The Occurrence of Red Abalone Shells in Northern Channel Island Archaeological Middens: Implications for Climatic Reconstruction

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Abstract - Certain archaeological sites on the northern Channel Islands dating between *ca.* 4,500 and 7,500 B.P. contain unusually high frequencies of red abalone *(Haliotis rufescens)* shells. Assuming that aboriginal peoples living at these sites collected shellfish principally from the intertidal zone, the high frequency of red abalone shells may reflect a time when sea water temperatures were cooler than present, allowing red abalone to be the dominant abalone species in the intertidal zone.

Introduction

A spectacular feature of certain archaeological sites on the northern Channel Islands is the presence of midden deposits containing densely concentrated red abalone shells (*Haliotis rufescens*). In many cases, the shells are so dense as to form a continuous layer in which shells of other species are either absent or in minor quantities. In other cases, red abalone shells are a prominent constituent of a varied assemblage of shellfish remains. The red abalone middens are typically quite thin, no more than perhaps 25 cm thick, even at sites where red abalone is mixed with a number of other species. These middens are especially intriguing because today red abalone inhabit a subtidal zone around the northern Channel Islands and therefore are not obtainable in the intertidal zone in the substantial numbers implied by their dense concentrations in the middens. Instead, black abalone *(Haliotis cracherodii)* is the common intertidal species, and shells of this species often are found in considerable quantities in midden deposits which typically either overlie the strata containing abundant red abalone shells or are in nearby sites. In the red abalone middens, black abalone shells are either absent or very rare, and when they do occur, they are frequently unusually small in size.

It is significant that most of the red abalone middens appear to represent relatively short-term occupations and that in most of them red abalone shells occur in the hundreds, while in a few of them their numbers probably are in the thousands. These quantities, along with their relatively high proportional abundance in comparison to other shellfish species, imply that considerable numbers of red abalone could be obtained in one collection episode. In short, red abalone was abundant enough to have been a significant dietary staple to the prehistoric groups who created the red abalone middens.

As early as 1955, Hubbs (1955) postulated that the 7,000-year-old red abalone middens found by Orr on Santa Rosa Island are indicative of times during which sea water temperatures were cooler than today. Hubbs (1958, 1967) argued, in other words, that red abalone would flourish only if sea water temperatures were sufficiently cooler than today to cause red abalone to displace black abalone in the intertidal zone. Orr (1968:97) adopted Hubbs' position, arguing that the early phase of Santa Rosa Island's Dune Dweller Period, dating between about 6,800 and 7,500 B.P., was characterized by cooler than present sea water temperatures.

The implications of the red abalone middens are obvious. If indeed they reflect cooler sea water conditions, their occurrence can be used as a climatic indicator. Following Hubbs' logic, sea water temperatures would have to have been significantly cooler than is the case today for red abalone to be prevalent in the intertidal zone, perhaps as cool as coastal waters of central or northern California. Since sea water temperature varies reasonably closely with air temperature (Hubbs 1948; Namias 1969), the times during which the red abalone middens were formed would have been characterized by significantly cooler climatic conditions, and we can assume that the marine and terrestrial biotic environments of the Santa Barbara Channel were also quite different than those of today. Human populations, therefore, would have been adapting to much different environmental conditions than exist today.

Another important implication is the potential to use the archaeological record as a measure of climatic change independent of other sources of data, such as fossil pollen. Specifically, the evidence of climatic change from the deep sea cores taken from the floor of the Santa Barbara Channel (Heusser 1978; Pisias 1978, 1979) may be evaluated. Should discrepancies between the climatic sequences based on these cores and the sequence of red abalone middens be discovered, careful scrutiny of the deep sea core data would be justified.

Relationship Between Abalone Habitat and Water Temperature

Unfortunately, Hubbs cites no definitive data to support his claim that red abalone would displace black abalone during periods of cooler sea water temperature. One must ask, therefore, whether Hubbs' argument indeed has a legitimate basis. This issue is of special concern because published descriptions of red and black abalone (*e.g.*, Cox 1962; Abbott & Haderlie 1980) generally indicate that the extents of their distribution along the California coast are nearly identical and that the bulk of red abalone populations are subtidal throughout their range.

However, significant differences in the abundance of red and black abalone in the intertidal zone do exist, and these differences generally correlate with the north-south gradient in water temperature along the California coast. In broad terms, black abalone occurs in the intertidal zone from San Francisco Bay south into Baja California, but is very rare north of this point, whereas red abalone occurs in noticeable quantities in the intertidal (and subtidal) zone from Cape Mendocino south roughly to Port San Luis (Ault 1985:3, 16; Curtner 1917; Leighton 1968:3; Thompson 1920).

Quantitative data on the densities of the two species at different points along the California coast are rare, and what data are available must be used with caution in light of the intensity of abalone shorepicking along many portions of the coast. Quadrat surveys at Diablo Canyon along the San Luis Obispo County coast indicate that both red and black abalone are present in the intertidal zone, but that black abalone is usually more abundant than red (Gotshall *et al.* 1984:119-131). Survey data collected near Point Arena in Mendocino County indicate that red abalone is the only abalone species in the intertidal zone (Gotshall *et al.* 1974b:57-92, 95; see also Miller *et al.* 1974:37).

These disparate data on the distribution and abundance of red and black abalone allow a reasonably clear picture to be presented. Along the Santa Barbara Channel, red abalone is almost exclusively subtidal, whereas black abalone frequently is very abundant intertidally. Along much of the central California coast north of Santa Barbara County to San Francisco Bay, red and black abalone occur together in the intertidal zone, red normally in the lower intertidal and black in the mid intertidal. Although the data are not available, red probably increases in abundance along the central California coast as one moves northward. At any rate, north of San Francisco black abalone becomes extremely rare and red abalone is the dominant abalone species in the intertidal zone.

Although the distributional data imply that water temperature is a significant factor determining differences between red and black abalone habitat preferences, data indicating differences in water temperature tolerance between the two species would allow a stronger case to be made. Fortunately, the upper extreme of temperature tolerance of both red and black has been investigated. Under controlled laboratory conditions, black abalone tolerates temperatures up to approximately 26-27°C (Hines *et al.* 1980), whereas red abalone tolerates temperatures up to approximately 24-25°C (Gotshall *et al.* 1974a:75-87). Although no data are reported on the lower extreme temperature tolerance of the two species, one may conclude that sea water temperature undoubtedly plays an important role in affecting distribution and abundance. It turns out, then, that Hubbs' assertions do have a strong foundation in fact.

Two other pieces of information imply that the habitat of the abalones is indeed affected by sea water temperature. One is found in uplifted beach deposits along the upper edge of the seacliff of southeastern San Miguel Island. Dating into Pleistocene and well beyond the range of human occupation (so far as we know), these beach deposits contain abundant red abalone shells in the absence of black abalone. The implication is that cooler sea water temperatures during some portion of the Pleistocene favored red abalone over black. The other piece of information is the much greater frequency of red abalone middens on San Miguel Island than on the other northern Channel Islands (see discussion below), which would be expected in light of the significantly lower sea water temperatures around that island in comparison to those farther east (Hubbs 1967). Assuming a comparable temperature gradient existed throughout prehistory, one would expect that San Miguel Island witnessed relatively more and longer periods during which sea water temperatures were cool enough for red abalone to be prevalent in the intertidal zone, and that aboriginal populations of this island would therefore have formed relatively more red abalone middens.

Temporal and Spatial Distribution of the Sites

Seventeen sites on Santa Cruz, Santa Rosa and San Miguel Islands containing unusually high frequencies of red abalone shells have been recorded and dated by the radiocarbon method (Table 1). In some cases, the complete site deposit, which is normally less than 25 cm thick, contains unusually high frequencies of red abalone shells; in others, only one stratum, almost always the bottommost, contains the red abalone shells. Several other dated sites beyond the 17 documented so far also may fit into this category, but the available data on characteristics of these sites are insufficient for making a confident assignment.

The radiocarbon dates for the 17 sites (Table 1) are best used uncorrected for 13C/12C fractionation or the reservoir effect for two reasons: first, many of the dates are not associated with 13C/12C fractionation corrections, and second, the two correction factors tend to cancel each other in the Santa Barbara Channel region (Taylor 1987:120-121, 128-129), making the uncorrected date a close approximation of the fully corrected date.

The earliest occurrences of red abalone middens have been reported by Orr (1968). In the course of his investigations on the northwest coast of Santa Rosa Island, he obtained a series of radiocarbon dates between 6,500 ± 200 and 7,400 ± 200 B.P. from three sites, one of which was a cemetery containing a number of red abalone shells as mortuary offerings and a distinct pile of red abalone shells. Orr also obtained comparably early radiocarbon dates from two additional sites which also may contain significant amounts of red abalone shells, but the available documentation of the contexts of these dates does not allow confident assignment.

On San Miguel Island, Rozaire & Kritzman report, on site record forms resulting from a survey of the island (Rozaire 1965), the presence of numerous sites containing red

Table 1. Radiocarbon dates of red abalone middens. All are listed in Breschini, Haversat & Erlandson (1988.)

Site	Locality	Uncorrected Date	C-13/C-12 Corrected Date	Lab No.	Material
SANTA CRUZ ISLAND SUITE					
SCRI-34	Christi Beach	5270±180	---	UCR-1607	*Haliotis rufescens*
SCRI-109	Punta Arena	4600±150	---	UCR-209	*H. rufescens*
SCRI-109	Punta Arena	4790±150	---	UCR-201	Wood Charcoal
SCRI-236	Christi Beach	4435±100	---	UCR-131	Wood Charcoal
SCRI-333	Forneys Cove	4590±195	4610±195	UCR-1832	Wood Charcoal
SCRI-333	Forneys Cove	5190±135	---	UCR-1530	Wood Charcoal
SCRI-424	Forneys Cove	5120±125	5550±125	UCR-1833	*H. rufescens*
SCRI-426	Forneys Cove	4680±100	5100±100	UCR-1834	*H. rufescens*
SCRI-427	Forneys Cove	4990±100	5430±100	UCR-1835	*H. rufescens*
SCRI-428	Forneys Cove	3795±100	4220±100	UCR-1836	*H. rufescens*
SCRI-429	Forneys Cove	6775±130	7195±130	UCR-1837	*H. rufescens*
SCRI-430	Forneys Cove	5325±125	5745±125	UCR-1838	*H. rufescens*
SANTA ROSA ISLAND SUITE					
SCRI-3	Tecolote Point	7070±250	---	L290-D	*H. rufescens*
SCRI-3	Tecolote Point	7120±120	---	UCLA-663A	*H. rufescens*
SCRI-3	Tecolote Point	7210±400	---	UCLA-663C	*H. rufescens*
SCRI-3	Tecolote Point	7230±120	---	UCLA-663B	*H. rufescens*
SCRI-4	Arlington Cn. Mouth	6500±200	---	UCLA-659B	*Haliotis* spp.
SCRI-4	Arlington Cn. Mouth	6550±120	---	UCLA-659C	*Haliotis* sp.
SCRI-6	Arlington Cn. Mouth	6820±160	---	L-257	*H. rufescens*
SCRI-6	Arlington Cn. Mouth	7400±200	---	LJ-27	*H. rufescens*
SAN MIGUEL ISLAND SUITE					
SMI-350	Harris Point	6030±150	---	I-3717	*H. rufescens*
SMI-388	Simonton Cove	6450±130	---	I-4587	*H. rufescens*
SMI-492	E. of Pt. Bennett	4920±180	---	Beta-5807	*H. rufescens*
SMI-557	SE Coast	5525±130	5950±130	UCR-1831	*H. rufescens*

abalone shells in the absence of black abalone shells.[1] In fact, 74 of the 542 sites they recorded, or nearly 14%, fall into this category, implying that there are more such sites on San Miguel Island than on all the rest of the northern Channel Islands combined. They are especially abundant within the eroding dune deposits along the northern coast of the island, and some occur in very durable calichified soil matrices. Four of the sites containing midden with abundant red abalone shells have been dated so far, the dates ranging between 4,920 ± 80 and 6,450 ± 130 B.P.

On Santa Cruz Island, 10 sites containing red abalone middens have been discovered, their dates ranging between 3,795 ± 100 and 6,775±130. At a site near the western extreme of the island (SCRI-333), three distinct red abalone layers recently were discovered forming the bottommost strata at the site (L. Wilcoxon, pers. comm.). One of these layers is associated with the two radiocarbon dates listed in Table 1. Seven other sites near the western end of the island also contain distinct red abalone middens visible in erosional profiles. Two sites are located on the southwest coast of the island, one at Christi Beach (SCRI-236) and the other located at the mouth of Canada de los Sauces about 1 km to the south (SCRI-34). By far the largest red abalone midden known to exist on the northern Channel Islands, having dense midden deposits approximately 1 m thick, is at Punta Arena, on the south coast of the island.

1. Greenwood (1978:84) notes that indication of the presence at sites of *Haliotis corrugata* (pink or corrugated abalone) on the Kritzman/Rozaire site record forms for San Miguel Island is undoubtedly a result of mistaken species assignment. This is likely because when common instead of scientific names of species are given on the site record forms, red abalone rather than pink abalone is always specified.

Considering all the dates from the northern Channel Islands together, two relatively distinct time periods appear to exist: one centering around 5,000 B.P. and the other around 7,000 B.P (Fig. 1). The dates from only three sites depart from this pattern. Two sites on San Miguel Island fall between these two clusters, and one site on Santa Cruz Island appears to be significantly more recent than the younger of the two clusters.

There are several possible reasons for these departures. The two sites on San Miguel Island may indicate that red abalone was collected exclusive of black abalone during longer or more frequent periods of time than was the case on the other islands, a possibility that also is suggested by the much greater abundance of red abalone middens on this island, as well as the occurrence of middens with moderately high proportions of red abalone shells known to date to much later periods in prehistory (Walker & Snethkamp 1984:79). The anomalously young date from Santa Cruz Island may indicate that the later of the two clusters actually embraces times more recent than *ca.* 4,500. Alternatively, the date itself may be in error, as might also be the case with the two San Miguel Island dates. Although the available dates are sufficient to suggest that red abalone were important during two distinct periods, more data are needed in order to ascertain the precise durations of these periods, to determine whether other periods also exist, and to assess variations in these periods between the islands.

Red abalone middens also occur elsewhere in southern and central California. It is known that they occur frequently on San Nicolas Island to the south, perhaps in densities approximating those on San Miguel Island (G. Kritzman, pers. comm.). They also have been reported to occur in coastal San Luis Obispo County, where Greenwood (1972:67, 87) found a red abalone stratum at each of two sites at Diablo Canyon.

Significantly, red abalone middens have not been discovered at coastal sites on Vandenberg Air Force Base, despite extensive archaeological survey and test excavations over the past 15 years (Glassow *et al.* 1976, 1981; Chambers Consultants & Planners 1984). Although red abalone middens also have not been found in sites on the Santa Barbara Channel mainland, aspects of the shellfish assemblage at SBA-53, a site on the edge of the ancient Goleta Slough which has been radiocarbon dated between 4,600 and 5,000 B.P., are suggestive of island assemblages. At this site red abalone is apparently one of the rarer species, but it occurs in the absence of black abalone (Harrison & Harrison 1966:55). Indeed, one of the three radiocarbon dates was obtained from a whole red abalone shell, and another from a large fragment (Harrison & Harrison 1966:34). The lack of known red abalone middens in sites of the Vandenberg region is difficult to explain on the basis of current knowledge, but their apparent lack along the Santa Barbara Channel mainland could easily be accounted for by the generally low dependence on shellfish inhabiting the open coast by populations of this region and the scarcity of habitats conducive to red abalone.

Hypotheses Concerning Cultural Behavior

A complicating factor in using the relative abundances of red and black abalone shells in archaeological middens as a reflection of water temperature fluctuation is the possibility that distinctive forms of human collecting behavior intervened between the proportions of the two species in the intertidal zone and the proportions of their shells in archaeological sites. On the basis of various lines of evidence, two hypotheses may be proposed that consider the cultural behavior related to abalone collecting.

The first hypothesis concerns the way in which red abalone was exploited by human populations. If the bulk of red abalone were subtidal throughout prehistory, the prehistoric inhabitants of the northern Channel Islands may have dived for them, much in the manner that

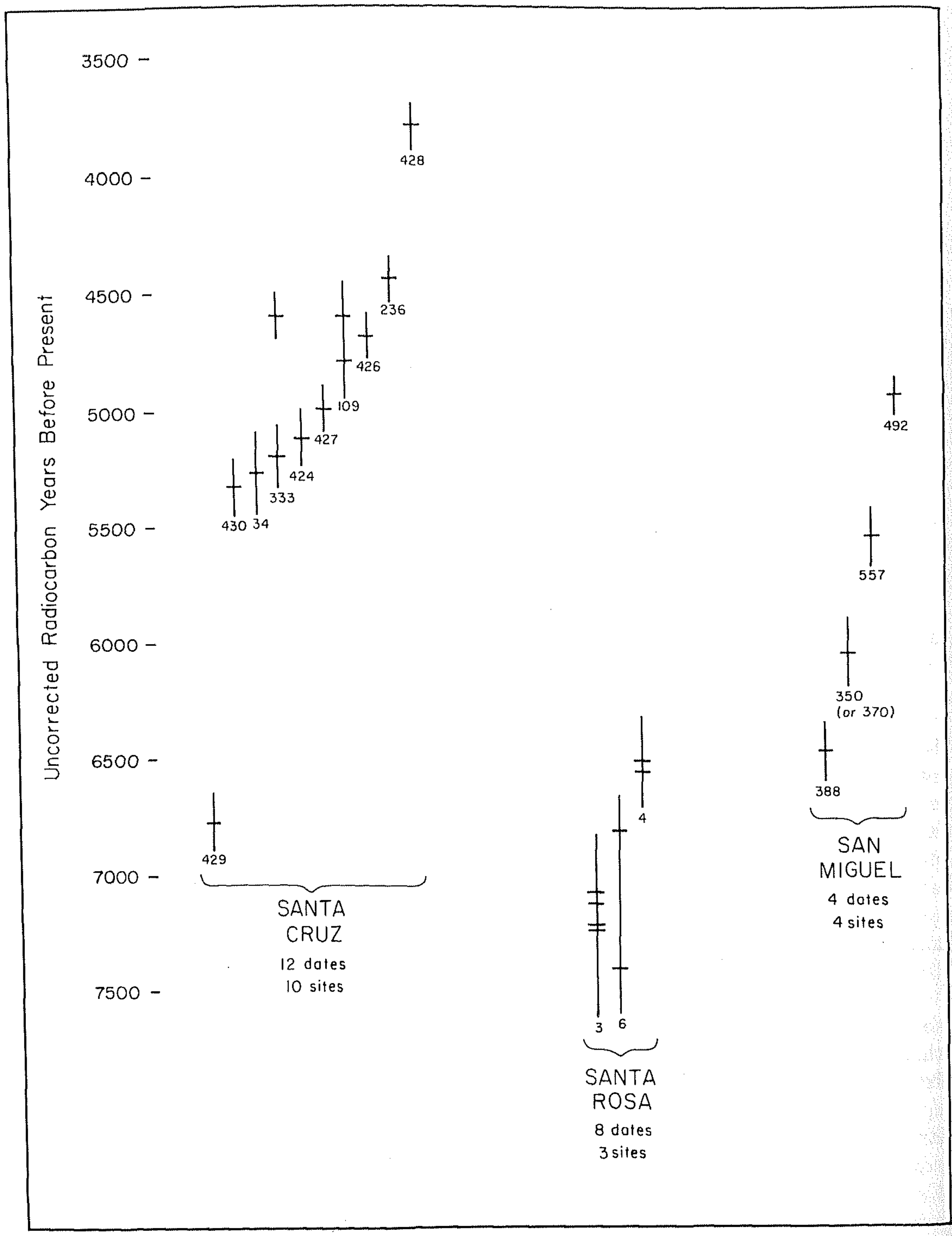

Figure 1. Distribution of radiocarbon dates for red abalone middens. Horizontal lines indicate the dates and the vertical lines bisecting them indicate 1 σ SE. Numbers below the dates are designations of the sites to which the dates pertain.

they are collected today. Red abalone may have been considered tastier than black abalone, as they are today, and so long as red abalone was relatively accessible and abundant in shallow subtidal waters, one might argue that they were collected in preference to black abalone.

Walker & Snethkamp (1984:209) believe this hypothesis is supported by data they collected from western San Miguel Island. Midden samples collected from seven sites yielded shellfish remains indicating that red abalone occurs in association with other currently low intertidal/subtidal species such as brown turban *(Tegula brunnea)* and giant chiton *(Cryptochiton stelleri)* (Walker & Snethkamp 1984:79). This hypothesis faces several problems, however, that diminish its ability to account for the red abalone middens.

First, since these species occur with red abalone at least sporadically in the lower intertidal zone today, Walker and Snethkamp's argument makes sense only if the quantities in the middens represent a rate of collection not possible unless subtidal populations also were collected. Such a rate has not been demonstrated. Second, one wonders whether the brown turban and giant chiton also might have increased in abundance in the intertidal zone along with red abalone during periods of cooler water temperatures. Third, it is difficult to imagine why red abalone would have been so much more preferable than black abalone that prehistoric peoples were willing to disregard the much easier access to black abalone in the intertidal zone and expend the energy to acquire subtidal red abalone. Diving for red abalone would be expected if black abalone earlier had been depleted in the intertidal zone. If this were the case, relatively intensive intertidal exploitation of black abalone should immediately precede periods when diving for red abalone prevailed. Data from midden samples obtained from western San Miguel Island sites are suggestive of such a pattern in that both red and black abalone vary considerably in abundance through time (Walker & Snethkamp 1984:72-106). In other cases, however, especially on Santa Cruz and Santa Rosa Islands, red abalone middens occur at the very base of site deposits with no indication that intense intertidal shellfish collection preceded the formation of the middens.

A final problem arises when evidence from human skeletal remains is considered. If inhabitants of the northern Channel Islands were diving regularly for shellfish, a condition characterized by a boney lesions in the ear canal of divers known as auditory exostoses should have a noticeable incidence in the skeletal remains from prehistoric cemeteries. Kennedy (1986:407) reports that a skeletal sample of 86 individuals from a prehistoric island cemetery contained 37.2% exhibiting auditory exostoses (location and date of the sample is not reported). On the other hand, Walker reports that this condition occurs only very rarely in skeletal remains from island sites. Of the seven skeletal populations from Santa Cruz and Santa Rosa Islands that he analyzed, percentages of auditory exostoses varied between less than 1% to 5% (P. Walker, pers. comm.). Although Kennedy's and Walker's data appear contradictory, at least one may infer that diving for abalone or other resources was a sporadic activity through much of prehistory. It is conceivable, of course, that the red abalone middens represent only brief but intensive episodes of diving for abalone, a possibility that can not be evaluated effectively without more data on the volume and dating of the middens.

A variant of this hypothesis argues that red abalone was collected only from the intertidal zone while black abalone was left largely untouched. This argument also is based on the assumption that red abalone would have been preferred because it is tastier than black abalone. To account for the red abalone middens, however, enough red abalones must have been present in the intertidal zone to satisfy demand. The high densities and great numbers of red abalone shells in some of the Santa Cruz and San Miguel Island sites, which imply short-term episodes of intensive shellfish collection, indicate that red abalone must have been relatively abundant in the intertidal zone, undoubtedly much more abundant than it is today. Furthermore, one would expect a relatively gradual increase through time in the proportion of black to red abalone shells in middens as red abalone gradually became overexploited. Such a pattern is not known to exist; instead, red abalone middens are always quite distinct from middens in which black abalone shells are more abundant than red abalone shells, at least on Santa Rosa and Santa Cruz Islands.

The second hypothesis proposes that red abalone middens were created as a result of scavenging for red abalone on beaches after intense winter storms dislodged numbers of abalone from their subtidal habitat and washed them ashore. This hypothesis is suggested by information provided by a long-time resident of Lompoc, California, who remembers collecting beached abalones after winter storms prior to *ca.* 1960 (L. Spanne, pers. comm.). He recalls that scattered red abalones could be found on sandy beaches next to rocky headlands between the mouth of the Santa Ynez River and Purisima Point and along the Santa Barbara Channel mainland coast between Gaviota and Point Conception. When the next low tide occurred after a storm, one could collect the legal limit of red abalones in very short order. Apparently, red abalones living on marginal substrates, *i.e.*, ones that were gravelly or sandy, were dislodged by the heavy surge of winter storms and washed ashore. This presumption is consistent with the fact that beached red abalones after winter storms ceased to occur about the time that commercial landings of red abalones markedly increased (see Burge *et al.* 1975). The implication is that human predation created a situation in which red abalones no longer lived on marginal substrates.

If conditions that existed historically prior to *ca.* 1960 also existed prehistorically, a small group of scavengers might have been able to collect perhaps more than a dozen red abalones from beaches near a site under these fortuitous circumstances. As is the case with the previous hypothesis, however, this one makes sense only if shellfish of the intertidal zone had been intensively exploited immediately prior to the collection of red abalone, so that few abalones of either species were still available in the intertidal zone. As discussed above, the evidence from Santa Cruz Island indicates otherwise. Still, one would expect that beached red abalones certainly would have been collected if they were available, and this hypothesis might account for the sporadic occurrence of red abalone shells in middens through the span of prehistory following the period in question.

Conclusion

The hypothesis proposing that the red abalone middens were formed during periods when sea water temperatures favored the existence of red abalone in the intertidal zone appears to have substantial support from the available data, which includes the current distribution of red and black abalone along the central and northern California coast and differences in the water temperature tolerance of these two species. The distinct periods of time to which the red abalone middens date, the lack of evidence of blending with deposits dating later in time, and the larger number of red abalone middens on San Miguel Island also favor this hypothesis.

In contrast, the two hypotheses arguing that the red abalone middens are a result of human collecting patterns do not stand up well to the archaeological and biological data. Neither hypothesis can account for the near absence of black abalone in the middens, especially since the red abalone middens appear to represent the first utilization of particular intertidal localities around the islands. This fact implies that there was not an earlier time during which black abalones were largely depleted from the intertidal zones. Still, there is no reason why these two hypotheses might not account for some of the variation observed among the red abalone middens, as well as for the more sporadic occurrence of red abalone shells in later midden deposits.

If indeed the occurrence of red abalone middens reflects times during prehistory when sea water temperatures were cooler, several interesting questions come to mind. How long were these periods of relatively cool sea water? What climatic conditions prevailed during these periods of cooler sea water? How were food resources affected by cooler sea water conditions and differing climatic conditions. If food resources were affected, what was the effect on subsistence practices and other aspects of cultural behavior? These questions are worthy of consideration as we attempt to learn more about the behavior of red and black abalone in response to sea water temperature fluctuations.

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