AN EARLIER EXTIRPATION OF FUR SEALS IN THE MONTEREY BAY REGION: RECENT FINDINGS AND SOCIAL IMPLICATIONS

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*Numerous remains of northern fur seal (*Callorhinus ursinus*) at the Moss Landing Hill Site (CA-MNT-234) permit detailed insights into human offtake, carcass handling, and the time span over which the animals were preyed upon in the area. Fourteen direct AMS dates on Moss Landing Hill fur seals, plus 18 other direct dates on fish and terrestrial mammal bone, put their last appearance closer to 2000-1600 cal B.P. than to 1000-800 cal B.P., or the span of the Medieval Climatic Anomaly droughts. Other dates from the greater Monterey Bay also suggest fur seals disappeared before the MCA's extreme dry conditions affected central California. This shifts their extermination from a time of environmental crisis to one of socio-cultural elaboration, raising questions about the social motivations for their regional extirpation.*

INTRODUCTION

This paper focuses on long-term history of human uses of northern fur seals (*Callorhinus ursinus*) around the greater Monterey Bay. Our zooarchaeological analyses build upon broader coordinated research on northern fur seal biogeography and paleoecology, involving bone stable isotopes, dating, and mortality profile analyses (Burton and Koch 1999; Burton et al. 2001; Gifford-Gonzalez et al. 2005; Newsome et al. 2006, 2007). Findings from this prior research on fur seal ecology provide a context for the present one that focuses on the human and social dimensions of northern fur seal exploitation. Implications of these findings will be discussed in relation to earlier models proposed for "tragedies of the commons," and finally, we will touch on broader issues in the application of optimal foraging/optimal diet models to zooarchaeological data.

MATERIALS

Evidence derives from ongoing research at two site clusters, one in the Moss Landing area, most especially the Moss Landing Hill Site (MNT-234), and the other at Point Año Nuevo, specifically SMA-18 and SMA-218. MNT-234 is located on a stabilized sand dune very near the junction of Elkhorn Slough and the Monterey Submarine Canyon, at the center of the Monterey Bay shoreline. Point Año Nuevo is located some 80 km north of Moss Landing on the open seacoast. A peninsula with a recently detached island at its farthest extent, it is today a haul-out for California sea lions (*Zalophus californianus*). The mainland reportedly was a former haul-out for Steller sea lion (*Eumetopias jubatus*) (Fiscus and Baines 1966); presently it is home to a breeding colony of northern elephant seals (*Mirounga angustirostris*) founded in the twentieth century (LeBoeuf and Panken 1977). Zooarchaeological data point not only to an absence of elephant seals but also of Steller sea lions, with *Callorhinus* the dominant pinniped in all sites sampled to date.

The SMA-18 faunal analysis is completed, with some 4,467 vertebrate elements, of which 2,289 are mammal remains recovered in several successive excavations of the site (Table 1). A full reanalysis of slightly older SMA-218, the later residential site SMA-97 (Hylkema 1991), and other Año Nuevo sites, is needed before a full picture of the archaeological evidence for fur seal exploitation can be gained. Findings for MNT-234 are preliminary rather than definitive, as about 5,600 of an estimated 7,500 identifiable specimens from the so-called Primary Midden have been recorded, including taxonomic composition (Table 2), element representation, and bone modifications by human and non-human agents.

METHODS

Faunal materials from MNT-234 are normally archived at California State University's Moss Landing Marine Laboratories. Our analysis has been conducted there and in our own laboratory at UC Santa Cruz. Primary data fields include element, portion, symmetry, and taxonomic identification, age estimates based on visual inspection of tooth eruption, bone size and texture in the case of immature specimens, and epiphyseal fusion. Metric data were recorded from all measurable *Callorhinus* mandibles, limb bones, and selected carpals and tarsals for age estimation based on logistical growth curves from modern specimens as developed by Etnier (2002; Newsome et al. 2007).

Bone surface modifications recorded for each specimen included cuts, scrapes, chops, percussion marks, carnivore

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Table 1. CA-SMA-18: Identifiable Mammal Specimens. Identifications by Diane Gifford-Gonzalez, Tom Garlinghouse, Ben Curry, Patrick Omeara. From Hylkema et al. 2006

Linnaean Taxon	Common Name	NISP	Percent
Pinnipedia	Seals and sea lions		
Callorhinus ursinus	Northern fur seal	99	9.3
Arctocephaline indet.	Indeterminate fur seal	12	1.1
Zalophus californianus	California sea lion	12	1.1
Otariid indet.	Indeterminate eared seal	29	2.7
Phoca vitulina	Harbor seal	5	0.5
Mirounga angustirostris	Northern elephant seal	1	0.1
Pinniped indet.	Indeterminate pinniped	5	0.5
Cetacea	Whales, dolphins, porpoises		
Phocoena phocoena	White-sided dolphin	1	0.1
cf. *Eschrichtius robustus*	cf. Gray whale	2	0.2
Carnivora	Carnivores		
Enhydra lutris	Sea otter	67	6.3
Mephitis mephitis	Skunk	5	0.5
Mustela frenata	Weasel	1	0.1
Urocyon cinereargenteus	Gray fox	1	0.1
Canis sp.	Coyote and/or dog	6	0.6
Ursus arctos horribilis	Grizzly bear	1	0.1
Procyon lotor	Raccoon	1	0.1
Terrestrial carnivore indet.	Indeterminate terrestrial carnivore	4	0.4
Ruminata	Ruminants		
Cervus canadensis	Elk	27	2.5
Odocoileus hemionus	Mule deer	48	4.5
Medium ruminant indet.	Deer/Pronghorn sized ruminant	123	11.5
Leporidae	Rabbits and hares		
Sylvilagus sp.	Cottontail rabbit	388	36.4
Lepus californicus	Black-tailed jackrabbit/hare	6	0.6
Leporid indet.	Indeterminate rabbit or hare	19	1.8
Rodentia	Rodents		
Neotoma fuscipes	Dusky-footed woodrat	26	2.4
Perognathus sp.	Indeterminate pocket mouse	1	0.1
Peromyscus sp.	Field mouse	8	0.8
Microtus californicus	California mouse	33	3.1
Thomomys talpoides	Pocket gopher	97	9.1
Rodentia indet.	Indeterminate rodent	38	3.6
	Total	1,066	100.0

Table 2. MNT-234: Interim Results for the Primary Midden Mammalian Assemblage, Showing More Identifiable Elements Only

Linnaean Taxon	Common Name	NISP	Percent
Pinnipedia	Seals and sea lions		
Callorhinus ursinus	Northern fur seal	2,071	45.7
Arctocephalus townsendi	Guadalupe fur seal	41	0.9
Arctocephaline *indet.*	Indeterminate fur seal	267	5.9
Zalophus californianus	California sea lion	92	2.0
Eumetopias jubatus	Steller sea lion	6	0.1
Otariid *indet.*	Indeterminate eared seal	86	1.9
Phoca vitulina	Harbor seal	9	0.2
Pinniped *indet.*	Indeterminate pinniped	271	6.0
Cetacea	Whales, dolphins etc.		
Cetacea indet.	Cetaceans	1	0.0
Delphinid indet.	Indeterminate dolphin	1	0.0
Carnivora	Carnivores		
Enhydra lutris	Sea otter	62	1.4
Lutra canadensis	River otter	1	0.0
Taxidea taxus	Badger	1	0.0
Mustela indet.	Weasel	3	0.1
Mephitis mephitis	Striped skunk	3	0.1
Felis concolor	Puma	1	0.0
Felis rufus	Bobcat	3	0.1
Felid indet.	Felid indet.	8	0.2
Urocyon cinereargenteus	Gray fox	4	0.1
Canis latrans	Coyote	55	1.2
Canis cf. *latrans*	Indeterminate canine cf. coyote	47	1.0
Procyon lotor	Raccoon	16	0.4
Carnivore indet.	Carnivore indet.	12	0.3
Ruminata	Ruminants		
Cervus canadensis	Elk	13	0.3
Odocoileus hemionus	Mule deer	61	1.3
Antilocapra americana	Pronghorn antelope	10	0.2
Medium ruminant	Deer/pronghorn sized ruminant	24	0.5
Leporidae	Rabbits and hares		
Sylvilagus bachmani	Cottontail rabbit	179	3.9
Lepus californicus	Jackrabbit	4	0.1
Leporid indet.	Indeterminate rabbit or hare	3	0.1
Rodentia	Rodents		
Neotoma fuscipes	Dusky-footed woodrat	53	1.2
Perognathus sp.	Pocket mouse	2	0.0
Peromyscus sp.	Field mouse	107	2.4
Microtus californicus	California vole	469	10.3
Thomomys bottae	Pocket gopher	533	11.8
Spermophilus beecheyi	Beechey's ground squirrel	13	0.3
Insectivora	Insectivores		
Scapanus latimanus	Shrew	1	0.0
	Total	4,533	100.0

and rodent gnawing, carnivore stomach-acid etching, root etching, and thermal modifications to color and structure. With the permission of Moss Landing Marine Laboratories, we sampled bones of selected taxa for bone stable isotope assay and radiocarbon dating, and are collaborating with Elizabeth Hadly's (Stanford University) ancient DNA laboratory to sample MNT-234 *Callorhinus* for ancient DNA, which they have been successful in amplifying in a pilot study with other sites.

RESULTS

At SMA-18, 10 percent of the remains were northern fur seals, including the remains of adult males, females, juveniles, and young-of-the-year (Table 1). At the MNT-234 Primary Midden, nearly 47 percent of identified specimens derive from this species (Table 2).

Site Formation at the CA-MNT-234 Primary Midden

The Primary Midden deposit on which this analysis is based is extensive even in its reduced form, covering 165 m northeast/southwest by nearly 100 m northwest/southeast. The deposit is more than 3 m in depth. Based on an impressive array of single-shell radiocarbon dates, Breschini and Haversat (1995; G. Breschini, personal communication 2006) and Milliken et al. (1999) concluded that the Primary Midden spanned some 5,000 years, from 5500 to 500 B.P.

In the course of our analysis, a pattern emerged in the frequencies of bone elements in the vertical section of the Primary Midden, roughly resembling a normal curve (Figure 1). This raised the question of whether the primary midden was created over 5,000 years or reflected a dominant, briefer span of deposition, evinced in the peak of bone specimens between 120 and 220 cm in depth. To address this, we ran 34 direct AMS radiocarbon dates on bones of northern fur seal (14), Guadalupe fur seal (1), coyote (12), and Pacific hake (7). These cluster between ca. 1500 and 2100 cal B.P., with a marine correction of 250 ± 35 years (Stuiver and Polach 1977). Specimens yielding these dates, like the shells dated earlier, were distributed more or less randomly over the entire vertical 3 m, with slightly greater density at 120-220 cm.

These results suggest that the MNT-234 Primary Midden deposit represents a few hundred years' sample of human and ecological time in the early second millennium B.P. The

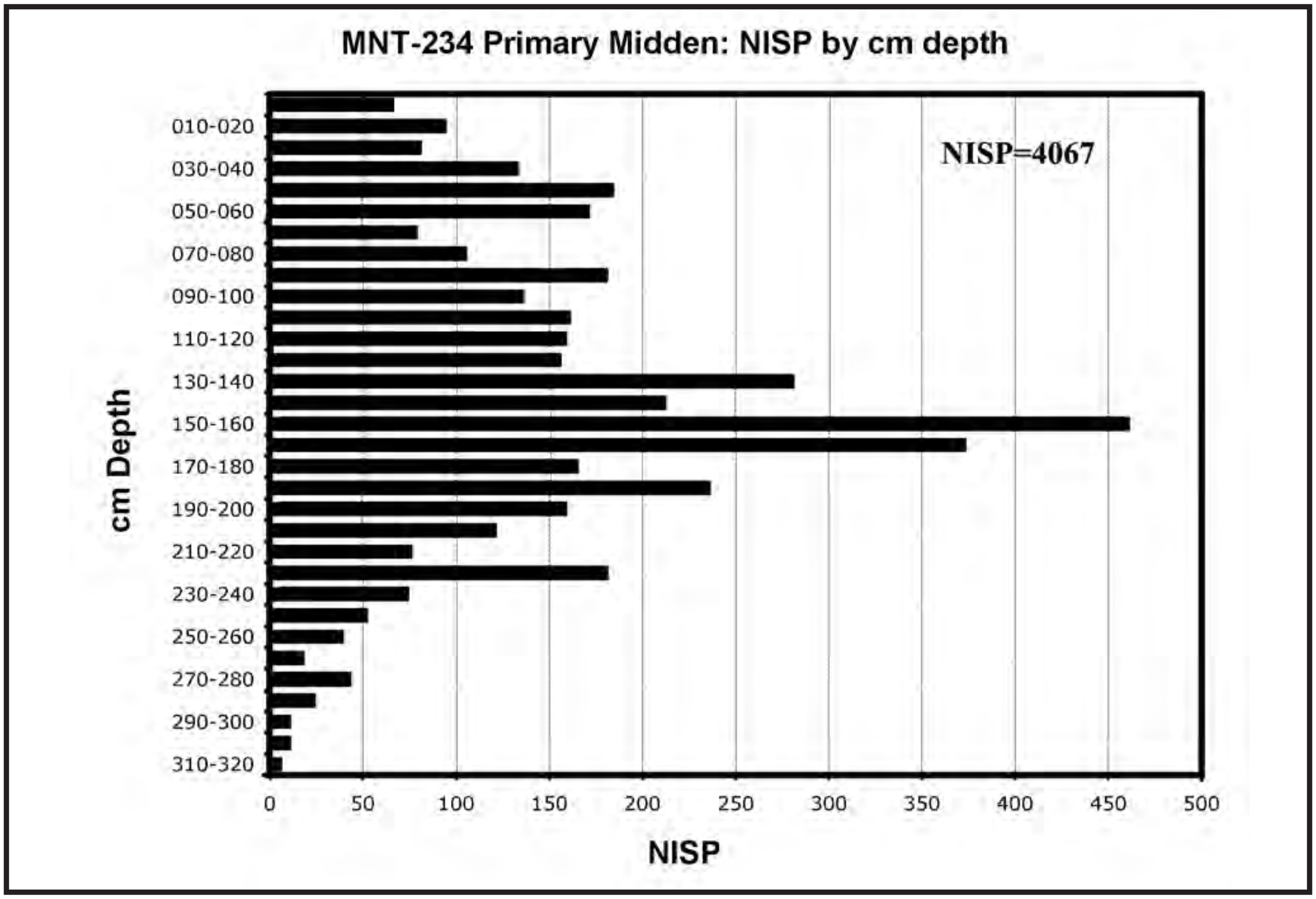

Figure 1. MNT-234 Primary Midden: vertical distribution of bird and mammal bones, showing a peak of specimens between 130 and 190 cm depth below datum, with a falloff on either side of the peak.

importance of the Primary Midden in regional historical ecology and archaeology is not diminished by these findings. It is the largest regional faunal assemblage recovered with well-controlled methods, and it constitutes the largest, best constrained temporal sample of *Callorhinus* between San Miguel Island and the Olympic Peninsula. Although the Primary Midden materials are extremely vertically dispersed, there is very little evidence that this deposit is "mixed" in the classic sense. It therefore can be used as a single temporal and behavioral sample.

Isotopic Analyses and Osteometric Age Estimates for Fur Seals at CA-MNT-234

A total of 80 *Callorhinus* specimens from the Primary Midden were sampled for bone isotopic data (Newsome et al. 2007). These same analyses were also carried out with a much smaller northern fur seal sample from SMA-18. Additionally, 101 of the MNT-234 Primary Midden *Callorhinus* specimens have been measured and have ages derived using Etnier's method. Our findings revealed several points about the Moss Landing and Año Nuevo fur seals:

1. Bone isotopes show that these individuals foraged far offshore on pelagic prey, as do their modern relatives, thus making it unlikely that the ancient *Callorhinus* were taken by humans close to shore, with the limited oceangoing watercraft that are inferred for regional aboriginal groups (Burton et al. 2001; Newsome et al. 2007).

2. Bone isotopes reveal that these animals did not migrate to the far north Pacific to breed for four months of the year, rather remaining in the middle latitudes offshore from the California coast. This foraging pattern resembles that displayed by northern fur seals living on the San Miguel Island rookery, which feed on the continental shelf break north to around the Canadian border for eight months of the year.

3. The faunal samples from both MNT-234 Primary Midden and SMA-18 are dominated by young-of-the-year, sub-adult to adult females, with a few elements from males of breeding age (Figure 2).

4. About half of aged Primary Midden individuals are young-of-the-year, with the preponderance younger than the four- to five-month weaning age of modern Pribilof *Callorhinus* (Figure 3). Bone isotopes in the young-of-the-year were 3 parts per thousand enriched in δ^{15}N above the level of adult females, as is typical of unweaned mammals (Burton et al. 2001).

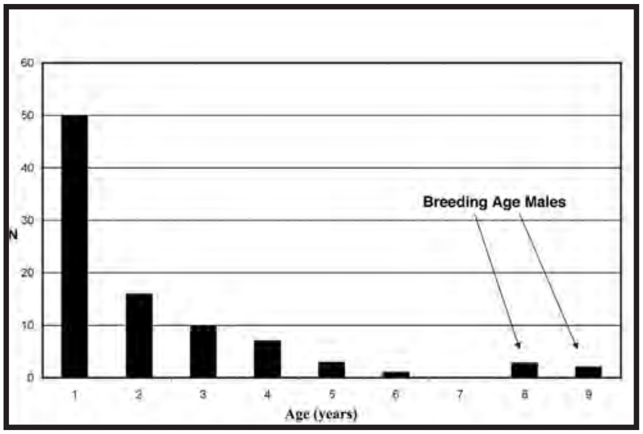

Figure 2. MNT-234 Primary Midden: age structure of the overall northern fur seal sample, as estimated from Etnier's 2002 von Bertalanffy logistical growth curves. Note dominance of young-of-the-year (see Figure 3).

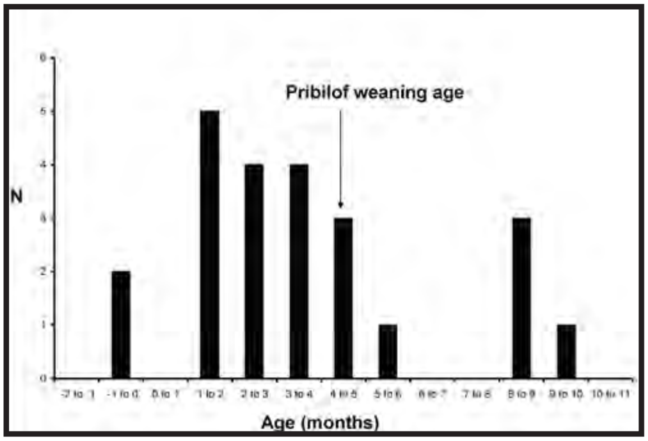

Figure 3. MNT-234 Primary Midden: age structure of the young-of-the-year (YOY) northern fur seal sample, as estimated from Etnier's 2002 von Bertalanffy logistical growth curves. Note dominance of young-of-the-year younger than the modal weaning age of young-of-the-year in the Pribilof Islands.

Age-at-death and bone isotopes are independent lines of evidence that both provide evidence for the existence of a northern fur seal rookery near Moss Landing.

Most archaeologists have accepted the presence of mainland rookeries, and Hildebrandt and Jones (2002) have made a shift from mainland to offshore breeding a centerpiece of their arguments for human depression of eared seal populations. However, many in the marine mammal management community have questioned, if not outright rejected, this assumption, even in the face of careful analyses of many *Callorhinus* archaeofaunas in places they do not occur today, from Ventura County to the Aleutians. We return to this issue later in this paper.

Table 3. Direct Radiocarbon Dates on Bones of Fur Seals (Callorhinus ursinus)*, Coyotes* (Canis latrans)*, and Pacific Hake* (Merluccius productus)

Site	**Unit**	**cm Depth**	**Taxon**	**Other ID**	**d^{13}C**	**Fraction Modern**	**±**	**D^{14}C**	**±**	**^{14}C Age**	**±**	**Marine corr. 2 sigma**
MNT-234	5	160-170	*Arctocephalus townsendi*	LLNL-123137	-20	0.73	0	-268.5	6.4	2510	70	1706-2112
MNT-234	1	000-010	*Callorhinus ursinus*	LLNL-123132	-20	0.73	0	-259.1	3.4	2570	40	1810-2090
MNT-234	1	050-060	*Callorhinus ursinus*	LLNL-123135	-20	0.74	0	-259.1	3.2	2410	35	1610-1870
MNT-234	1	140-150	*Callorhinus ursinus*	LLNL-56397	-14	0.71	0.01	-285.7	5.1	2600	60	1800-2150
MNT-234	1	150-160	*Callorhinus ursinus*	LLNL-123133	-20	0.74	0	-255.8	3.2	2375	35	1570-1850
MNT-234	1	160-170	*Callorhinus ursinus*	LLNL-123138	-20	0.74	0	-256.6	3.4	2380	40	1570-1850
MNT-234	1	180-190	*Callorhinus ursinus*	LLNL-5140	-18	0.7301	0.0028	-269.9	2.8	2525	35	1746-2016
MNT-234	1	190-200	*Callorhinus ursinus*	LLNL-123134	-20	0.74	0	-259.5	3.2	2415	35	1620-1880
MNT-234	1	190-200	*Callorhinus ursinus*	LLNL-123136	-20	0.74	0	-260.3	3.2	2420	35	1620-1880
MNT-234	1	200-210	*Callorhinus ursinus*	LLNL-123130	-20	0.74	0	-261.2	3.1	2430	35	1630-1900
MNT-234	1	210-220	*Callorhinus ursinus*	LLNL-56398	-14	0.74	0	-264.4	4.9	2470	60	1630-1990
MNT-234	1	200-210	*Callorhinus ursinus*	LLNL-123139	-20	0.73	0	-266.6	3.1	2490	35	1710-1970
MNT-234	1	220-230	*Callorhinus ursinus*	LLNL-123131	-20	0.73	0	-268.4	3.6	2510	40	1720-2000
MNT-234	1	220-230	*Callorhinus ursinus*	LLNL-56399	-14	0.72	0	-276.5	3.5	2700	60	1930-2290
MNT-234	4	040-050	*Canis* sp.	LLNL-5135	-18	0.7802	0.0034	-219.8	3.4	1995	40	1865-2054
MNT-234	4	050-060	*Canis* sp.	LLNL-5130	-18	0.8062	0.0032	-193.8	3.2	1730	35	1549-1714
MNT-234	5	120-130	*Canis* sp.	LLNL-5132	-18	0.7540	0.0043	-246.0	4.3	2270	50	2152-2280
MNT-234	5	130-140	*Canis latrans*	LLNL-5129	-18	0.7787	0.0034	-221.3	3.4	2010	35	1879-2054
MNT-234	1	150-160	*Canis latrans*	LLNL-5126	-18	0.7775	0.0029	-222.5	2.9	2020	35	1886-2061
MNT-234	1	150-160	*Canis latrans*	LLNL-5125	-18	0.7863	0.0041	-213.7	4.1	1930	45	1807-1989
MNT-234	5	160-170	*Canis latrans*	LLNL-5127	-18	0.7494	0.0032	-250.6	3.2	2320	35	2303-2368
MNT-234	5	160-170	*Canis latrans*	LLNL-5131	-18	0.7726	0.0039	-227.4	3.9	2075	45	1925-2152
MNT-234	1	170-180	*Canis latrans*	LLNL-5134	-18	0.7886	0.0030	-211.4	3.0	1910	35	1769-1932
MNT-234	5	170-180	*Canis latrans*	LLNL-5139	-18	0.7765	0.0029	-223.5	2.9	2030	35	1896-2065
MNT-234	1	180-190	*Canis* sp.	LLNL-5137	-18	0.7898	0.0031	-210.2	3.1	1895	35	1729-1900
MNT-234	1	190-200	*Canis latrans*	LLNL-5128	-18	0.7644	0.0048	-235.6	4.8	2160	55	2044-2211

Site	Unit	cm Depth	Taxon	Other ID	d^{13}C	Fraction Modern	±	D^{14}C	±	^{14}C Age	±	Marine corr. 2 sigma
MNT-234	4	050-060	*Merluccius productus*	LLNL-77480	-20	0.7325	0.0039	-267.5	3.9	2500	45	1679-1933
MNT-234	4	110-120	*Merluccius productus*	LLNL-77481	-20	0.7405	0.0029	-259.5	2.9	2415	35	1663-1923
MNT-234	1	140-150	*Merluccius productus*	LLNL-77475	-20	0.7366	0.0030	-263.4	3.0	2455	35	1551-2029
MNT-234	1	150-160	*Merluccius productus*	LLNL-77476	-20	0.7377	0.0029	-262.3	2.9	2445	35	1564-1847
MNT-234	1	200-210	*Merluccius productus*	LLNL-77477	-20	0.7370	0.0079	-263.0	7.9	2450	90	1592-1858
MNT-234	1	270-280	*Merluccius productus*	LLNL-77479	-20	0.7427	0.0029	-257.3	2.9	2390	35	1616-1878
MNT-234	1	250-260	*Merluccius productus*	LLNL-77478	-20	0.7442	0.0035	-255.8	3.5	2375	40	1703-1993
SCR-35	TBA	TBA	*Callorhinus ursinus*	LLNL-50787	-15	0.7	0	-304.9	3.7	2920	50	2204-2540
SMA 18	N4/E0	000-020	*Callorhinus ursinus*	LLNL-123128	-20	0.7910	0	-00209	3.4	1885	35	1070-1290
SMA 18	N5/W11	020-040	*Callorhinus ursinus*	LLNL-123129	-20	0.77	0	-00225	3.2	2055	35	1260-1480

LLNL: Lawrence Livermore National Laboratories Center for Accelerator Mass Spectrometry. d^{13}C values are the assumed values according to Stuiver and Polach (1977:355) when given; quoted age is in radiocarbon years using the Libby half life of 5568 years and following the conventions of Stuiver and Polach (1977). Radiocarbon concentration is given as fraction Modern, D^{14}C, and conventional radiocarbon age; sample preparation backgrounds have been subtracted, based on measurements of samples of ^{14}C-free coal; backgrounds were scaled relative to sample size.

CA-MNT-234: Sex-Specific Selective Butchery and Transport

Our analysis of the Primary Midden identified all skeletal elements of pinnipeds and other mammals, with the goal of assessing selective butchery and transport of different-sized pinnipeds, according to their species or their sex. Results indicate very different handling of male versus females and young. Sub-adult and adult males are present, but their representation is very different from those of females and young. Male specimens are much fewer, and the relationship between NISP and MNI differs substantially, with more individual males represented by relatively fewer specimens than is the case with females or young-of-the-year (Table 4). Bones of the skull and the ribs (with highest meat utility) predominate (Savelle et al. 1996). Since males weigh up to 250 kg, this probably reflects a highly selective pattern of butchery and transport. While high frequencies of skull parts may seem counterintuitive, heavy representation of mandibles was also found in Oregon Steller sea lions assemblages (Savelle et al. 1996). Female and young-of-the-year element representations track together, despite differences in size, reflecting similar handling of their bodies. It is likely that the females, weighing up to 45 kg, were brought to the site skeletally whole, as were young-of-the-year.

In sum, bone elements of the very large male fur seals are much rarer, and their body segments are not represented in the assemblages the same way as those of females and immature animals of the same species. This has methodological implications. It is imperative to analyze elements of all body segments before generalizing about human uses of various taxonomic, age, and sex classes in a site. Bone specimens representing sub-adult and adult males in the MNT-234 assemblage are the very elements assigned to “pinniped indet.” or “otariid indet.” in many analyses. With comparative specimens, it is possible to identify such elements to species and sex among eared seals.

Radiocarbon Dating the Disappearance of Northern Fur Seals from Monterey Bay

In Monterey Bay and at Point Año Nuevo, northern fur seals are well represented in the archaeological record from about 2200 to 1200 B.P. (Table 1). Data from Moss Landing and Point Año Nuevo suggest they drop out of the archaeofaunal record before the extremely warm, dry epoch at ca. 1000-800 B.P. documented by paleoecological records in the Sierra and San Francisco Bay (Malamud-Roam et al. 2006; Stine 1994), the regional expression of the Medieval Warm Period.

This means that northern fur seals seem to have disappeared not during the peak of climatic deterioration and settlement reorganization in the region (Jones 1999), but 200-400 years earlier, and that they made up the preponderance of some regional faunal assemblages earlier still. In other words, the species began its regional decline during the late Middle Period (Hylkema's Año Nuevo Phase), ca. 3000-900 BP. Future analyses of archaeofaunas from Point Año Nuevo may reveal occurrences later than ca. 1200 BP. The general trend, however, is that these gregariously breeding eared seals underwent a decline coincident with the peak of human population growth and cultural elaboration in Central California.

Mainland Rookeries and "Pinniped Driftwood"

While some marine mammal managers are willing to accept the isotopic and archaeofaunal evidence that *Callorhinus* once foraged at middle latitudes, they dispute that the species could have had rookeries on the mainland. Some have proposed an alternative explanation for the fur seal bones at Moss Landing Hill, arguing that these are remains of animals washed off the Farallon Islands, which are known to have supported a very large fur seal colony in the early nineteenth century (Busch 1985; Pyle et al. 2001). According to this scenario, young-of-the-year that were swept to sea may not have been able to regain land, drifting southward with prevailing currents and finally stranding near Moss Landing.

To assess the "pinniped driftwood" hypothesis, Sunseri evaluated the potential of seasonal currents to carry fur seals from the Farallons during their June-November breeding season. Her analysis was based upon documented seasonal fluctuations in strength and direction of the California Current compiled and modeled by Paduan (1999). Two currents could have carried young-of-the-year south from the Farallons to Moss Landing: the Upwelling season and the Oceanic season patterns. The Upwelling season overlaps with the *Callorhinus* breeding season from June to mid-August (Figure 4). The strongest currents from the Farallons would flow southward to Carmel, while weaker currents would flow to just north of Moss Landing and hit the shore near the Pajaro River. However, currents offshore of Moss Landing generally flow northward during June and July, which might deflect drifting one- to two-month-old pups. In July, currents into Monterey Bay are weak, lacking a single vector of flow and generally diverting to either the north or south of Moss Landing (towards the Pajaro or Salinas river outlet).

The Oceanic current season overlaps with the *Callorhinus* breeding season from mid-August to early November. In August and September, the strongest currents into Monterey Bay flow strongly southward toward the Monterey Peninsula, rather than into the middle of the bay (Figure 4), while the currents offshore of Moss Landing flow to the north and northwest. In October the strongest currents entering the bay flow toward the Moss Landing and Salinas River coastline. However, they are met by countercurrents flowing from this coastline to the west and southwest, likely diverting the flow southward toward the Monterey Peninsula.

It thus does not seem highly likely that the very young (one- to three-month-old) fur seals found in at MNT-234 (Figure 3) would have been carried consistently from the Farallons to Moss Landing by currents running June through September. This scenario would have been more likely in October, but only if westward countercurrents around Moss Landing and the Salinas River were weaker than the dominant eastward current. In October, young-of-the-year fur seals on the Farallons would be four to five months old. Since the preponderance of young-of-the-year from MNT-234 are in fact less than four months of age, that is, from the age span less likely to have been transported to the Moss Landing area, the pinniped driftwood scenario is not sustained by the current models.

Discussion

Our research findings address wider issues in the interpretation of marine mammal hunting patterns in the Monterey Bay region. We believe we have three independent lines of evidence strongly suggesting that *Callorhinus* in second and third millennia B.P. California were not behaving as their contemporary relatives do.

Mechanisms of Decline of the Central California Northern Fur Seal

Narratives in the archaeological literature assume that northern fur seals and other high-ranked prey were stable over time and space in their demography and behavioral ecology, until the time that human hunters depressed the resource (Broughton 1994). However, we know that the Holocene has seen dynamic changes in oceanic and terrestrial climates, and plant and animal adaptations must have had a certain range of flexibility to allow them to adjust to such fluctuations.

Even in their present reduced population levels, northern fur seals live in a broad range of latitudes with different levels of primary productivity. Variations in primary productivity affect population levels of primary, secondary, and tertiary consumers. Middle-latitude populations of *Callorhinus* are vulnerable to the full impact of ENSO events much more than are *Callorhinus* that breed and forage in the far north Pacific, where El Niño events do not affect primary productivity. On San Miguel Island, Melin and DeLong (2000) report an 80 percent drop in pup survival from the 1997 to the 1998 birth cohorts, associated with a strong El Niño events. All central California coastal populations, even those clustered around productive hotspots such as the deep water near San Miguel Island, the Monterey Submarine Canyon, and the Farallons, would have been subject to such fluctuations, at least from around 6000 B.P., when, accumulating evidence suggests, ENSO events took on their present scale in the Pacific (Sandweiss et al. 1996, 2001). Humans would have been preying not on an equitably distributed resource in a diachronic sense, but rather on a fluctuating food base.

Lyman (2003) notes that among gregariously breeding pinnipeds, sub-adult and younger adult males, given their great abundance and lack of importance to species propagation, are sustainable prey. Offtake of sub-adult fur seal males is seen at the Ozette site (Etnier 2002) and of immature Steller sea lion males in Oregon sites (Lyman 2003). However, Monterey Bay sites are dominated by remains of females and young, with few males. This continues to be a puzzling pattern, explicable if immature males were not available for human predation, if they perhaps did not haul out during the breeding season. In any case, this pattern of offtake focused on females and pups would have rendered middle-latitude California *Callorhinus* much more vulnerable to slight increments in human harvesting. Sunseri and Etnier (2005) modeled predator-prey relations using a cumulative distribution function (CDF), predicting northern fur seal population declines with differing harvesting levels. The CDF model specified the number of years at which a hypothetical population of 1,000 individuals would decline to only two individuals, the definition of near-extinction in the model. Harvest rates of 10 percent of females per year are modeled to drive the population to extinction within 100 years, and 20-30 percent harvesting rates would result in extinction within 50 years. We hope to have more realistic estimates of prehistoric population levels for the Farallons and central California once meta-population estimates based on DNA diversity are available. In the meantime, archaeologists would do well to take these geographically variable behavioral responses of the prey species into account when they construct scenarios for population depression in different species .

The Tragedy of the Commons Scenario Revisited

In the now-classic narrative of "a tragedy of the commons" (Hardin 1968), the disappearance of fur seals and other migratory eared seals from archaeological sites, and their replacement by such taxa as sea otters and harbor seals, was explained as aboriginal over-cropping of high-ranked food resources to the point of their extinction, then moving down the list to harder-to-procure, lower-ranked marine mammals (Hildebrandt and Jones 1992, 2002; Porcasi et al. 2000). In central California, northern fur seals would certainly be the highest-ranked of all mammal species on a nutritional basis alone, except for members of the Cetacea, which were not regularly taken by hunting (Table 4). The high fat content of *Callorhinus* would make it a highly attractive food source. With their dense, high-quality pelts as well as food value, fur seals are thus super-resources, combining food value with the value of a preservable and exchangeable product.

Optimal foraging theory would predict that northern fur seal rookeries, a patchy, seasonally predictable, and rich resource, would be a defended resource rather than an

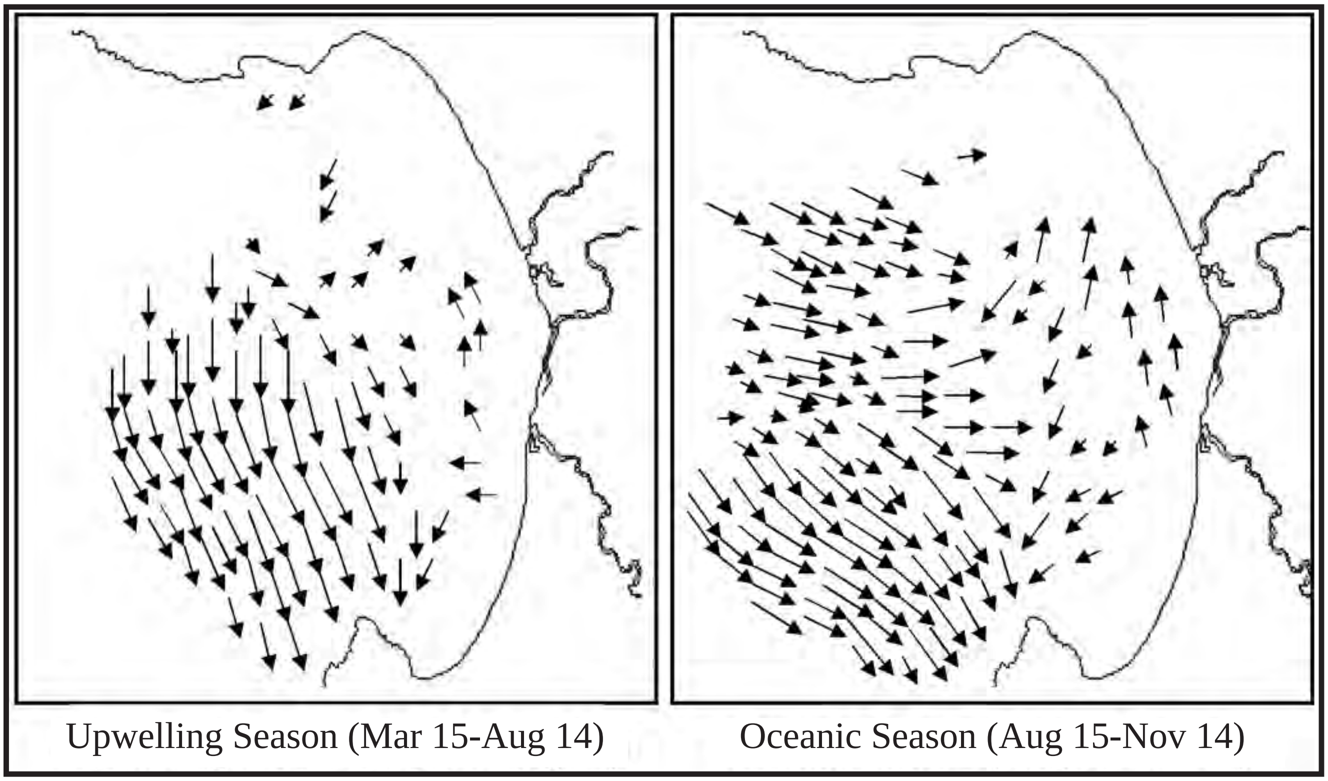

Figure 4. Two sets of currents that could possibly have carried young-of-the-year (the "pinniped driftwood" hypothesis) south from the Farallon Islands to the Moss Landing area, after Paduan (1999). Note that each seasonal current set has countervailing currents from the center of the Monterey Bay that may "push" any stranding animals away during these seasons.

undefended "commons" of the sort referred to by Hardin (1968) in his original essay. Both the Año Nuevo and Moss Landing areas have large residential sites near what probably were point sources of fur seals, which may reflect aggregation (at least during the fur seal breeding season) for the purpose of monopolizing the resource.

Explaining Shifts in Taxonomic Prey Choices in the California Archaeological Record

As Hildebrandt and McGuire (2006) emphasized recently, resource depression will not normally drive taxa to extinction. Foragers will move to lower-ranked resources long before the last of a deeply depressed population dies out. However, hunting of rare animals for prestige purposes can lead to such an extinction. Arguments over whether humans hunt rare species to enhance their reproductive success (costly signaling) or to enhance the social status of corporate kin groups (social aggrandizing) may be less than fruitful, since the archaeological outcomes of these two causal alternatives approach equifinality.

The extirpation of fur seals has usually been seen as a case of humans exhausting a high-ranked food resource, rather than a possible case of over-cropping a species to produce a highly valued item of exchange. Here, we are not arguing that aboriginal people hunted fur seals solely to obtain pelts as a major trade item of non-subsistence, or "prestige," goods. They may have had nutritional motivations, such as a need to acquire carbohydrates from other groups. In any case, cured fur seal pelts weigh between a fraction of a kilogram for newborns to a few kilograms for older males (J. Bradley, personal communication 2007). They are thus high-value, low-weight items ideal for transport over considerable distances, for whatever purposes.

Fur seal pelts added value to the acquisition of every individual, from young-of-the-year to adults. The cost involved in predation was balanced by the immediate payoff of highly nutritious, fatty meat in an otherwise lean-meat diet (Speth and Spielmann 1983). Once cured, these were not simply warm, durable clothing for members of a foraging group, but also a relatively light, high-value item of longer-distance exchange.

CONCLUSION

The power and efficacy of such theories have been demonstrated beyond a doubt in animal behavioral studies, and their relevance for explaining some human choices has been shown as well. For zooarchaeologists, this body of theory has been especially valuable. However, the fact that humans can often be seen making choices in subsistence that appear logical within this theoretical framework should not blind us to the fact that humans employ unique strategies to solve nutritional impasses. Rather than exhausting a resource and moving to the next most abundant and ranked food, humans can create media of exchange to, in essence, "jump currencies" to achieve nutritional, technological, or social goals. We must raise our gaze from simple calorie input/output models that work well with non-human species and accommodate this fact when analyzing fauna assemblages.

Archaeologists probably would never interpret the Chumash intensification in *Olivella* procurement as reflecting desperate Indians settling for a low-nutrient food. We know that the manufacture and circulation of beads for both inland foods and technological raw materials was a problem-solving tactic. The later shift by coastal populations to sea otter procurement should thus be read not simply as a move to a lower-ranked food resource, but as an intensive exploitation of a relatively common – and at that point in time, probably renewable – source of pelts, each weighing less than 2 kg.

To acknowledge the added product value of such animals, as well as their variable ecologies, enriches our understanding of historically situated cases of predation on the species that produced different outcomes in different parts of their ranges. It does not require rejecting models and predictions based on behavioral ecology, but rather it asks that we incorporate into our models more complexity and more realism regarding human resource procurement.

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Table 4. MNT-234 Primary Midden: Frequencies of Callorhinus *Elements, Grouped by Body Segment Butchery Units Used by Contemporary Aleut Butchers, Sorted According to Age and Sex*

Aleut Butchery Segment	**Elements in Segment**		**∑ NISP per Butchery Segment**	**Body percent**	**MNT-234 YOY NISP**	**MNT-234 YOY SUM Seg**	**MNT-234 YOY percent**	**MNT-234 YOY MNI/ NISP**	**MNT-234 F ≥2 yr. NISP**	**MNT-234 F ≥2 yr. SUM Seg**	**MNT-234 F ≥2 yr. percent**	**MNT-234 F ≥2 yr. MNI/ NISP**	**MNT-234 M ≥2 yr. NISP**	**MNT-234 M ≥2 yr. SUM Seg**	**MNT-234 M ≥2 yr. percent**	**MNT-234 M ≥2 yr. MNI/ NISP**
								0.05				0.03				0.09
Head	Head ∑		3	1.9 %		24	4.0 %			87	6.3 %			21	24.1 %	
	Cranium	1			10		0.0 %		50		3.6 %		10		11.5 %	
	Dentary	2	2	1.3 %	28		0.0 %		37		2.7 %		11		12.6 %	
Trunk	Trunk ∑		68	42.8 %		248	41.0 %			331	24.0 %			44	50.6 %	
	Cervicals	7		4.4 %	32		5.3 %		74		5.4 %		1		0.1 %	
	Thoracics	14		8.8 %	36		6.0 %		65		4.7 %		0		0.0 %	
	Ribs	30		18.9 %	117		19.3 %		248		18.0 %		33		37.9 %	
	Lumbars	5		3.1 %	7		1.2 %		27		2.0 %		2		2.3 %	
	Sacrals	4		2.5 %	2		0.3 %		11		0.8 %		0		0.0 %	
	Innominate	2		1.3 %	21		3.5 %		27		2.0 %		2		2.3 %	
	Femur	2		1.3 %	16		2.6 %		29		2.1 %		0		0.0 %	
	Tibia	2		1.3 %	14		2.3 %		41		3.0 %		4		4.6 %	
	Fibula	2		1.3 %	3		0.5 %		10		0.8 %		2		2.3 %	
Foreleg	Foreleg ∑		8	5.0 %		73	12.1 %			114	8.3 %			9	10.3 %	
	Scapula	2		1.3 %	9		1.5 %		37		2.7 %		3		3.4 %	
	Humerus	2		1.3 %	37		6.1 %		25		1.8 %		3		3.4 %	
	Radius	2		1.3 %	14		2.3 %		25		1.8 %		1		1.1 %	
	Ulna	2		1.3 %	13		2.1 %		27		2.1 %		2		2.3 %	
Flippers	Flippers ∑		78	49.1 %		260	43.0 %			847	61.4 %			13	14.9 %	
	Carpals	16		10.1 %	40		6.6 %		16		1.2 %		2		2.3 %	
	Tarsals	14		8.8 %	22		3.6 %		52		3.8 %		3		3.4 %	
	Metacarpals	10		6.3 %	17		4.1 %		41		3.0 %		4		4.6 %	
	Metatarsals	10		6.3 %	18		3.0 %		11		0.8 %		2		2.3 %	
	Phalanges	28		17.6 %	163		26.9 %		727		52.7 %		1		1.1 %	
																Site Total
	Grand Totals		159	100.0%		605	100.0%			1379	100.0%			87	100.0%	2071

Table 5. Nutritional Values of Northern Fur Seal and Other Central Coast Foods

Nutritional Value	**Male Morthern Fur Seal**	**Female Northern Fur Seal**	**Deer**	**Rabbit**	**Fish**	**Acorn**
Kcal/individual	328,500	58,400	80,550	81	289	510
g fat	6,480	3,240	4,320	17	4	31
g protein	62,825	11,168.9	15,405	155	62	8
g carbohydrate	0	0	0	0	0	54

Information from http://www.calorie-count.com and http://www.nutritiondata.com. Northern fur seal data are calculated by estimating this resource relative to deer values based on a ratio of body mass and ratios of fat thickness in mm.

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Correction/Addendum (2/25/2010):

The authors regret that they did not appropriately acknowledge the source for the radiocarbon dates of Pacific hake as discussed in our article. While the dates on mammal bone were funded by the NSF grant we noted, the dates on fish bone were kindly supplied by Cristie Boone, who dated them as part of her dissertation research at UC Santa Cruz. They were supported by the following two grants: 1) a CDELSI Graduate Student Mini-Grant Award in Ocean Health and Environmental Change, and 2) a STEPS Institute Graduate Research Grant. Pre-processing of the samples was done with the help of Dr. Kena Fox-Dobbs, using the lab of Dr. Paul Koch at UCSC. Our apologies to all of the above for this inadvertent omission.