well dated in other contexts, and by changes in lithic raw material sources (Hylkema 2002; Jones et al. 2007:125 –146; Milliken et al. 2007:120–121). Regional sites that testify to this succession are SCR-7, the lower component of SCR-20, SCR-3, and SCR-40 for the Sand Hill Bluff Phase, with SMA-18 (Hildebrandt et al. 2009b) and SMA-218 (Hylkema 2002) for the Año Nuevo Phase.

Hylkema interpreted a distinct change in SCR-9's stratigraphy near 70 cm. below the surface as signaling the break between these two phases. A combination of notched projectile points, Rossi Square-stemmed points, and other contracting stemmed forms, plus milling gear generally characteristic of the Sand Hill Bluff Phase—predominantly handstones and milling slabs, with rarer mortars and pestles—was recovered from

deposits at 70–200 cm. The lower deposits were also distinguished by several lenses of ash and burned soil in alternating levels down to sterile matrix at 190–200 cm. (Fig. 2). These "roasting features" were filled with small, mostly complete, charred California mussel (*Mytilus californianus*) shells and lesser amounts of other dietary mollusk species and vertebrate remains. Artifact densities between these roasting features were greater than in the top 70 cm. of the site. Monterey chert from Point Año Nuevo was the principal flaked-stone raw material in this lower component, but some artifacts derived from more distantly sourced raw materials, such as Franciscan chert, suggest extensive networks of mobility or exchange existed (Hylkema 2002).

In deposits above 70 cm., Año Nuevo long-stemmed projectile point forms indicative of the Año Nuevo Phase dominate. Exotic Franciscan cherts disappear, and Monterey chert is the near-exclusive raw material, indicating more localized, everyday lithic raw material acquisition. However, obsidian lanceolates from northern Californian sources are also present, reflecting continued participation in long-distance exchange networks.

RESEARCH QUESTIONS

This article addresses three points concerning SCR-9 that have been raised in the California central coast archaeological literature. First, researchers have proposed a major shift in mobility patterns from the Early to the Middle Period in the northern part of the central coast, with later groups occupying smaller ranges and obtaining resources through a more logistical strategy than earlier
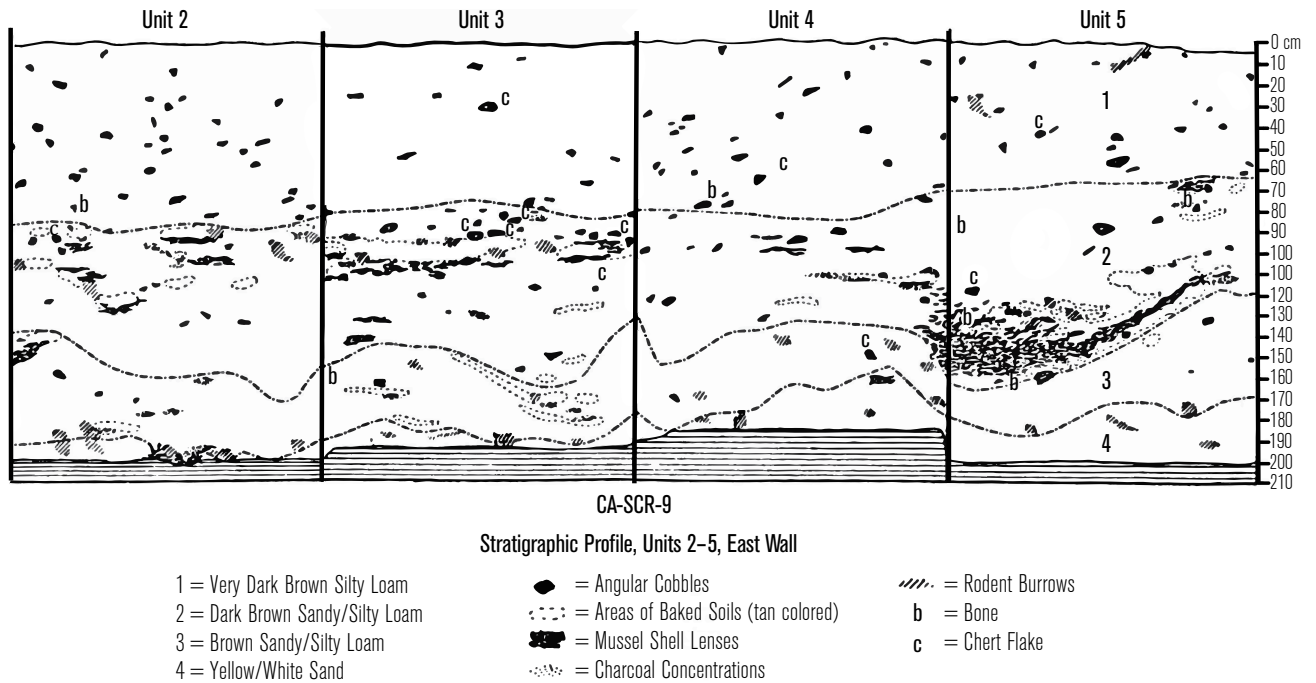
CA-SCR-9

Stratigraphic Profile, Units 2–5, East Wall

1 = Very Dark Brown Silty Loam	● = Angular Cobbles	/// = Rodent Burrows
2 = Dark Brown Sandy/Silty Loam	⁞ = Areas of Baked Soils (tan colored)	b = Bone
3 = Brown Sandy/Silty Loam	▧ = Mussel Shell Lenses	c = Chert Flake
4 = Yellow/White Sand	⋯ = Charcoal Concentrations	

Figure 2. SCR-9: Stratigraphic section of Units 2–5 (see text for details).

ones (e.g., Breschini and Haversat 1991; Hylkema 2002; Jones et al. 2007). The SCR-9 archaeofaunal sample can address whether major shifts in prey choice or intensity of handling tactics track with the technological and mobility shifts that differentiate Sand Hill Bluff from Año Nuevo phases in the Santa Cruz Mountains.

Second, Hildebrandt et al. (2009b) proposed that SCR-9 had a functional link to coastal sites on Point Año Nuevo, comparing it with early Middle Period SMA-218 (Table 1), which produced many northern fur seal (*Callorhinus ursinus*) remains and numerous Año Nuevo long-stemmed points. Pinniped taxonomic identifications, age classes, and element representation in the SCR-9 assemblage can address whether northern fur seals, either whole or butchered and selectively transported, were incorporated into seasonal foraging activities at SCR-9.

Third, Hylkema (2002) suggested that site use was strongly seasonal, and archaeofaunal data on seasonally breeding species, such as deer and fur seals, are ideally suited to address this question. Specifically, the SCR-9 archaeofauna can ascertain whether the locality was occupied during the June–October *Callorhinus* breeding season at Point Año Nuevo, when the species would have been vulnerable to human hunters and other predators.

METHODS

Excavation

Hylkema initially placed a single, 1 m.² excavation unit (Unit 1) near the site's center to assess site integrity, revealing a 1.8 m.-deep deposit with substantial volumes of mollusk shell, bone, stone tool debitage, and other artifacts. Ten meters to the west, he excavated four adjacent 1.5 m.² units (Units 2–5), forming a 6 m. × 1.5 m. trench (Fig. 2). Each unit was excavated in 10 cm. levels to sterile soil at about 200 cm. in depth, which was marked by an abrupt change from very dark brown, shell-rich, midden soil to a yellow-white sand matrix containing no cultural materials (Fig. 2). Deposits from Unit 1 were dry-screened using 1/8" mesh, Unit 2 deposits were wet-screened with 1/8" mesh, while Units 3, 4, and 5 were wet-screened through 1/4" mesh. Two 25 × 25 cm. column samples were excavated from the trench sidewall to provide volumetric control of mollusk shell, because only non-dietary mollusk shell from species such as *Olivella biplicata* were collected from other excavation units.

Vertebrate Analysis

During Hylkema's thesis research (Hylkema 1991, 2002), Dwight Simons identified about 700 vertebrate specimens, which were incorporated into the samples

analyzed for U.C. Santa Cruz senior thesis projects by Potenzone (2006–2007) and Nims (2010–2011). Potenzone and Nims each made preliminary identifications for non-carnivores in about one-third of the larger SCR-9 faunal assemblage, using comparative skeletons from the U.C. Santa Cruz vertebrate osteology collections. Identifications were spot-checked by Gifford-Gonzalez, and Nims further spot-checked the earlier, 2007 Potenzone analysis. Gifford-Gonzalez identified carnivore specimens, as well as marine mammals, using specimens from the same reference collections, augmented by several eared seal skeletons loaned by the California Academy of Science. U.C. Santa Cruz doctoral student Anneke Janzen assisted Nims with the identification of bird specimens, again using comparative specimens in the U.C. Santa Cruz vertebrate osteology collections. Ten fish bone specimens identified by Gobalet et al. (2004), and seven more specimens found in Potenzone's and Nims' analysis were identified by doctoral student Cristie Boone in 2010. All data described below were recorded in a customized FileMaker® database and later manipulated in Microsoft Excel®.

Sampling to Redundancy

The recovered SCR-9 assemblage contains an estimated 12,000 total NSP. Potenzone analyzed about 3,772 specimens, Nims analyzed an additional 4,169 specimens, and Gifford-Gonzalez selected and analyzed still another set of 134 identifiable mammal and bird specimens from the remaining unanalyzed specimens. The question arises as to whether much can be gained by analyzing the remainder of the assemblage. Increasing the size of an assemblage can increase the number of taxa that are observed, and may change the relative abundance of each taxon (Lyman 2008:142). However, at a certain point, no new taxa appear with further analysis.

To determine whether a sample represents the complete range of taxa in an assemblage, archaeologists can continue analyzing new subsamples until no new taxa are observed. This is called sampling-to-redundancy, and it has also been applied retroactively to determine whether an identified assemblage is representative of a larger parent population (e.g., McKechnie 2012). These approaches use species-area curves to determine visually whether a sample is sufficiently representative for a particular research question. If the curve levels off before all samples have been added to the graph, the identified assemblage can be considered representative of the deposited assemblage (Lyman and Ames 2007). If not, then redundancy may not have been achieved, or the remaining assemblage may represent a different statistical population with unique patterning. To determine whether SCR-9's identified archaeofaunal sample is representative of the recovered assemblage, we created a species-area curve by adding the number of new mammalian taxa identified during each month of zooarchaeological analysis in the order that they were analyzed.

Identification and Recording Protocols

Because excavations at the Middle Holocene-age Sand Hill Bluff Site (SCR-7) yielded pronghorn antelope (*Antilocapra americana*) specimens (Jones and Hildebrandt 1990), all medium-sized artiodactyl specimens from SCR-9 with potentially diagnostic features (long bone joint surfaces, metapodials, carpals, tarsals, phalanges) were compared with both pronghorn and mule deer (*Odocoileus hemionus*) elements. Gifford-Gonzalez checked all putative pronghorn identifications twice during the analysis and made a final check of eight specimens previously identified as *Antilocapra*. Ultimately, none were found to be consistent with *Antilocapra* morphology and were assigned to either *Odocoileus* or cf. *Odocoileus*. All specimens assigned to *Odocoileus* bore clear morphological traits of that species, whereas those assigned to cf. *Odocoileus* were those specimens that lacked such morphological indicators. Given the results of the detailed *Antilocapra–Odocoileus* comparisons, cf. *Odocoileus* specimens are highly likely to derive from mule deer. While these categories are kept distinct in our summary table of taxonomic attributions, they are merged in a number of other analyses.

Larger cervid specimens too fragmentary to be identified definitively as elk (*Cervus elaphus canadensis*) were tallied as elk for two reasons: no other cervids of comparable size existed in the region in pre-colonial times, and the relative gracility of elk bones would readily distinguish them from stratigraphically-intrusive historic cattle bones. Very small fragments of antler that could not be assigned to elk or deer were assigned to the category of "Cervidae, indet." because antlers only derive from members of the deer family.

Eared seal specimens were compared with skeletal elements of male and female northern fur seals and with California sea lions (*Zalophus californianus*), with occasional checks of female Steller sea lion (*Eumetopias jubatus*). Male northern fur seals overlap in size with both male California sea lions and female Steller sea lions, but details of their osteology differ. Elements of the small (30–50 kg.) female *Callorhinus* are distinctive, although they do overlap in size and (for some elements) morphology with those of the Guadalupe fur seal (*Arctocephalus townsendi*), an occasional visitor to the Monterey Bay area (Burton et al. 2002). Gifford-Gonzalez consulted as-yet unpublished notes and photographs of the latter species during identification, and is confident that the SCR-9 female fur seal specimens are *Callorhinus*.

Non-fish specimens too fragmentary to be attributed to a tetrapod class were assigned to the category "indeterminate vertebrate." These were mainly long-bone shaft fragments of medium-sized animals with thin-walled medullary cavities, which—for highly fragmented specimens lacking morphological landmarks—are difficult to distinguish between medium birds (e.g., ducks, cormorants) and lagomorphs. Patterns of thermal modification to such specimens may shed some light on this problem (see below).

Bone surface modifications were identified using a 10× binocular loupe, and verified with a 20× light microscope as necessary. Surface modifications to animal bones by humans were originally recorded as cut, scrape, and chop marks, hammerstone loading points, counterblow fractures, and anvil marks. Thermal alterations were documented using two criteria: bone color (after Shipman et al. 1984) and morphological alteration (e.g., calcination, vitrification). Human modifications to bone were aggregated into four general types: cutting tool marks, chop marks, percussion marks, and thermal alterations. Nonhuman modifications recorded included carnivore and rodent gnawing, root etching, and weathering, using Behrensmeyer's (1978) criteria, which apply only to bone tissue of unburnt, larger, adult mammal specimens. Lyman and Fox (1996) noted that although various skeletal elements proceed through Behrensmeyer's five weathering stages at different rates, weathering stages may be useful for studying site formation processes on a gross scale.

Lyman (2008:250–2510) distinguishes two dimensions of fragmentation: the *extent* of fragmentation, and the *intensity* of fragmentation. Measures of fragmentation extent represent how many specimens are broken. To determine fragmentation extent, each specimen was assigned a portion code that indicated which section of a skeletal element it represented and whether the specimen was a complete element. For cervid specimens, we also recorded which of Lyman's (1984) bone mineral density scan sites were present so that possible patterns of density-mediated destruction could be identified by comparing body-part representation to Lam et al.'s (1999) bone mineral density (BMD) CT scan values for caribou, another cervid. If more than one scan site was observed on a single specimen, we only recorded the least dense portion.

Measures of fragmentation *intensity* represent the average size, or number, or specimens that each skeletal element has been broken into. Cannon (2013) has demonstrated that average specimen size is a useful, valid measure of bone fragmentation that can also be used to compare fragmentation among specific taxa. To measure specimen size, we recorded the maximum dimension of specimens in millimeters with nested measurement templates, and we recorded the weight of specimens to the nearest tenth of a gram. Because multiple specimens with identical provenience, taxonomic and anatomical attributions, and bone modifications were bagged together, the aggregate weight of each whole bag lot was recorded, but only the maximum dimension of the largest specimen in a bag lot was recorded. Although weight is likely a valid measure of fragmentation intensity, it may be affected to an unknown degree by diagenetic processes. Therefore, we focus our attention on specimen size in this paper.

Assessing Shifts in Prey Choice and Processing Intensity
To assess Hylkema's earlier assertion that a shift in predation accompanied the change in mobility patterns from Sand Hill Bluff to Año Nuevo phases, we performed Spearman's rank-order correlation test for mammal species abundances in each phase, measuring taxonomic abundance using NISP. At the suggestion of a reviewer, we repeated this test using MNE values that were derived for all mammal species and family-level taxa at the site. MNE is the minimum number of whole

elements necessary to produce the number of specimens from a given taxon and skeletal element observed in an assemblage (Lyman 2008:218–22).

Derivation of MNE has been a topic of considerable debate in archaeology since the 1990s (see Marean et al. 2001). Our analysis determined MNE (and therefore minimum number if individuals [MNI]) using a non-graphical permutation of the overlap method: each specimen was assigned a portion code that indicated which section of a skeletal element it represented. For example, a fragmentary specimen that represented only the lateral part of a femur's distal end received portion code DSLAT, while one representing the entire distal end of a femur received portion code DS (see Gifford and Crader 1977). All specimens of bilaterally symmetrical elements of a given species from the same side of the body that display anatomical overlap—such as the distolateral and distal femur specimens—must represent different skeletal elements. MNE was derived for every element attributed to a given taxon, and then summed to produce a measure of taxonomic abundance.

We also explored whether there were any shifts in burning or bone comminution. We used the chi-squared test to determine whether patterns of thermal alteration changed over time, and Student's t test to evaluate whether fragmentation intensity, measured as the mean maximum dimension, changed over time.

Because few other assemblages in the regional literature present details on specimen size, we derived two other, widely used measures of fragmentation intensity (NISP:MNE and NSP:NISP) that can be used for comparisons to other assemblages, for the Sand Hill Bluff and Año Nuevo phases. The ratio of the number of identified specimens (NISP) to the minimum number of elements (MNE) represented for a single taxon, excluding complete specimens (Lyman 2008:251–252), was derived using the sum of MNE values for every element attributed to *Odocoileus* and *Cervus* in a given phase. Higher NISP:MNE ratios indicate elements were broken into more pieces, while ratios approaching 1:1 imply each specimen is relatively complete. However, as elements are broken into smaller and smaller pieces, fewer of these are likely to be identifiable to element (Lyman 2008:253–254). Thus, a NISP:MNE ratio approaching 1:1 could indicate specimens are relatively complete, *or* that they are fragmented beyond

recognition, creating a problem of equifinality. This problem can be overcome by comparing NISP:MNE ratios with other measures of fragmentation, such as NSP:NISP (Wolverton 2002:91).

The ratio of the number of specimens (NSP) to the NISP in an assemblage also measures fragmentation intensity. Cannon (2013:411) showed that unlike NISP:MNE, NSP:NISP increases linearly with fragmentation intensity. Higher NSP:NISP ratios indicate greater fragmentation, with few identifiable specimens relative to the number of specimens in the assemblage (Wolverton et al. 2008:16). Ratios of NSP:NISP approaching 1:1 suggest that all specimens are complete enough to enable identification. NSP:NISP ratios were derived for each phase using the NISP and total NSP recorded for mammals.

Because bone becomes less resilient and more friable as the organic component burns away (Fairgrieve 2008), it is fair to ask whether fragmentation in the SCR-9 archaeofauna results from the thermal stresses to which many specimens were subjected. In other words, was specimen fragmentation predominantly caused by burning and subsequent taphonomic effects rather than by direct percussion on fresh bones? We explored this question statistically using the chi-squared test to determine whether burning and fragmentation extent were statistically related. For this test, we measured fragmentation extent and burning as binary variables. Each specimen was tallied as either complete or broken using the portion code that was recorded for it, where CO indicates the specimen was complete, and all other values indicate the specimen was broken. We used our records of thermal alteration to determine whether specimens were burned or not.

Assessing Regional Connections

To assess Hildebrandt et al.'s (2009b) hypothesis that SCR-9 was functionally linked to Point Año Nuevo, we used the taxonomic, age (see below), and element representation of pinnipeds to establish whether the inhabitants of SCR-9 were connected to the northern fur seal procurement at sites such as the early Middle Period SMA-218. We also used patterns of element representation for cervids to explore differential body-part transport decisions that were made for the most abundant taxa in the assemblage.

To determine whether bone mineral density (BMD) mediated destruction explains body-part representation in this assemblage, we also compared the frequency of Lyman's (1984) scan sites on all *Odocoileus* and *Cervus* specimens to Lam et al.'s (1999) CT scan BMD values for caribou using Spearman's correlation test. We calculated Spearman's rho (r_s) twice using two distinct measures of abundance: NISP and normed NISP (NNISP), where NNISP is equal to the NISP for each element divided by the frequency of that element in a complete skeleton. If these tests showed that density-mediated destruction explained cervid body-part representation, then differential destruction may also account for patterns of body-part representation in other taxonomic groups.

Assessing Seasonality

To assess Hylkema's (2002) earlier suggestion that site use on the California central coast was strongly seasonal, we used species representation of migratory birds to determine which seasons the site was occupied. We also examined the age-class profiles of species with seasonal breeding patterns, such as deer and fur seals, to explore SCR-9's season of occupation.

Deer specimens were initially assigned to general age classes of neonate, one-year, two-year, and adult specimens based on comparison with the skeletons of known-age individuals. Their states of dental eruption and wear, cranial suture fusion, and/or epiphyseal fusion were recorded and then used to ascribe age-at-death more closely, using Severinghaus (1949) for dentitions and Purdue (1983) for epiphyseal fusions. All specimens assigned to the "indeterminate" age category *by definition* did not display bone-size ranges or woven bone-surface textures that would place them in the "neonate" or "young juvenile" categories. Hence, this class represents *only* older, larger-bodied individuals of older juvenile, young adult, or adult age that cannot be further subdivided. Elk specimens were assigned to general age categories using the same protocol and element size. Northern fur seal specimens were similarly assigned to general age classes of young, older juvenile, young adult, and adult based on comparison with the skeletons of known-age individuals.

Statistical Analyses and Effect Size

Because it is possible to observe nonrandom but practically insignificant relationships, particularly when there is a large number of observed cases (Wolverton et al. 2014), we also report the *effect size* for each test that we use. While statistical tests determine whether relationships between variables are *statistically* significant and not the product of chance, measures of effect size help determine whether such relationships are *practically* significant. Assessing practical significance is necessary to evaluate how meaningful a relationship between variables is in a real world context.

For Spearman's correlation test, effect size is measured with the coefficient of determination (R^2), which signifies how much of the variation in one variable can be explained by the other target variable. A coefficient equal to or less than 10% indicates a trivial relationship exists between the variables, 25% is moderate, and coefficients of 50% or greater demonstrate that a strong relationship exists.

Effect size for the chi-squared test was measured using phi (φ), which is calculated by taking the square root of the test statistic (χ^2) divided by the sample size. If the result is less than 0.1, the relationship between the target variables should be considered weak. Values of phi roughly equal to 0.3 are considered moderate, and 0.5 indicates a strong relationship.

Finally, effect size for Student's *t* test was measured using Cohen's *d*, which is equal to the difference between two means divided by the pooled standard deviation. When Cohen's *d* is less than or equal to 0.2, the differences between means is minimal. A value of 0.5 is moderate, and values of 0.8 or greater are only observed when the difference between two means is substantial and meaningful.

RESULTS

The analyzed sample contained 8,075 specimens, consisting of 97.6% mammal, 1.8% bird, 0.2% fishes, three small reptile vertebrae, and 0.4% (NSP = 31) "indeterminate vertebrate" specimens. Sand Hill Bluff Phase units produced a total of 6,897 vertebrate specimens, while Año Nuevo Phase deposits yielded 1,177 specimens (Fig. 3). Of the total assemblage, 3,031 mammal specimens (Table 2), 107 bird specimens (Table 3), and 31 vertebrate specimens were too fragmentary to permit finer-grained taxonomic identification. Three specimens, while identifiable (two *Odocoileus*, one *Sylvilagus*),
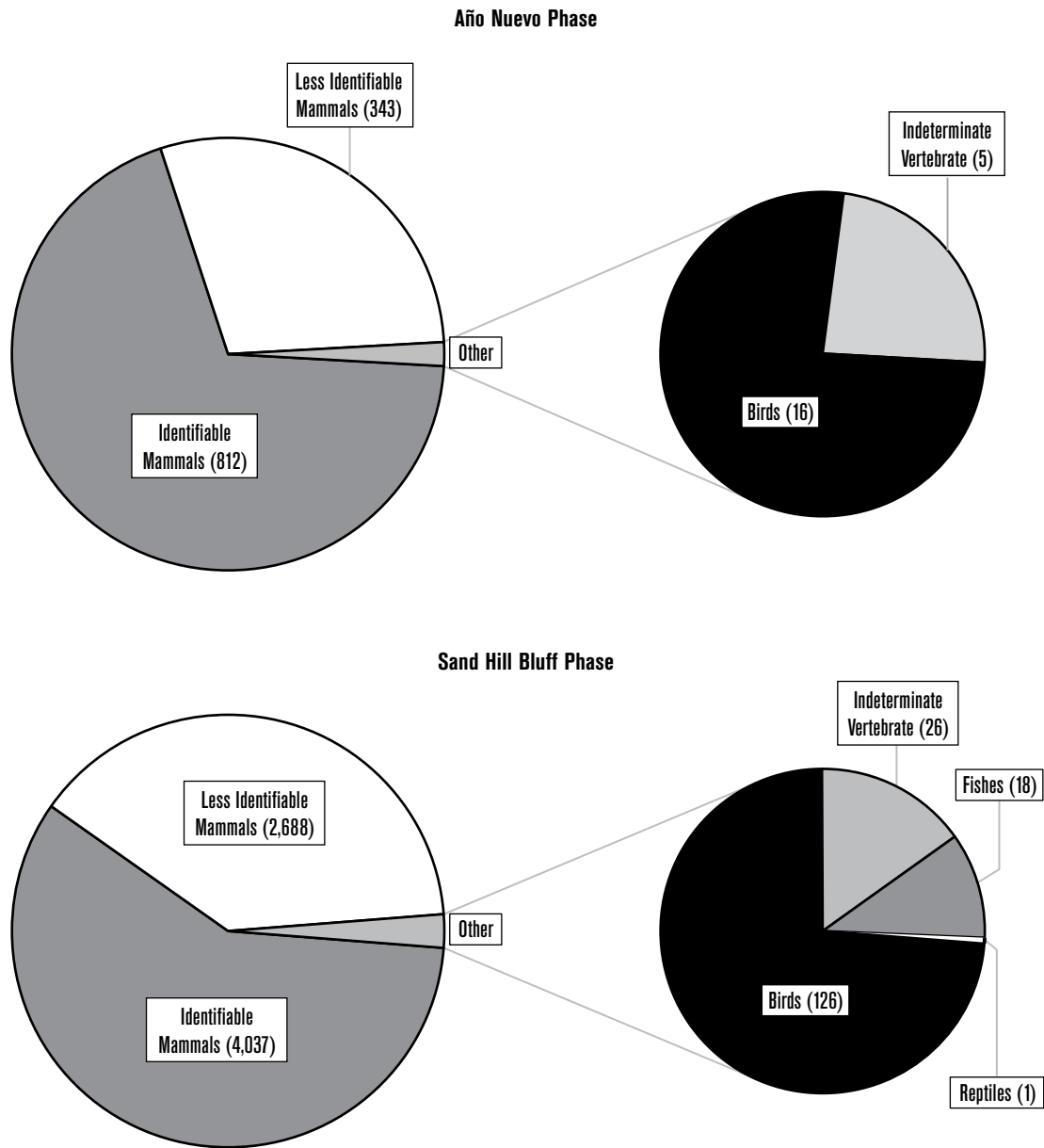
Año Nuevo Phase

Sand Hill Bluff Phase

Figure 3. SCR-9: Taxonomic composition of the Año Nuevo and Sand Hill Bluff phases by NSP for each vertebrate class.

lacked provenience data. Thus, the total number of all Sand Hill Bluff and Año Nuevo Phase specimens in the tables is 8,072.

Is the Archaeofauna Sampled to Redundancy?

The cumulative richness curve for SCR-9 demonstrates that the assemblage has been sampled to redundancy, with redundancy reached in March of 2011 (Fig. 4). Interestingly, some new taxa were added in several samples that had very small sample sizes. For example,

the five specimens recorded in October 2007 contained two new taxa, and the 191 specimens recorded in October 2010 contained three new taxa. We consider the results discussed here to be representative of the taxa in the entire recovered sample.

Taxonomic Representation

Mule deer (*Odocoileus hemionus*) dominate the taxonomically identifiable mammals, accounting for about 81% of identifiable mammal specimens (Table 2).

Table 2

IDENTIFIABLE MAMMALS[a] IN SAND HILL BLUFF (SHB) AND AÑO NUEVO (AN) PHASES

Taxon	Common Name	SHB NISP	SHB %	SHB MNE	AN NISP	AN %	AN MNE	Total NISP
Cervus elaphus canadensis	Elk	177	4.4	52	34	4.2	21	211
Odocoileus hemionus	Mule deer	1,438	35.6	469	243	29.9	105	1,681
cf. *Odocoileus*	cf. Mule deer	1,848	45.8	–	418	51.5	–	2,266
Cervidae indet.	Indet. antler fragments	21	0.5	–	9	1.1	–	30
cf. *Canis latrans*	Coyote	14	0.4	10	4	0.5	4	18
Urocyon cinereoargenteus	Gray fox	1	<0.1	1	1	0.1	1	2
Procyon lotor	Raccoon	0	0	0	1	0.1	1	1
Ursus arctos horribilis	Grizzly bear	4	0.1	4	0	0	0	4
Lynx rufus	Bobcat	7	0.2	5	0	0	0	7
Puma concolor	Mountain lion	2	0.1	2	0	0	0	2
Mephitis mephitis	Striped skunk	1	<0.1	1	2	0.3	2	3
Enhydra lutris	Sea otter	14	0.4	12	4	0.5	4	18
Pinnipedia indet.	Pinniped indet.	25	0.6	3	0	0	0	25
Otariidae indet.	Eared seal indet.	13	0.3	6	3	0.4	3	16
Zalophus californianus	California sea lion	6	0.2	6	2	0.3	2	8
Callorhinus ursinus	Northern fur seal	70	1.7	38	16	2	11	86
Phoca vitulina	Harbor seal	2	0.1	2	0	0	0	2
Mirounga angustirostris	Northern elephant seal	1	<0.1	1	0	0	0	1
Cetacea	Large whale indet.	53	1.3	3	0	0	0	53
Rodentia indet.	Rodent indet.	31	0.8	–	9	1.1	–	40
Sciuridae indet.	Squirrel indet.	15	0.4	10	8	1	5	23
Peromyscus californicus	California mouse	1	0	1	0	0	0	1
Microtus californicus	California vole	2	0.1	2	0	0	0	2
Neotoma fuscipes	Dusky-footed woodrat	38	0.9	19	3	0.4	3	41
Thomomys bottae	Botta's pocket gopher	49	1.2	18	23	2.8	19	72
Lepus californicus	Black-tailed jackrabbit	3	0.1	1	0	0	0	3
Sylvilagus bachmani	Brush rabbit	201	5	80	32	3.9	27	233
Total NISP		4,037	100	746	812	100	208	4,849

Less Identifiable Size Class	Mammal Size Equivalencies	SHB NSP	SHB %		AN NSP	AN %		Total NSP
Mammal Size Indet.	Mammal Size Indet.	2,379	88.5		241	70.3		2,620
Very Small Mammal	Small rodents, mole	0	0		0	0		0
Small Mammal	Rabbit, larger rodents	10	0.4		4	1.2		14
Medium Mammal	Coyote, raccoon, bobcat	146	5.4		33	9.6		179
Large Mammal	Female NFS, deer	151	5.6		65	19		216
Very Large Mammal	Male NFS, elk	2	0.1		0	0		2
Less ID Total		2,688	100		343	100		3,031
Mammalia Total NSP		6,726			1,156			7,882

[a]Identifiable mammals by NISP, %NISP ("%") and the sum of MNE for all elements, and less identifiable mammals by NSP.

Elk account for slightly over 4%. Pronghorn antelopes are definitively not in evidence in the assemblage. All remaining identifiable mammals account for only 13% of the assemblage.

The size of cetacean remains indicates they are from larger whales, such as the gray, humpback, or blue, all of which visit the coastal region at different seasons. All 53 specimens were found below 80 cm. in depth, with the majority concentrated between 140–200 cm. in Unit 2. Given that most of these specimens were too fragmentary to determine the skeletal element, it cannot be determined whether these could represent more than one individual.

Among bird species, Brandt's cormorant (*Phalacrocorax penicillatus*) is the most common, closely followed

Table 3

BIRDS AND FISHES BY NSP (NUMBER OF SPECIMENS)

| Taxon	Common Name	NISP	%
Birds			
Anas cyanoptera	Cinnamon teal	1	0.7
Aythya valisineria	Canvasback duck	1	0.7
Anatidae indet.	Ducks, geese, and swans	8	5.6
Aechmophorus occidentalis	Western grebe	2	1.4
Podiceps nigricollis	Black-necked grebe	5	3.5
cf. *Uria aalge*	Common murre	4	2.8
Larus occidentalis	Western gull	1	0.7
Phalacrocorax penicillatus	Brandt's cormorant	6	4.2
Ardea alba	Great egret	1	0.7
Ardea herodias	Great blue heron	2	1.4
Buteo jamaicensis	Red-tailed hawk	1	0.7
Melanerpes formicivorus	California woodpecker	1	0.7
Callipepla californica	California quail	2	1.4
Aves indet.	Aves indet.	107	75.4
Total NISP Birds		142	100
Fishes			
Carcharhinidae	Requiem sharks	1	5.6
Embiotocidae	Surfperches	2	11.1
Damalichthys vacca	Pile perch	1	5.6
Oncorhynchus sp.	Pacific salmon/trout	3	16.7
Cebidichthys violaceus	Monkeyface prickleback	3	16.7
Ophiodon elongatus	Lingcod	2	11.1
Scorpaenichthys marmoratus	Cabezon	2	11.1
Actinopterygii indet.	Ray-finned fishes	4	22.2
Total NISP Fishes		18	100
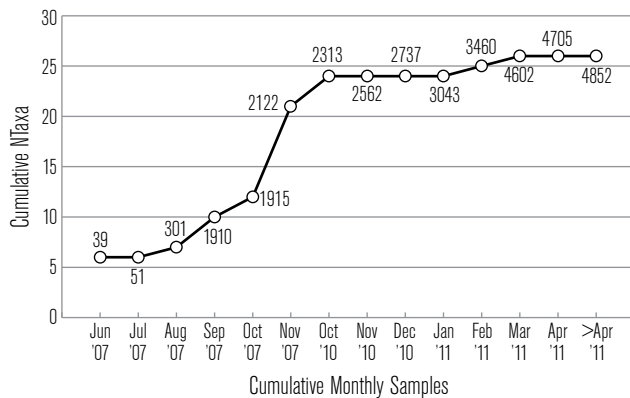
Figure 4. Cumulative richness (NTaxa) of mammalian taxa in the identified SCR-9 assemblage in monthly increments of recorded materials. Sample size (cumulative NISP) is reported with each sample.

by black-necked grebes (*Podiceps nigricollis*) and murres (*Uria aalge*). Indeterminate duck, goose, or swan (Anatidae) specimens were the most numerous taxonomic group; two duck species—cinnamon teal (*Anas cyanoptera*) and canvasback duck (*Aythya valisineria*)—were definitively identified (Table 3).

Gobalet et al. (2004) and Boone (2012) identified 17 fish specimens; all species are from nearshore marine habitats, except for salmon, a seasonal visitor to freshwater streams, rivers, and nearshore habitats (Table 3). Many more fish specimens would likely have been recovered from the excavation had finer-grained recovery methods been used. Thus, this report is likely to seriously underestimate the contribution of marine fishes to the SCR-9 diet. The balance of this article will focus on the analysis of the mammal remains.

Bone Surface Modifications

Cut marks occur on 305 specimens, or 3.8% of the aggregate assemblage. Taxon-specific differences in cutting-tool modification are evident. Cervid species display higher frequencies than any other taxon, with 6.7% of specimens displaying marks from cutting tools (Table 4). Chops were noted on 83 specimens, 79 of which were identified as cervid elements, where they were concentrated on long-bone articular ends and bones of the fore and hind feet. SCR-9 cervids also display the highest concentration of percussion marks (246 of 255 specimens), mainly on long bones.

Thermal alterations, especially color changes, are present on 54% of all SCR-9 specimens (Table 4). Approximately 27% of all thermally-altered vertebrate specimens were exposed to temperatures of ≥645 °C (Fig. 5), as described by Shipman et al. (1984). Frequencies of thermal alteration vary among animal classes and species groups. Pinnipeds, birds, and indeterminate vertebrates closely match the assemblage's average rate, while lagomorphs, rodents, and indeterminate mammals show markedly lower rates of thermal alteration (Table 4). Cervids and sea otters (*Enhydra lutris*) exhibit greater-than-average rates of burning and thermally-induced changes to bone texture.

Carnivore modifications appear on 110 specimens, 102 of which were identified as cervid remains (Table 4). Only four cervid long-bone fragments show evidence of carnivore stomach acid etching, while all other carnivore-

Table 4

AGGREGATE SURFACE MODIFICATION BY TAXONOMIC CATEGORY

Taxon	Count	Cut		Chop		Percussion		Burnt		Carnivore[a]	
		#[b]	%[c]	#[b]	%[c]	#[b]	%[c]	#[b]	%[c]	#[b]	%[c]
Cervidae	4,190	282	6.7	79	1.9	246	5.9	2,610	62.3	102	2.4
Enhydra lutris	18	0	0	0	0	1	5.6	15	83.3	0	0
Pinnipedia	138	5	3.6	1	0.7	0	0	80	58.0	2	1.5
Rodentia	179	1	0.6	0	0	0	0	53	29.6	3	1.7
Leporidae	237	0	0	0	0	2	0.8	83	35.0	1	0.4
Mammalia indet.	3,031	7	0.2	2	0.1	3	0.1	1,370	45.2	1	<0.1
Aves	142	1	0.7	0	0	0	0	75	52.8	0	0
Vertebrata indet.	31	0	0	0	0	0	0	17	54.8	0	0
Other	287	10	3.5	1	0.3	3	1.0	104	36.1	4	1.4
Total	8,075	305	3.8	83	1.0	255	3.2	4,353	54.0	110	1.4

[a]Carnivore: carnivore modifications; [b]"#": number of specimens; [c]"%": percent of total taxon NISP.
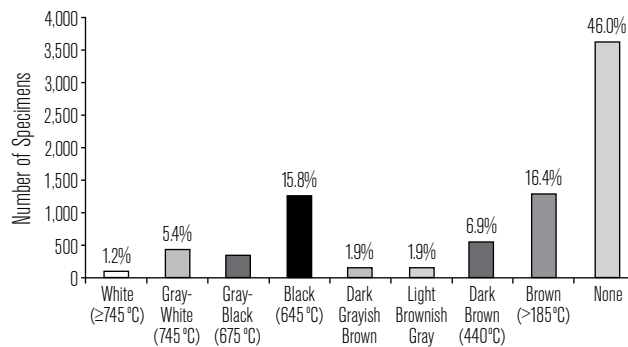

Figure 5. SCR-9: Thermal alteration of mammal bone (NISP = 7,882) by color and associated temperature ranges specimens would have had to reach in ºC (Shipman et al. 1984).

modified specimens bear combinations of tooth pits, scores, punctures, and furrowing, as described by Binford (1981). Tooth mark sizes suggest specimens were gnawed by coyotes or by similarly sized domestic dogs.

Rodent gnawing appears on 31 specimens, the majority of which are cervids (28 NISP). Root etching was more common, with over 12% of all specimens displaying some level of intensity of this modification (997 NISP). There was little evidence of bone weathering in the 1,757 specimens that could be assessed for such damage. All but seven of these specimens met the criteria for weathering stages 0 through 2 as described by Behrensmeyer (1978), and the remaining seven specimens belong to Behrensmeyer's weathering Stage 3. Overall, these measures suggest that animal bone in this assemblage was

not heavily modified by rodent activity, root etching, or weathering agents, before or after deposition.

Prey Choice Over Time

Comparing the abundance of the identified mammalian species in each phase reveals few substantial changes in prey choice. Deer was the dominant mammal species in both phases, representing about 81% of identifiable mammals in each component (Table 2). The next two most abundant species, elk and brush rabbit (*Sylvilagus bachmani*), which are nearly tied in rank order abundance in both phases, show no substantial changes in relative abundance over time. Among the remaining taxa represented by NISP >30, cetaceans are the only group showing marked differences in relative abundance between the two phases, with 53 specimens in the Sand Hill Bluff Phase and none in the Año Nuevo Phase. Many more taxa are represented in the Sand Hill Bluff component than in the Año Nuevo component, likely a product of the differences in sample size for each assemblage.

Spearman's correlation test confirms these obser-vations, showing there are no statistically significant changes in the rank order abundance of mammalian taxa in the Sand Hill Bluff and Año Nuevo phases, whether abundance is measured using NISP ($r_s = 0.657$; df = 22; $p < 0.001$) or the sum of MNE for all elements attributed to a species ($r_s = 0.789$; df = 22; $p < 0.001$) (Table 2). The effect size for each test shows the correlation for NISP is moderately strong ($r_s^2 = 43\%$), and the correlation for

MNE is very strong ($r_s^2 = 62\%$). Consistency in patterns of prey exploitation between the Sand Hill Bluff and Año Nuevo phases is therefore both statistically and practically significant.

Processing Intensity Over Time

Close analysis of thermal alterations and bone fragmentation intensity in each component suggests there was little to no change in prey handling between the Año Nuevo and the Sand Hill Bluff phases. Año Nuevo Phase specimens do appear to exhibit greater frequencies of burning than specimens from the earlier component. In the Sand Hill Bluff Phase, 51.7% of specimens (3,567 NISP) were thermally altered, while in the Año Nuevo Phase, 67.3% (792 NISP) displayed thermal alteration (Table 5). The χ^2 results indicate this difference is statistically significant ($\chi^2 = 98.85$, df = 1, $p = < 0.0001$). If burning rates remained the same over time, we would expect to see 542 unburned specimens in the Año Nuevo component, but we instead observed 385 specimens unburned. However, the effect size for this test ($\varphi = 0.11$) indicates the magnitude of change in the rate of thermal alteration is not meaningful.

Both components are marked by patterns of extensive fragmentation, though more specimens have been broken in the Sand Hill Bluff Phase sample (95.7%) than in the Año Nuevo Phase sample (94.4%; Table 5). Considering the high rates of thermal alteration and specimen fragmentation that has been observed, it is reasonable to ask whether these two variables are related to one another. We used the chi-squared test to determine whether frequencies of thermal alteration and the extent of fragmentation are correlated. Results of this test show that burning and bone fragmentation are statistically dependent ($\chi^2 = 21.195$; df = 1; $p < 0.001$). If fragmentation and burning were not related, we would expect to see 167 complete specimens with no burning, but 210 were observed (Table 6). However, the effect size of this test indicates the relationship between burning and fragmentation is extremely weak ($\varphi = 0.05$). Practically speaking, complete specimens are very uncommon in this assemblage, and a very large number of specimens have been broken, although they display no evidence of having been burnt. Therefore, burning does not strongly predict specimen fragmentation, and vice versa.

Table 5

FRAGMENTATION AND BURNING IN SCR-9 PHASES

	Sand Hill Bluff	Año Nuevo	Total
NISP Burned	2,411	556	2,967
NID[a]/LID[b] Burned	1,151	236	1,387
Total Burned	3,562	792	4,354
Not Burned	3,333	385	3,718
Total	**6,895**	**1,177**	**8,072**
Complete	297	65	362
Broken	6,598	1,112	7,710
Total	**6,895**	**1,177**	**8,072**

[a]"NID": nonidentifiable; [b]"LID": Less identifiable (e.g., vertebral fragments not further identifiable, diaphysis fragments).

Table 6

NUMBER OF SPECIMENS WITH BURNING COMPARED TO FRAGMENTATION EXTENT

	Complete	Broken	Total
Burned	153	4,201	4,354
Not Burned	210	3,511	3,721
Total	**363**	**7,712**	**8,075**

Fragmentation intensity was also very high in both phases: the average maximum dimension of specimens in the Sand Hill Bluff Phase was 28.4 ± 16 mm., and in the Año Nuevo Phase it was 26.8 ± 18 mm. (Table 7). Considering that over 92% of the recorded specimens derive from large mammals, this small average specimen size indicates the assemblage is highly fragmented. Cervid specimens themselves had a mean maximum dimension of 28.9 ± 12 mm. in the Sand Hill Bluff Phase, and 30.4 ± 15 mm. in the Año Nuevo Phase.

Comparisons of the average maximum dimensions of elk specimens, deer specimens, and all mammal specimens appear to suggest that fragmentation *intensity* in the Año Nuevo Phase was greater than the Sand Hill Bluff Phase (Table 7), even though fragmentation was slightly more *extensive* in the earlier component. However, Student's *t* test shows that differences in the mean maximum dimension for *Cervus* specimens (Table 7) are not statistically significant ($t = 0.0537$; df = 209; $p = 0.957$; Cohen's $d = 0.010$). Changes in average specimen size for *Odocoileus* ($t = 2.022$; df = 3945; $p = 0.043$; Cohen's $d = 0.08$) and all mammals combined

Table 7

FRAGMENTATION MEASURES FOR AÑO NUEVO AND SAND HILL BLUFF PHASES

Taxon	NISP	MNE	NSP	NISP:MNE	NSP:NISP	Av. Max. Dim. (mm.) [SD[a]]
Año Nuevo Phase (000 – 070 cm.)						
Cervus[b]	32	19		1.684		37.4 [±20.4]
Odocoileus[b]	635	79		8.038		29.8 [±20.1]
Mammalia	812		1,155		1.424	27.1 [±17.6]
Sand Hill Bluff Phase (070 – 200 cm.)						
Cervus[b]	166	41		4.049		37.6 [±19.8]
Odocoileus[b]	3,112	303		10.271		31.3 [±16.8]
Mammalia	4,037		6,725		1.666	28.8 [±16.3]

[a]"SD": Standard Deviation; [b]NISP and MNE for *Cervus* and *Odocoileus* are for incomplete specimens only.

$(t = 3.235;$ df $= 7878;$ $p < 0.001;$ Cohen's $d = 0.10)$ are statistically significant. However, the actual differences in average maximum dimensions are on the order of millimeters, so small as to be negligible in practical human terms.

Measurements of fragmentation intensity derived from taxonomic abundance measures contradict the results of specimen size comparisons, suggesting fragmentation intensity was slightly higher in the Sand Hill Bluff component than in the Año Nuevo component. NISP:MNE ratios are slightly higher for Sand Hill Bluff Phase cervid specimens, indicating they are slightly more fragmented than the cervid specimens in the Año Nuevo Phase (Table 7). NSP:NISP ratios also indicate the Sand Hill Bluff assemblage is slightly more fragmented.

In sum, differences in the average specimen size (measured as the mean maximum dimension of specimens) between the two components of SCR-9 in terms of average specimen size are negligible, and indicate there was virtually no change in fragmentation intensity. The suite of measures for fragmentation intensity and fragmentation extent all suggest SCR-9 specimens are highly fragmented, and that there was no noticeable change in processing intensity over time.

Age Structures in the Northern Fur Seal Sample
Reproductive-age females account for 55% of all northern fur seal specimens, with some representation of younger and breeding-age males (Table 8). Young-of-the-year, pups less than six months of age, and slightly larger juveniles, are well represented (NISP=11).

Table 8

AGE AND SEX REPRESENTATION OF
***CALLORHINUS URSINUS* INDIVIDUALS**

Age	Unknown	Sex		Totals	%
		Female	Male		
Young of year	9	0	1	10	12.2
Older Juvenile	6	9	2	17	20.7
Young Adult	0	3	3	6	7.3
Adult	3	45	1	49	59.8
Totals	18	57	7	82	100
%	22	69.5	8.5	100	

Male fur seals account for about 9% of all *Callorhinus* specimens (NISP=12), but their low representation may be partly related to the difficulty of making definitive taxonomic identifications for like-sized eared seals from very fragmentary specimens. Male California sea lions and female Steller sea lions are similar in size to male fur seals, are known to have been present in this region, and are morphologically convergent.

Body Segment Representation
Given the highly fragmented state of this assemblage, monitoring differential body-part transport decisions for large bodied prey such as elk versus the smaller deer is not straightforward. A very rough, NISP-based comparison of major body segments between these size categories shows fragments of deer-sized and elk body segments do not approximate their proportions of the cervid body (Fig. 6). Ribs and thoracic vertebrae are less
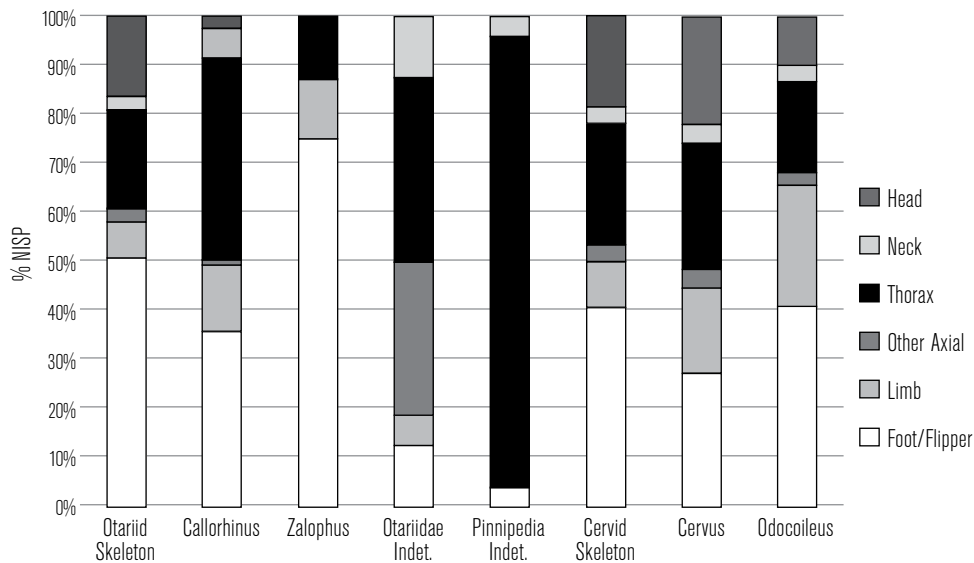
Figure 6. SCR-9: Body segment representation in pinnipeds and cervid specimens, by %NISP, compared to segment representation for eared seal (otariid) and cervid skeletons. "Head": NISP for cranium, mandibles, dentition, and hyoid (antlers are excluded); "Neck": NISP for cervical vertebrae; "Thorax": NISP for thoracic vertebrae, ribs, and sternebrae; "Other Axial": lumbar vertebrae and sacrum; "Limb": NISP for scapula, innominate, and all long bones; "Foot/Flipper": NISP for carpals, metacarpals, phalanges of the manus, plus tarsals, metatarsals, phalanges of the pes.

Callorhinus is repre-sented predominantly by ribs and thoracic vertebrae (41%), as well as bones of the flipper (37%), with few elements from the head or limbs, despite the very durable nature of pinniped mandibles, teeth, and limb bones (Fig. 6). Fur seal males are represented by neck, thorax, and flipper bones (Fig. 6). The same bias toward thoracic and axial elements exists among California sea lion (*Zalophus californianus*) and indeterminate large eared-seal specimens. Specimens that were so fragmentary they could

common than predicted by body segment proportion in both groups, while the long-bone elements are much more common than predicted, possibly suggesting that density-mediated destruction accounts for patterns of body segment representation in this assemblage.

However, bone mineral density does not predict element survivorship in SCR-9 cervids. We compared the frequency of BMD scan sites in all cervid specimens—using NISP and NNISP (Grayson and Frey 2004)—to BMD values for caribou with Spearman's correlation test. According to our results, BMD does not predict the rates of scan site occurrence measured in NISP (r_S=0.130; df=97; p=0.201; r_S^2=1.7%). While density and scan site frequency are statistically correlated when frequency is measured as NNISP (r_S=0.245; df=97; p=0.014), the relationship is very weak in practical terms (r_S^2=6%) and BMD has no predictive power. Therefore, density-mediated destruction does not explain body segment representation for cervids, and it is unlikely to explain body segment representation in other taxa as well.

Pinniped element frequencies are strongly biased toward specific body segments, following a pattern that deviates from that observed for cervids (Fig. 6). Female

not be assigned to either eared seals or true seals were assigned to "Pinniped indet." This category is dominated by rib fragments (Fig. 6). Because only three of 128 identifiable pinniped elements were from harbor (*Phoca vitulina*) or elephant seals (*Mirounga angustirostris*), this "Pinniped indet." category most likely represents the ribs of eared seal species. Implications of patterns in cervid and pinniped body segment representation will be discussed below.

Age Structures in the Cervid Sample

Deer and elk specimens preponderantly derive from older juvenile through adult deer (Table 9). If the "indeterminate" age category—which excludes very young individuals—is included, 97.4% of specimens come from older juveniles of 18–24 months and adults over 24 months in age. Individuals in these categories have reached sexual maturity and (for females) almost their full body size. Implications of the presence of neonate and even some fetal bones for seasonality will be discussed below. Elk specimens range from younger juveniles through adults, although as with deer, the sample is dominated by older juveniles through adults.

Table 9

**AGE REPRESENTATION OF CERVID SPECIES.
DEER AGES FROM SEVERINGHAUS (1949) FOR DENTITIONS
AND PURDUE (1983) FOR EPIPHYSEAL FUSIONS**

Age (Months)	Taxon		Totals	% of Age
	Odocoileus	*Cervus*		
Fetal: (<0)	3	0	3	0.1
Neonate (0 – 6)	5	0	5	0.1
Young Juvenile (7 –18)	110	10	120	2.9
Older Juvenile (19 – 24)	158	6	164	3.9
Young Adult (24 – 36)	21	7	28	0.7
Adult (>36)	1,631	87	1,718	41.3
Older Juvenile to Adult (19 –>36)	2,015	101	2,116	50.9
Totals	3,947	211	4,158	100
% of Artiodactyls	94.9	5.1	100	

DISCUSSION

Prey Choice

Prior work in California central coast archaeology has suggested that the transition between the Sand Hill Bluff and Año Nuevo phases was marked by decreases in the size of ranges that human groups occupied, and by a shift to more logistical foraging strategies (e.g., Breschini and Haversat 1991; Hylkema 2002; Jones et al. 2007). However, a rank-order comparison of mammalian taxonomic abundance in the Sand Hill Bluff and Año Nuevo components of SCR-9 shows no statistical or practical changes in prey choice between these two phases. Moreover, there are no substantial changes in the exploitation of terrestrial, upland resource patches in the vicinity of SCR-9 relative to the logistical exploitation and transport of distant, marine shoreline resources to the site.

The primary sources of animal protein represented by the vertebrates of SCR-9 were mule deer, which would have been available throughout the year in the uplands of the Santa Cruz Mountains. Whitaker (2009) has shown that mule deer can sustain high rates of predation without population collapse, allowing the SCR-9 occupants to regularly crop prime-age animals without causing exploitation depression in local deer populations. While elk would be higher ranked than deer, based on the assumption that their larger body size provided greater caloric returns, elk may be more vulnerable to exploitation depression. Indeed, elk become increasingly rare in regional archaeofaunas

from the Early through Late periods, suggesting that exploitation depression might have occurred (Geary et al. 2009; Gifford-Gonzalez et al. 2013). Decreases in the frequencies of *Cervus* are not in evidence at SCR-9, though elk specimens are much less common than deer in both phases.

Lagomorphs, which would be available in upland and near to shoreline resource patches, should rank lower than cervids in human diets. While they can be captured passively by setting simple snares on their runways, their small body size and exceptionally lean meat provide low rates of return relative to deer and elk. At only 5% of identified mammal remains, they are represented in much lower proportions at SCR-9 than at the nearby sites of SMA-18 (*Sylvilagus*: 29% NISP; Geary et al. 2009) or SMA-113 (*Sylvilagus*: 13% NISP; Gifford-Gonzalez et al. 2013). SMA-18 rabbit remains were also characterized by extensive carnivore modification, suggesting they might have been captured to provision domestic dogs (Geary et al. 2009). In contrast, SCR-9 rabbit remains lack carnivore modification (Table 4), suggesting they were likely processed for human consumption.

Human predation may account for the presence of wood rats (*Neotoma fuscipes*) in the assemblage as well. These nocturnal rodents do not actively burrow into the ground, nor do they use other rodents' burrows. They sleep during the day in above ground "lodges" that are often clustered in "villages" (Bonadio 2000), allowing for easy capture with simple weapons and little energetic investment. *Neotoma* specimens also display high rates of thermal alteration (32% NISP), and one displays a cut mark, suggesting culinary processing.

It is less clear if gophers (*Thomomys bottae*) are present in the SCR-9 assemblage due to human predation, or whether they are intrusive. Active gopher burrowing zones normally extend to only 55 cm. below the surface (Erlandson 1984), but their occurrence in lower levels may reflect gopher activity in relation to the level of the land surface in earlier times. Krotovinas were documented in all excavation levels, and gophers do sometimes die in their burrows. About 18% of pocket gopher specimens in the SCR-9 assemblage have been thermally altered, but each of these burned specimens displays color changes across the entire surface of the bone, as is typical of elements exposed to heat once stripped of their meat. This contrasts with thermal

alterations to gopher specimens from SMA-18, where a similar proportion (23%) are thermally altered but where the alterations are localized on frontal, nasal, and jaw elements, a patterning anatomically consistent with the practice of roasting gophers whole (Geary et al. 2009).

Despite the ample, reliable sources of animal protein locally available to SCR-9's inhabitants, marine mammals are well represented throughout the site's occupation. With more calories per kilogram of flesh and more dietary fat than cervids, pinnipeds would have been ranked even more highly than cervids when they were available. *Callorhinus* pelts also have potential value as commodities in regional exchange systems, increasing the ranking of this prey item if goals beyond caloric returns are considered. However, in contrast to the terrestrial prey items, pinnipeds are not always readily available for capture. Eared seal species would only have been available in considerable numbers during the five to six months of the year that their migration and breeding patterns bring them to shore in this region. Importantly, they are never distributed evenly on a shoreline, but instead congregate in densely populated rookeries. While other pinniped species residing on the California coast throughout the year—such as harbor seals (*Phoca vitulina*)—are more evenly distributed on the shoreline, they are also known to relocate to offshore rocks and sea stacks in response to human predation, resulting in microhabitat depression.

Sea otters (*Enhydra lutris*) would be ranked lower than pinnipeds if body size and body fat are used to approximate caloric returns. Sea otter specimens are poorly represented in the SCR-9 assemblage, but they display extremely high frequencies of thermal alteration, with burning observed on 83% of sea otter specimens, 30% higher than the assemblage average (Table 4). In contrast, only 57% of SCR-9 pinnipeds are burned (Table 4). No nutritionally-based explanation has been found for this differential handling of sea otters, which may have arisen from other, cultural considerations. It would be worthwhile to geographically map this form of handling of *Enhydra* versus other marine mammals.

Frequencies of avian species show a preference for fatty water birds, such as Brandt's cormorant, murres, grebes, and geese and ducks (Table 3), which are common to all Monterey Bay area sites analyzed by Gifford-Gonzalez, except SMA-113, where birds are very rare (Gifford-Gonzalez et al. 2013).The frequency of thermal alteration for birds (55%) closely resembles the alteration rates on specimens in the "indeterminate vertebrate" category (53%), suggesting that these diaphysis fragments are more likely to have derived from avian limb bones than from rabbits, which display much lower rates of burning (35%).

Fishes, especially small, fat-rich species such as sardines or herring, are largely absent from the SCR-9 archaeofauna even though they are present in the well-recovered SMA-113 assemblage. These resources may have provided reliable sources of lipids in winter and spring months of the year (Boone 2012), in addition to those available from fatty overwintering and resident bird species. However, the near-absence of fish and the low frequencies of bird remains could be explained by the relatively coarse mesh sizes used in the SCR-9 excavations.

In addition to the analyzed sample of vertebrate remains, the SCR-9 deposits included large quantities of unanalyzed marine shell. In one column sample measuring $0.5\,m.^3$ in volume, Hylkema recorded over 40 kg. of dietary shell species, over 95% of which were estimated to be *Mytilus californianus*. Therefore, there are approximately 80 kg. of shell remains per cubic meter of midden at SCR-9, demonstrating that the upland site's occupants were heavily provisioned with shellfish from marine resource patches, even if the vertebrate remains do not mirror the strength of this association. The motivations behind the transport of marine shellfish to the uplands of SCR-9 remain unexplored, and merit further research.

In sum, ample evidence exists for some logistical foraging in both the Sand Hill Bluff and Año Nuevo phase components at SCR-9. The bulk of the vertebrate remains derive from species present in the immediate vicinity of the site, although the presence of marine vertebrate taxa demonstrates that logistical forays to more distant resource patches occurred throughout the site's occupation.

Prey Transport

Patterns of element representation for cervids and pinnipeds reflect the selective transport of body segments. Based on the assumptions of central place foraging

models, hunters can be expected to cut down costs associated with transporting whole carcasses by breaking bodies of larger animals into manageable segments and discarding, stripping, or consuming low utility portions at the procurement locale. Selective transport decisions are based, among other things, upon the nutritional value of the body segments, the available processing technology, and the distance between the procurement site and the central residential site (Lupo 2006).

For deer and elk, the absence of cervid rib elements at SCR-9 (Fig. 6) suggests these segments were discarded in the field after the costal muscle meat was stripped from them. While the intensive, on-site fragmentation of cervid elements could cause differential destruction of these fragile elements and produce element frequencies that mimic patterns of selective transport (cf. Grayson 1989; Lyman 1985), statistical comparisons of cervid element frequencies and BMD values do not support this argument (see above). Moreover, the relatively delicate rib bones of small, female northern fur seals are overrepresented relative to the number of ribs in the eared seal body (Fig. 6), suggesting that human segment selection and differential transport explain body segment representation in this assemblage.

While SCR-9's marine mollusks and fishes could have been transported from the relatively close shoreline at the mouth of San Vicente Creek, northern fur seals were probably taken at Point Año Nuevo, a former northern fur seal rookery (Gifford-Gonzalez 2011). Historically, Point Año Nuevo was a rookery for Steller sea lions, as it is for northern elephant seals (*Mirounga angustirostris*) today (Allen et al. 2011; Le Boeuf 1994). A large upwelling cell immediately north of Point Año Nuevo (Trainer et al. 2000) may have attracted the eared seal species to the point, as otariid females are "income breeders" that must forage repeatedly in rich waters during lactation, unlike the "capital breeder" elephant seals.

Notwithstanding osteological proof of transport of *Callorhinus* to SCR-9, travel between the site and Point Año Nuevo would have presented challenges. Coastal beach access would have been impeded by the sheer and unstable cliffs between the mouth of Waddell Creek and the Point itself. Instead, pedestrians could circumvent the 19 km. of intervening northeast-southwest trending ridgelines in the Coastal Range by travelling along the 1,800–2,000 ft. contour for 18 km.

north-northwest, the course that Empire Grade Road follows today. After descending a moderate slope into the upper drainage of Waddell Creek's north branch, where Big Basin Way runs today, Point Año Nuevo could be reached by hiking a short distance to the head of Año Nuevo Creek and then following it down to the shoreline. Alternatively, seaworthy tule balsas could have facilitated travel between Año Nuevo and SCR-9 by being launched near San Vicente Creek or Molina Creek to the north. Regardless of the mode of access, carcass transport between Point Año Nuevo and the upland site of SCR-9 would have incurred substantial energetic costs.

The patterns of element representation for northern fur seals appear to reflect energy saving practices of selective transport of body segments. Female fur seals weigh 30–50 kg. and males 175–275 kg., and both sexes (but especially males) would require processing for longer-range transport. Relative to their rank in Savelle et al.'s (1996:Table 5) otariid utility index, northern fur seal head (62.8% modified meat utility index [MMUI]) and neck (94.8% MMUI) elements are underrepresented, probably because brains and tongues have a short shelf-life. It is likely that such parts were extracted and consumed soon after butchery, while the fat and meat from these segments were transported farther inland (Gifford-Gonzalez and Hildebrandt 2012). Meanwhile, the very heavy, marrow-free long bones of Otariidae could have been stripped of meat and abandoned at or near the butchery site (Gifford-Gonzalez and Hildebrandt 2012). Flippers are also well represented, despite their relatively low utility index (6.2% MMUI), probably because they are characterized by a high fat-to-weight ratio. Flippers are valued delicacies among many circumpolar peoples (Mitchelmore 2011; Scheffer 1948), and similar tastes could have developed on the California coast.

Seasonality

Mule deer specimens testify to human occupation of SCR-9 during several seasons. All antler specimens from SCR-9 that were complete enough to have pedicle zones show they were shed naturally, suggesting they were collected in late winter or early spring, when mule deer and elk drop their antlers. The presence of some neonatal mule deer remains, on the other hand, indicate humans hunted deer soon after they gave birth in late spring

to early summer (Taber and Dasmann 1957), and the remains of young juveniles are indicative of hunting in late summer through fall (Table 9).

In the elk sample, neonates are absent while young-of-the-year, older juvenile, and adult individuals are present, suggesting that humans preyed upon elk herds in late summer or autumn, following the late spring to early summer calving season (Table 9).

Eared seals are summer breeders that generally come to shore late in spring and leave by early fall (Allen et al. 2011; Gifford-Gonzalez 2011). The wide range of ages represented for northern fur seals, which congregate on shore in rookeries between April and November, implies human predation occurred during this entire span (Table 8). One neonatal and two young juvenile California sea lion specimens further confirm summer occupation of the site, as these pinnipeds haul out year-round on the coast but only breed from May to early August (Allen et al. 2011).

In contrast to the strong summer indicators presented by the mammalian taxa, avian remains suggest SCR-9 was also occupied during the winter. The western grebe, canvasback duck, and western gull, all found in the SCR-9 archaeofauna, are only present on the California central coast during winter months (Peterson and Peterson 2008). Weighing all seasonal indicators, SCR-9 was probably used at least intermittently throughout the year, with a very strong signal for occupation from early summer to early fall. Interestingly, these different lines of evidence suggest SCR-9 inhabitants were exploiting upland terrestrial resources and marine resource patches simultaneously.

Intensity of Processing

The most striking aspect of the SCR-9 assemblage is the extreme intensity of fragmentation in the elements of cervids. Cervid specimens show the highest frequencies of percussion-associated surface modifications (Table 4), which could be associated with marrow extraction or more intensive bone reduction practices. Fracturing long bones for marrow extraction usually leaves the epiphyseal ends of the bones intact, as the moving fronts of the fracture force terminate when they reach cancellous tissue in these zones of an element (Blumenschine 1988). However, the SCR-9 cervid specimens demonstrate intensive fragmentation of both cancellous and compact bone, with an average maximum dimension that is smaller than the typical size of shaft fragments produced by marrow extraction. These patterns of extreme bone reduction are not unique to SCR-9, as similarly intense fragmentation has also been noted at other northern Santa Cruz and southern San Mateo County sites from the Middle and Late periods (Geary et al. 2009; Gifford-Gonzalez et al. 2013).

The zooarchaeological literature usually interprets patterns of intensive bone reduction as a signal of bone grease extraction (Binford 1978; Leechman 1951; Outram 2001; Vehik 1977). These patterns are typically observed for mass kills of ungulates in prime condition in strongly seasonal climates, where fat shortages in winter can lead to starvation on lean meat diets with few carbohydrates (Speth and Spielmann 1983). However, mule deer and elk live in relatively small groups and were probably not subjected to mass kills. In addition, deer would have reached prime condition in the fall, but the consistency of bone comminution at SCR-9 and SMA-113 (where cervid specimens are even smaller on average: 21.2 ± 12.2 mm.) suggests cervid bone was heavily processed regardless of season (Gifford-Gonzalez et al. 2013). Cases of intensively fragmented ruminant bone have also been identified within the greater central California region in Santa Clara Valley at sites such as CA-SCL-119, where cervid specimens have an average maximum dimension of 34.8 ± 35.9 mm. for the Middle Period component, and 27.0 ± 21.8 mm. for the Middle-Late Transition component (Sunseri 2015).

This begs the question of why central coast peoples invested so much energy in reducing ungulate bones into small fragments. Though Wohlgemuth (2010) characterizes this region's edible plants as unproductive, some plant carbohydrates would have been available year round in the form of fresh tubers from marshes or through storage of seasonally available nuts and seeds, and even low quantities of carbohydrate or fat are sufficient to offset the vicious physiological cycle of "protein poisoning" (Speth and Spielmann 1983).

Cases that parallel the extreme bone reduction observed in California central coast sites exist in the South American Puna and in Patagonia, where foragers hunted small family herds of guanaco and vicuña, taking only a few individuals at a time. Argentine zooarchaeologists using specimen size to document

fragmentation of camelid bones report 20–70 mm. modal maximum dimensions, including specimens from articular ends of long bones (De Nigris 2005; Mondini and Elkin 2011; Stoessel 2014). However, in contrast to Stoessel's (2014) study, which shows intensification in camelid fragmentation over time, the labor-intensive reduction of ungulate bone appears relatively constant in California central coast Early, Middle, and Late Period sites. At SCR-9 in particular, there is no evidence for meaningful changes in the intensity of processing over time.

Intensive bone reduction on the California central coast could be related to energetic trade-offs rather than survival-driven bone grease extraction. Reducing mammal bone into small fragments reduces the volume of water and the amount of fuel that is required for simmering a mixture of bone and water, which facilitates bone grease and collagen extraction (Janzen et al. 2014). The products of such techniques could be consumed immediately as a soup, rather than rendered and stored for use in lean seasons, as most North American bone grease extraction literature assumes. Unfortunately, very little is currently known about the culinary technology of the California central coast, and the energetic trade-offs of different practices (e.g., Thoms 2009) and methodological approaches to recognizing those practices (e.g., Sunseri 2015) merit further research.

CONCLUSIONS

Returning to the research questions defined at the outset of this article, we conclude, first, that there were no changes in prey choice at SCR-9 during the Sand Hill Bluff to Año Nuevo Phase transition. The vertebrate remains indicate SCR-9's occupants consistently targeted prime-age deer and made logistical forays to coastal resource patches throughout the sequence. Second, the northern fur seals represented in the SCR-9 assemblage support assertions by Hylkema (2002) and Hildebrandt et al. (2009b) that SCR-9 was linked to the acquisition of northern fur seals somewhere along the San Mateo coast, most likely Point Año Nuevo. However, it is also possible that this prey item was acquired through exchange relations with peoples living closer to and controlling pinniped rookeries on the Point, rather than through direct procurement. Third, archaeofaunal evidence from seasonally available migratory birds and fur seals, as well

as age structures in the deer and elk samples, indicates that SCR-9 was occupied in early summer, fall, and winter, with much stronger signatures of site use during the early summer through autumn months, when cervids would have been in peak condition.

The SCR-9 archaeofaunal sample also provides evidence for extensive mule deer carcass processing practices, including body segmentation, selective transport of body segments, and intensive bone reduction. Such levels of bone fragmentation, which are typical of labor-intensive bone grease extraction practices in other regions, remain unexplained at this site and in other closely analyzed assemblages from the California central coast. The motivation behind such intensive processing warrants additional research into the costs and benefits of artiodactyl carcass handling practices.

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