VARIATION IN MARINE FAUNA UTILIZATION BY MIDDLE HOLOCENE OCCUPANTS OF SANTA CRUZ ISLAND

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Abstract—Human occupants of western Santa Cruz Island between 6,500 and 5,000 years ago utilized a variety of marine animals as food resources, including diverse shellfish species, a variety of nearshore fishes, pinnipeds, and dolphins. However, archaeological sites of this age exhibit considerable variation in the importance of particular taxa, as revealed in preserved shells and bones in site deposits. Much of this variation appears related to differences in local abundance of particular faunal species or categories. The small size of the majority of the known sites implies that relatively small social units frequently moved from one locus to another as resources, particularly shellfish, became depleted. However, two sites of this time period are quite large, implying that certain locations were especially popular, probably because of unusually high productivity of marine resources.

Keywords: archaeology, food, marine fauna, middle Holocene, resources, Santa Cruz Island

INTRODUCTION

A distinctive type of prehistoric site on western Santa Cruz Island, and on Santa Rosa and San Miguel islands as well, is typified by an abundance of whole or nearly whole red abalone shells (*Haliotis rufescens*) mixed with shells of other species, particularly California mussel (*Mytilus californianus*). I have referred to these sites as red abalone middens, and have focused much of my research on them over the last ten years (Glassow 1993, 2000, Glassow et al. 1994). On Santa Cruz Island, the sites typically are buried under alluvial or eolian deposits and are identified only if erosion has exposed them along the edge of a seacliff or arroyo bank. Radiocarbon dates exist for 12 of these sites (reported in Glassow 1993, but including recently obtained dates), and several more have not yet been dated. All but one occur in the vicinity of Christy Beach and between Black Point and Forney's Cove, and it is likely that many more in these localities remain completely obscured by overlying deposits. All date between 6,300 and 5,300 BP, with the possibility that a few may have deposits as early as 6,800 BP. (These and all other dates mentioned in this paper are given in calibrated years BP.) On Santa Rosa and San Miguel islands, however, red abalone middens date to a broader time span: at least as early as 7,500 BP and perhaps as late as 3,000 BP (Glassow 1993).

All but two of the documented sites appear to be small in area, probably under 50 m in diameter, and all but the same two have middens under a meter thick—most, in fact, being less than 30 cm thick. The two exceptions with regard to site characteristics are a site just north of Forney's Cove (CA-SCRI-333), known as El Montón, and a site located at Punta Arena, on the south coast of the island (CA-SCRI-109). The Punta Arena site is the easternmost red abalone midden known at this time. Both sites have red abalone midden deposits a meter or more thick, and both extend over areas at least 100 m in diameter. Furthermore, archaeological excavation in 1927 exposed a cemetery at the El Montón site, which King (1990, p.31) dates to the period under consideration (see also Hoover 1971), and three isolated human burials are known to have existed at the Punta Arena site. This contrast between relatively numerous small sites and two much larger sites obviously has implications for understanding the nature of subsistence and settlement systems during this interval of prehistory.

The abundance of small sites relatively close to one another implies that populations were very mobile during at least portions of the year and that

social units occupying them were small. Indeed, each of these small sites could have been produced by a group of several individuals over a period of several months, assuming a constant supply of food resources. The question, therefore, is how occupation of these small sites related to occupation of the two larger ones. Two hypotheses may be proposed in attempting to answer this question.

The first hypothesis entails the argument that one or both of the larger sites served as principal residential bases at which populations spent most time during the year and were relatively sedentary. The social unit occupying these residential bases may have been composed of several families, perhaps as many as 50 people, whereas the smaller sites were occupied by single families of no more than about 10 people when these larger groups dispersed. While people occupied the two larger sites, they may have engaged in a wider variety of activities than while occupying the smaller sites, especially activities of a social and ritual nature. King (1990, p. 117) proposed a more elaborate version of this hypothesis based on the analysis of mortuary practices revealed in the data obtained from the 1927 cemetery excavation at this site. He argued that the El Montón site was a relatively larger settlement whose population "probably controlled the most important ceremonies, and membership (in a community of this larger size) was probably necessary to acquire the most important positions" (King 1990, p. 117). In other words, King proposed that other, smaller sites were occupied by individuals who did not have the higher social status of individuals at the El Montón site.

The second hypothesis entails the argument that one or both of the larger sites was simply a more intensively used version of the smaller sites. Populations were attracted to these sites because resources were relatively more abundant and diverse, and as a consequence they visited the sites more frequently and/or stayed at them for longer periods of time. Although these sites have much larger volumes of deposits, they are functionally equivalent to the smaller sites with respect to their place within a settlement system, and the size of social units occupying the sites was not necessarily any larger than that occupying the smaller sites.

These two hypotheses may be viewed as two extremes of a range of possibilities. To evaluate these two hypotheses, or variants of them, the nature of activities taking place at sites dating to the time interval in question must be understood. As a starting point, it makes sense to identify the kinds of subsistence activities taking place at the sites, in part because subsistence remains are readily acquired and in part because understanding the relationship between subsistence activities and environmental contexts of the sites would allow a refinement of the hypotheses. However, data on such topics as tool manufacturing and social activities would be necessary for critical tests.

METHODS

The data for this analysis come from four sites: the Punta Arena site and three typical small sites (Fig. 1). Fieldwork in 1997 consisted of test excavation at these four sites for the purpose of obtaining baseline data for assessing the nature of the midden constituents and refining the chronology of red abalone middens. Sample sizes therefore are relatively small, and as a result inferences about subsistence must be developed with caution. I also made use of limited information currently available about subsistence remains from the El Montón site (from bucket auger testing in connection with a geophysical survey of the site).

The Punta Arena site is located on a prominent point of land on the southwestern coast of the island. The point is surrounded by a gently sloping bedrock shelf that extends through the intertidal zone, which as a consequence is relatively broad and very productive of intertidal shellfish such as

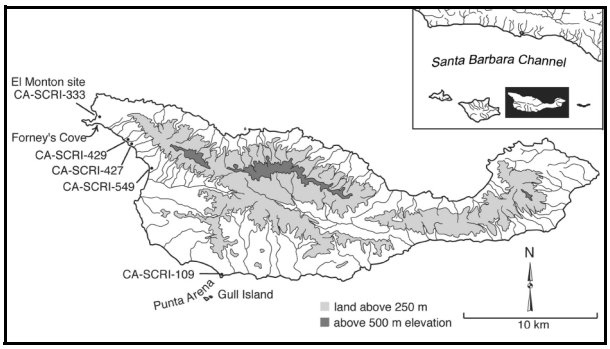

Figure 1. Locations of sites considered in the analysis.

Table 1. Radiocarbon dates for sites on Santa Cruz Island, CA, considered in the analysis

Site SCRI-	Unit and Stratum	Conventional age	Cal. date, BP	Cal. date, 1σ interval	Lab no.	Material
109	North, Strat. 15	5,520 ± 70	6,300	6,395–6,280	Beta 119186	Wood charcoal
109	North, Strat. 15	5,600 ± 80	5,730	5,865–5,635	Beta 119185	*Lithopoma un.*
109	North, Strat. 10	5,580 ± 60	5,710	5,795–5,635	Beta 119184	*Mytilus cal.*
109	North, Strat. 10	4,790 ± 150	5,511	5,677–5,320	UCR 0201	Wood charcoal
109	North, Strat. 10	5,030 ± 150	5,037	5,287 – 4,841	UCR 0209	*Haliotis cor.*
109	South, Strat. 15	7,370 ± 60	7,560	7,625–7,515	Beta 122001	*Tivela stu.*[1]
109	South, Strat. 15	5,940 ± 80	6,145	6,225–6,000	Beta 119191	*Mytilus cal.*
109	South, Strat. 11	5,740 ± 70	5,900	5,960–5,835	Beta 119190	*Mytilus cal.*
109	South, Strat. 2	5,210 ± 70	5,305	5,430–5,250	Beta 119189	*Haliotis cor.*
427	Col., Strat. 1	5,580 ± 70	5,710	5,835–5,625	Beta 122002	*Haliotis ruf.*
427	Col., Strat. 2B	5,840 ± 70	5,985	6,115–5,910	Beta 122003	*Haliotis* sp.
427	Col., Strat. 2A	5,900 ± 60	6,095	6,170–5,980	Beta 128111	*Mytilus cal.*[2]
427	Midden	5,420 ± 100	5,567	5,647–5,547	UCR 1835	*Haliotis ruf.*
428	Midden	5,720 ± 60	5,885	5,930–5,795	Beta 122004	*Haliotis ruf.*
428	Midden	4,225 ± 100	3,977	4,134–3,842	UCR 1836	*Haliotis ruf.*[3]
429	Midden	7,205 ± 130	7,421	7,537–7,319	UCR 1837	*Haliotis ruf.*[4]
429	Col. 2, midden	6,210 ± 70	6,395	6,470–6,305	Beta 122005	*Mytilus cal.*
549	Col. 1, Strat. 7	6,560 ± 60	6,785	6,865–6,715	Beta 122007	*Haliotis cra.*
549	Col. 1, Strat. 2	5,240 ± 70	5,325	5,455–5,275	Beta 122006	*Haliotis ruf.*

[1] Sample dated perhaps moved up from stratum directly below.
[2] 72 pieces of shell comprised the sample.
[3] Anomalously young; dating error suspected.
[4] Anomalously old; dating error suspected.

California mussel and (historically) black abalone (*Haliotis cracherodii*). Gull Island is located 1.5 km offshore, and the shallow intervening waters contain kelp forests that are productive of nearshore fishes and subtidal shellfish.

Two units, 0.25 x 1.5 m in area, were excavated along the walls of gullies that have cut into the midden deposits of the Punta Arena site. Radiocarbon dates indicate that this site was first occupied about 8,700 BP and was also occupied briefly around 2,000 BP. The bulk of the deposits, however, reaching slightly more than a meter in thickness, date between 6,300 and 5,300 BP (Glassow 2000, see also Table 1). At the completion of excavation of the two test units, 25- x 25-cm column samples were taken from each unit's back wall. Only those portions of the deposits dating within the interval of time between 6,300 and 5,300 BP are considered in this analysis. These deposits are approximately 1.5 m deep at the two locations of excavation. The marine vertebrate remains (bones and teeth) considered here are from the units (North unit: vol. = 0.47 m^3, South unit: vol. = 0.73 m^3), and the shellfish remains are from the column samples (North column sample: vol. = 85 dm^3, South column sample: vol. = 120.8 dm^3).

Site CA-SCRI-549 is one of a cluster of small red abalone middens located at or very near the seacliff overlooking Christy Beach. The site is located near the northern end of the beach, and occupants would have had access not only to the broad, sandy Christy Beach, but also to rocky intertidal zones north of the beach toward Black Point. The site's buried deposits are exposed on the face of the seacliff and along walls of small gullies cut back from the seacliff. The approximately 65 cm thick midden is buried under nearly 1.5 m of mudflow alluvium. A 25- x 25-cm column sample was obtained from a gully face where midden deposits were densest (vol. = 37.5 dm^3).

Site CA-SCRI-427 is located at the seacliff one km northwest of Black Point. The intertidal zone below this site is rocky, and in spots it is quite broad due to nearly horizontal shelves of bedrock extending out from shore. A 40- x 40-cm column sample was collected in an uneroded area a few meters from the seacliff edge, where the deposits are nearly 60 cm thick. At this location its deposits begin at the ground surface, but a short distance inland they are buried under windblown silt. Only collections from the middle of the three strata (stratum 2) are considered in the analysis. The lowermost and uppermost strata contained much lower densities of faunal remains and are likely to be sterile deposits contaminated by midden from above or below, respectively. Consequently, only

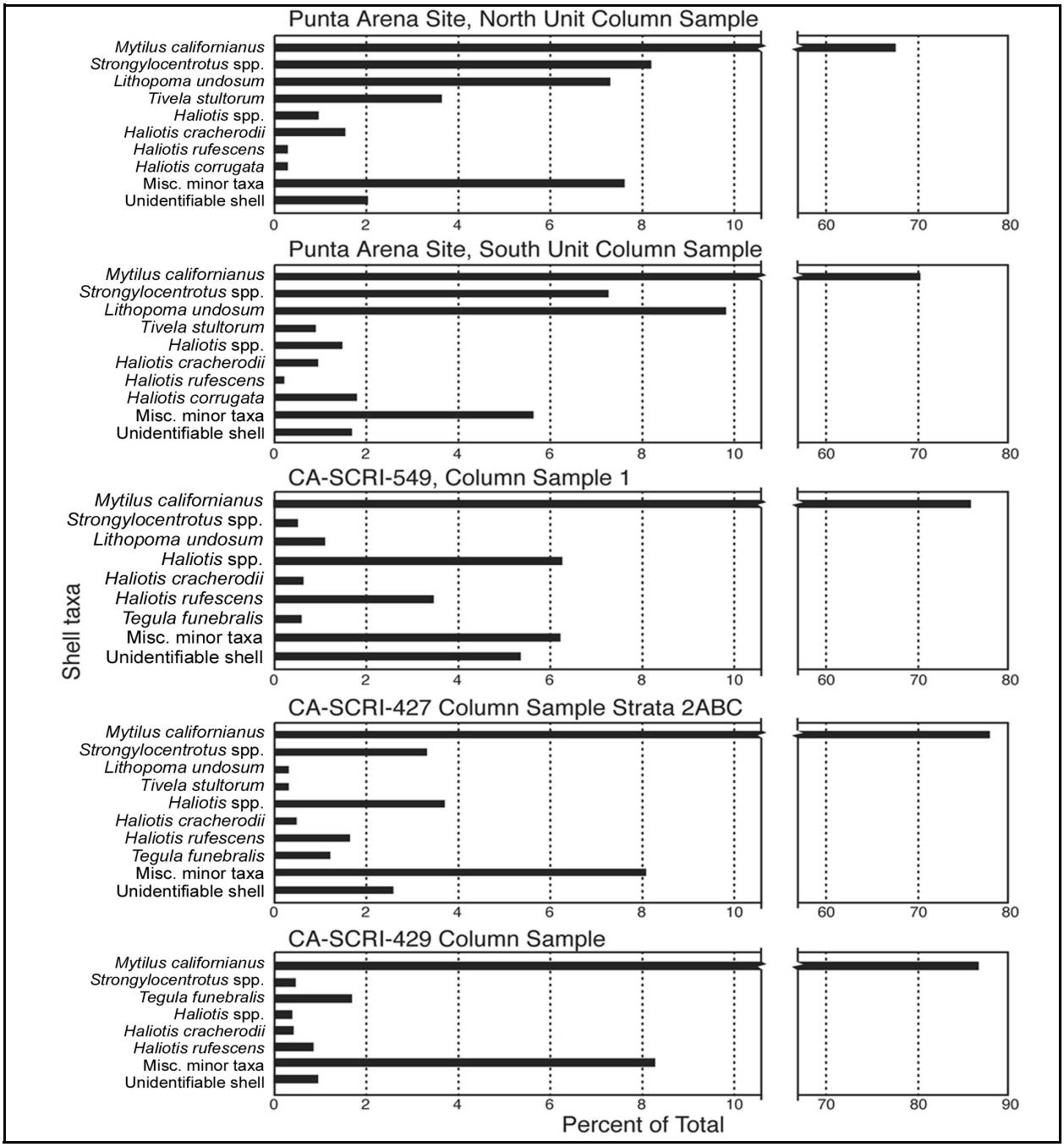

Figure 2. Taxa represented among the shellfish remains from the Punta Arena site and CA-SCRI-549, 427, and 429 on Santa Cruz Island, CA.

the contents of the middle stratum (divided arbitrarily into 2A, 2B, and 2C) are considered in this analysis (vol. = 47.6 dm^3).

Site CA-SCRI-429 is located at the seacliff 0.5 km northwest of CA-SCRI-427, and the shoreline habitat of the two sites is very similar. A 25- x 25-cm column sample was excavated from deposits about 75 cm from the seacliff edge, where the midden is covered by 15 cm of windblown silt. The midden was found to be very attenuated at this location, even though the exposure at the seacliff had moderately dense constituents. As a consequence, a second 25- x 25-cm column was excavated at the seacliff. In both locations the midden was approximately 20 cm thick, and the midden strata from both columns were combined for purposes of this analysis (vol. = 24.38 dm^3). Most likely, only a small vestige of the inland edge of this midden is left, the remainder having been lost to seacliff retreat. Because the density of faunal remains is much lower than at other sites tested, the sample from site 549 is small and therefore is only broadly comparable with other site samples.

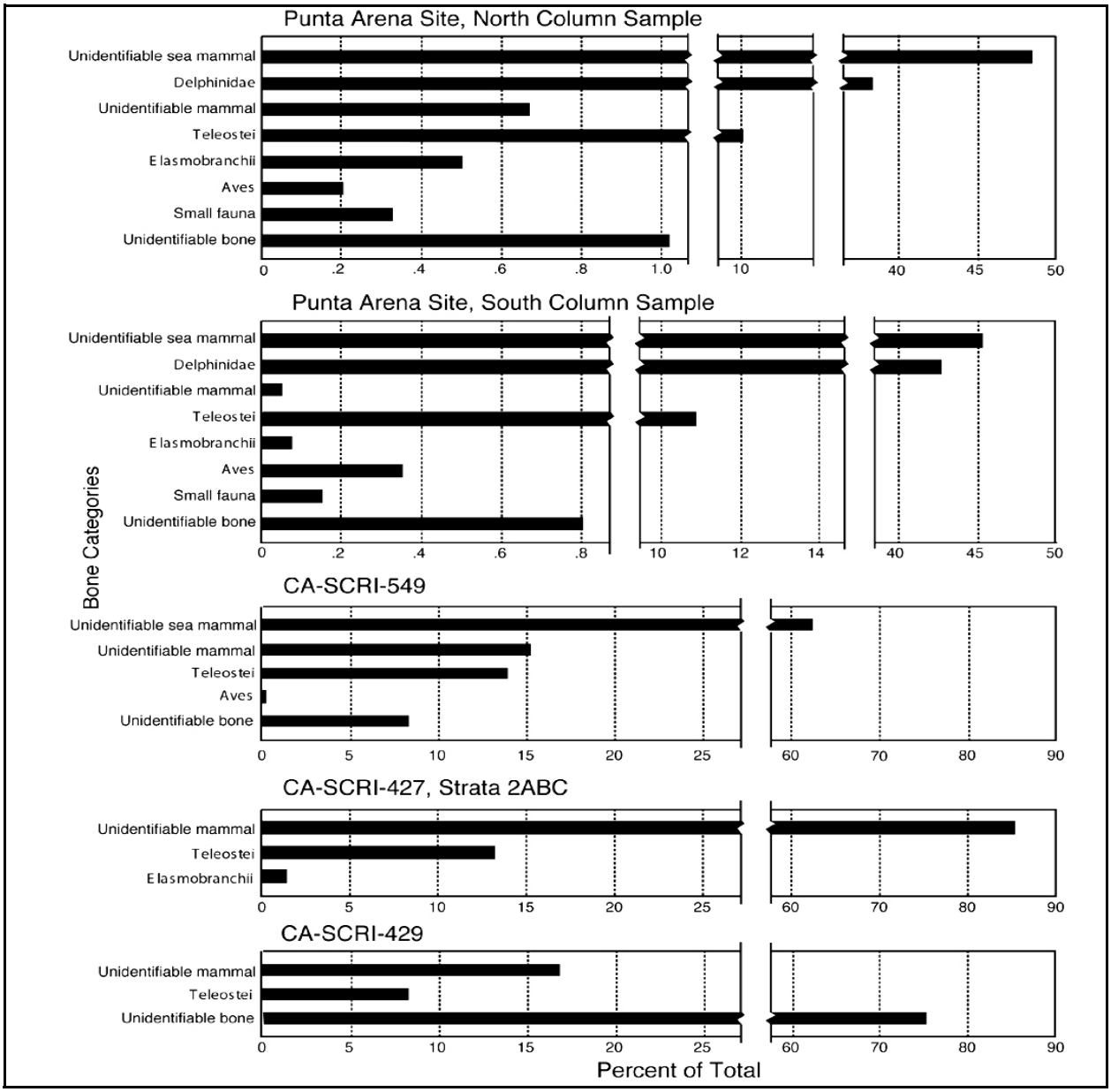

Figure 3. Faunal categories represented among the marine vertebrate remains from the Punta Arena site and sites CA-SCRI-549, 427, and 429 on Santa Cruz Island, CA.

Collection and processing procedures of the column samples taken from these four sites are similar; the slight differences did not affect the comparability of the data. Deposits of the two column samples obtained at the Punta Arena site were collected in bulk and brought to the University of California, Santa Barbara (UCSB), for flotation processing. The heavy fraction considered here was the portion caught by an 8-in. (20.3 cm) mesh lab sieve. Deposits of the column samples from the other sites were sifted in the field through a 8-in. mesh screen, and all material caught by the screen was brought to UCSB, where it was water-screened. Once the deposits were dry, they were sorted into constituent categories, including shell, bone, flaked stone, charcoal, and naturally occurring stone. The shell and bone were then identified to the most specific taxon possible.

The data used in the analysis presented here were derived mainly from the shellfish and vertebrate remains from the column samples. Supplemental information comes from comparatively rare finds of artifacts.

Radiocarbon dates established the age of occupation at the four sites (Table 1), and in the case of the Punta Arena site, these dates allow the deposits of concern here to be distinguished from those dating earlier and later. Four of the dates were obtained from samples collected in 1974 and 1984, whereas the remainder were obtained in connection with the 1997 fieldwork. All samples are marine shells except for two that consisted of multiple pieces of wood charcoal found in close proximity within a midden stratum. An aspect of the dating program was to determine whether CA-SCRI-428, from which a column sample was not collected, actually dated significantly younger than the other red abalone middens (Glassow 1993), as indicated by a date from a sample collected in 1984. The 1997 date from this site indicates that the 1984 date probably is erroneous.

RESULTS

The most obvious characteristic of red abalone middens is the relatively high density of marine shells, implying that shellfish were of prime importance to the diet. At the smaller red abalone middens such as sites 427, 429, and 549, casual inspection in the field leaves the impression that shellfish remains are the only dietary constituent present, but the analysis of column samples from these sites dispels this notion. Although animal bones are present in the deposits in sparing amounts, these reveal that the occupants of these sites also fished and hunted sea mammals. The more abundant bones in the Punta Arena site indicate the same.

Despite the high visibility of abalone shells, particularly those of red abalone, shell fragments of California mussel are by far the most abundant at all sites considered here, as is true of most sites of any time period on Santa Cruz Island. Weights of shellfish remains divided by taxa indicate that mussel is always more than 60% of the total, with other taxa always less than 10% each. Yet the relative importance of mussel does vary among the sites. At the Punta Arena site, mussel is between 67 and 71%, whereas at sites 427, 429, and 549 mussel is between 76% and 88% (Fig. 2). Relatively few species make up most of the difference at the Punta Arena site, the most important being sea urchin (*Stronglyocentrotus* spp, probably mostly *S. purpuratus*) and wavy top (*Lithopoma undosum*). At the other sites, these two species are not as important, and instead red abalone and black abalone are relatively more important, as is black turban (*Tegula funebralis*).

Sharp's (2000a, 2000b) analysis of shellfish remains from the Punta Arena site revealed that black abalone shell is substantially more abundant than red abalone shell. At sites 427, 429, and 549, however, red abalone clearly is more abundant (Fig. 2). However, other species of shellfish that are either smaller in size or typically occur as small

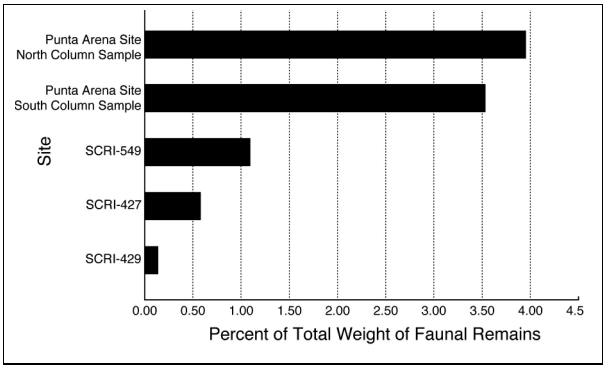

Figure 4. Percent of marine vertebrate bone weight to the total weight of faunal remains from the Punta Arena site and sites CA-SCRI-549, 427, and 429 on Santa Cruz Island, CA.

fragments often are more abundant as measured by weight.

Data derived from bone remains also exhibit significant differences among the sites. Unfortunately, most of the bone is highly fragmented, and because volumes of deposits excavated were quite small, the number of bones identified to the level of genus or species is very small. At all sites, the largest categories are undifferentiated mammal or undifferentiated sea mammal, both composed of bones of pinnipeds and cetaceans that are too fragmentary for further division (Fig. 3). At the Punta Arena site, however, this category includes mostly dolphin bones. Both the test unit and column sample collection contain substantial quantities of dolphin bones, particularly vertebrae. Clearly dolphins were significantly more important than pinnipeds to the inhabitants of this site. An analysis of the dolphin bones, particularly the periotic bone (an ear bone), revealed that four species are represented: northern right whale dolphin (*Lissodelphis borealis*), common dolphin (*Delphinus delphis*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and Risso's dolphin (*Grampus griseus*) (Glassow In press). At sites 427, 429, and 549, dolphin bone is either extremely rare or absent, based not only on the analysis of the column sample collections but also visual observation of exposed midden deposits. At these sites, the sea mammal bone undoubtedly is predominantly from pinnipeds, although no pinniped genera could be identified. As well, sea otter bones could not be identified at any of the sites, including the Punta Arena site.

Bones of fish, primarily teleost but including elasmobranch, comprise somewhat over 10% of the total bone weight at all sites. Because vertebrae, as well as mouth/throat parts of certain species, are relatively well preserved in the site deposits, taxonomic identification to family, genus, or species is possible (Appendix 1). At the Punta Arena site, jack mackerel (*Trachurus symmetricus*) is the dominant identified species, but fishes in the wrasse family (Labridae), including California sheephead (*Semicossyphus pulcher*), senorita (*Oxyjulis californica*), and other wrasses that could not be identified to species are at least as important. Surfperches (family Embiotocidae) are also well represented. Frequencies of identified fish bones are too few at the other sites to be confident of relative proportions, but some patterns nonetheless are apparent (Appendix 1). Considering just the vertebrae, surfperches are dominant at site 549, whereas at site 427 Pacific mackerel (*Scomber japonicus*) and herrings/sardines (family Clupeidae) are most prevalent. Too few identified fish remains are in the site 429 collection for meaningful comparison.

The relative dietary importance of vertebrate marine fauna to shellfish may be ascertained from the proportion of bone weight to the total weight of faunal remains (bone plus shell). At the Punta Arena site, bone weight is between 3.5% to 4.0% of the total faunal remains, whereas at the other three site it is somewhat more than 1.0% at its maximum (Fig. 4). Considering that proportions of fish bone and sea mammal bone are very similar at all four sites (Fig. 3), both fishing and sea mammal hunting were significantly more important to the occupants of the Punta Arena site. Bone is relatively more abundant at site 549 in comparison to sites 427 and 429, implying that shellfish collecting was somewhat less important to the inhabitants of site 549.

Artifacts from the Punta Arena site and the other three sites give clues to subsistence activities, but their quantities are too small for comparative analysis. All sites contain flakes and cores of local volcanic rocks and chalcedony, as well as chert from the eastern sector of the island. Deposits dating between 6,300 and 5,300 BP at the Punta Arena site yielded several projectile point fragments as well as several bone fishing gorges. At site 549 a stone mortar fragment and two stone digging stick weights were found exposed along gully walls within the same stratum from which the column sample was collected. These latter artifacts are the only evidence of the use of plant foods, assuming that the mortar fragment is associated with crushing some sort of plant product and that digging sticks were used to collect bulbs or tubers.

DISCUSSION

The two hypotheses presented earlier concern the degree of functional differentiation between the two larger sites, the Punta Arena site and the El Montón site, and the numerous small sites of which sites 549, 427 and 429 are examples. First, the

larger sites may have served as focal points within a settlement system, where larger numbers of people aggregated to participate in social and perhaps ritual activities. Second, the larger sites simply may be larger versions of smaller sites, where people resided more frequently and/or for longer periods of time before moving to another site. How might each of these two possibilities be manifest in subsistence practices? If the variation in subsistence practices between larger and smaller sites is accounted for by environmental differences alone, then the second hypothesis cannot be rejected, but neither could the first. If environmental differences do not account for all of the variation in subsistence practices—for instance, if there is evidence that some food resources are more intensively exploited by populations living at the two larger sites—then the second hypothesis may be rejected, at least tentatively, and the first hypothesis would as a consequence have some support.

The marine environment adjacent to the Punta Arena site obviously is one of the most productive around the perimeter of the island. Around 6,000 BP it may have been the most productive, given a slightly lower sea level and the extensive kelp forests growing from the relatively shallow rocky substrate between the point and Gull Island. In addition, the steep northern side of Santa Cruz Submarine Canyon is just beyond Gull Island, in which cool, nutrient-rich water rises at the canyon edge when upwelling occurs. The much greater dependence on sea mammal hunting and fishing by the occupants of Punta Arena undoubtedly is related to these environmental characteristics.

Although only cursory data from faunal remains are currently available for the El Montón site, a relatively greater dependence on vertebrate marine fauna may have been true here as well. This site has deposits approximately a meter deep dating to 5,000–5,700 BP (Wilcoxon 1993, Breschini et al. 1996, p. 70), and they appear to cover an area more than 100 m in diameter. Mussel was the dominant shellfish taxon collected, and red abalone appears to be more prevalent than black. This site is near the western extreme of the island, with the relatively quiet waters of Forney's Cove directly south of it. Extensive rocky intertidal zones and subtidal reefs exist nearby, as do sandy beaches. Kelp forests also are extensive in Forney's Cove, and the offshore rocks lining the cove's outer margin probably were a continuous spit of land when sea level was lower. In short, the marine environment near the El Montón site is very productive and in many respects is comparable to that near the Punta Arena site.

Punta Arena occupants depended somewhat less on mussel in relation to other shellfish species, and this is not easily explained by differences in intertidal habitat. Mussel is very abundant today adjacent to the point, and it probably was 6,000 years ago as well. The greater dependence on sea urchins and wavy top by Punta Arena inhabitants possibly is indicative of relatively more intensive shellfish collecting, assuming that both species would not yield as much food value as mussel for a given amount of effort devoted to collecting. However, in his analysis of Punta Arena shellfish remains, Sharp (2000b) did not find that lower proportions per stratum of mussel shell correlated with higher proportions of sea urchin and wavy top shells, which would be expected if collecting intensity accounts for the differing proportions. Again, differences in intertidal and nearshore habitats likely are the main determinant of the varying dependence on mussel relative to other shellfish species at the four sites considered in this analysis. In particular, the somewhat warmer water temperatures at Punta Arena, when compared to water temperatures near the west end of the island, probably account for the higher proportion of wavy top.

The varying proportions of fish taxa among the sites also appears related to environmental differences, and perhaps also differences in the season during which fishing was most intensive. The emphasis on jack mackerel and wrasses at the Punta Arena site and Pacific mackerel at site 427 may be due to the prevalence of these fishes, at least seasonally, above nearshore reefs and near or in kelp beds (Love 1996, pp. 240–241, 282–286, 312). These habitats are extensive near both sites. Conversely, the emphasis on surfperches by fishers at site 549 is expected, given that Christy Beach with its heavy surf is directly below this site.

On the basis of available data, the variation between the two larger sites and the numerous smaller sites appears to be largely the product of environmental differences. Subsistence activities at all sites were much the same, and the most essential differences were a product of abundance of and

access to marine vertebrates. Where marine vertebrates were abundant and could be acquired either on shore, offshore rocks, or in nearshore waters, they were relatively more important to the diet. At smaller sites, relatively more emphasis was placed on shellfish collecting. Occupation appears longest at locations where marine vertebrates could be acquired most economically, that is, at the Punta Arena and the El Montón sites. Duration of occupation appears to have been much shorter at locations where the main subsistence focus was on shellfish, because relatively large mussels and abalones could be depleted within a matter of weeks.

At present, there is little support for the hypothesis that larger sites were focal points of settlement systems and were functionally different from the smaller sites. However, this hypothesis cannot be rejected on the basis of subsistence data alone. Available resources allowing for longer duration of occupation by larger groups of people would be a prerequisite for more complex social and ritual activities. In other words, locations such as Punta Arena and Forney's Cove were selected not just because of their food resource productivity, but also because they allowed members of a larger social unit composed of several family groups to congregate. The presence of a well-defined cemetery at the El Montón site seems indicative of the more complex social and ritual activities that took place there.

CONCLUSION

Developing a model of hunter-gatherer subsistence and settlement strongly supported by a variety of data is always a difficult task that unfortunately requires a good deal of information from many sites. It is not surprising, therefore, that conclusions from the analysis just presented must remain tentative and simple. I have made a beginning by investigating subsistence practices at several sites located on the western part of Santa Cruz Island. However, data from more sites and larger samples must be acquired. Nonetheless, the analysis presented here is strong enough to conclude that variation in subsistence practices among sites occupied about 6,000 BP is largely determined by environmental differences—that subsistence was adjusted to the locally available and accessible marine food resources.

As a consequence of the analysis just presented, two intriguing questions may be asked regarding populations living on Santa Cruz Island between 6,300 and 5,300 BP: How many people, and how many relatively independent multi-family social units, occupied the island at this time? It is plausible that all the sites from the Christy Beach vicinity to Forney's Cove were used by one multi-family group at a given point in time. The Punta Arena site, however, is 8.5 km straight-line distance from the nearest of these sites, and coastal survey has been sufficiently thorough along the intervening coastline to be reasonably confident that no red abalone middens exist. Its separation from other red abalone middens may indicate that the Punta Arena site was used by a different multi-family unit that produced many other sites without an abundance of red abalone shells. However, current knowledge about the chronology of sites near the Punta Arena site, and along the coast between Punta Arena and Christy Beach, is too scanty for assessing this possibility.

Finally, it should not be assumed that population numbers and ecological adaptation remained constant through the roughly 1,000-yr interval when red abalone middens were being produced on western Santa Cruz Island. As more sites are dated and the chronologies of already-dated sites are refined, most likely some changes through time will be identified. It is possible, for instance, that some of the variation in subsistence practices discussed here is a product of shifting environmental circumstances or fluctuation in numbers of people living on the island.

In conclusion, the analysis presented here is one step along a long path toward a satisfying picture of life on Santa Cruz Island between 6,300 and 5,300 BP. Only small-scale test excavations have been undertaken at a few sites, resulting in comparatively small bodies of data. Yet the distinctive nature of red abalone middens and their discrete occurrence in time provokes continued attention by archaeologists working on Santa Cruz Island and other northern Channel Islands.

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Appendix 1. Fish remains from the Punta Arena site (North and South units) and CA-SCRI-549, 427, and 429.

Punta Arena Site, North and South Units

Common name	Element										Grand total
	Vertebrae		Jaw parts and teeth		Otoliths		Other		Total		
	North	South	North	South	North	South	North	South	North	South	
Jack Mackerel	165	146	-	-	-	-	-	-	165	146	311
Pacific Mackerel	12	1	-	-	-	-	-	-	12	1	13
Mackerel	145	59	-	-	13	34	-	-	158	93	251
Sheephead	24	20	120	186	-	-	-	-	144	206	350
Giant Kelpfish	7	7	-	-	-	-	-	-	7	7	14
Rockfish	43	40	2	3	4	8	-	-	49	51	100
Senorita	-	-	-	-	-	2	-	-	-	2	2
Croaker	-	-	-	-	-	1	-	-	-	1	1
Surfperch	57	74	22	30	1	6	-	-	80	110	190
Kelp Bass	2	-	-	-	-	-	-	-	2	-	2
Small Wrasse	414	125	4	12	-	-	-	-	418	137	555
Clupeid	32	13	-	-	-	-	-	-	32	13	45
Lingcod	7	1	4	8	-	1	-	-	11	10	21
Cabezon	6	8	-	-	-	-	-	-	6	8	14
Jacksmelt	7	6	-	-	-	-	-	-	7	6	13
Blacksmith	85	46	-	-	-	-	-	-	85	46	131
Halfmoon	-	1	-	-	-	-	-	-	-	1	1
Greeling	1	-	-	-	-	-	-	-	1	-	1
Mola Mola tailbones	-	-	-	-	-	-	5	-	5	-	5
Family Triakiddidae	117	10	44	13	-	-	-	-	161	23	184
Pacific Angel Shark	-	-	2	1	-	-	-	-	2	1	3
Shovelnose Guitarfish	1	1	-	-	-	-	-	-	1	1	2
Batray	1	1	1	1	-	-	-	-	2	2	4
Round stingray	-	1	-	-	-	-	-	-	-	1	1
Thornback	1	-	-	-	-	-	-	-	1	-	1
Unidentifable Elasmobranch	6	-	-	-	-	-	-	-	6	-	6
Total	1,133	560	199	254	18	52	5	0	1,355	866	2,221

CA-SCRI-549 Column

Common name	Element			
	Vertebrae	Pharyngeals	Teeth	Total
California Sheephead	-	2	14	16
Herrings/ Sardines	1	-	-	1
N/A	2	-	-	2
Pile Surfperch	-	2	37	39
Rockfish	3	-	-	3
Senorita	2	-	-	2
Sharks/Rays	1	-	-	1
Surfperch	12	-	-	12
Total	21	4	51	76

Appendix 1. (Continued) Fish remains from the Punta Arena site (North and South units) and CA-SCRI-549, 427, and 429.

CA-SCRI-427 Column

	Element					
Common name	Vertebrae	Pharyngeals	Teeth	Otoliths	Dermal denticles	Total
Bat Ray	-	-	1	-	-	1
California Sheephead	1	1	15	-	-	17
Herrings/Sardines	10	-	-	-	-	10
Pacific Mackerel	16	-	-	-	-	16
Pile Surfperch	-	-	2	-	-	2
Rockfish	2	-	-	1	-	3
Senorita	7	-	-	-	-	7
Surfperch	2	-	-	-	-	2
Houndsharks	2	-	-	-	-	2
Thornback ray	-	-	-	-	1	1
Total	40	1	18	1	1	61

CA-SCRI-429 Column

	Element		
Common name	Pharyngeals	Teeth	Total
California Sheephead	2	1	3
Pile Surfperch	-	1	1
Total	2	2	4