PREHISTORIC CHRONOLOGY AND ENVIRONMENTAL CHANGE AT THE PUNTA ARENA SITE, SANTA CRUZ ISLAND, CALIFORNIA

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ABSTRACT

Punta Arena, a prominent headland along the southern Santa Cruz Island coast, is the location of archaeological site CA-SCRI-109. It has yielded evidence of several periods of prehistoric occupation, the earliest dating ca. 6900 BC and the latest dating ca. 55 BC. The principal occupation occurred between 4200 and 3300 BC and is represented by thick midden deposits containing high concentrations of mussel shells mixed with frequent red and pink abalone shells. Bathymetric data and reconstruction of Holocene sea level rise indicate that during the earliest periods of occupation Punta Arena was connected to Gull Island, now more than a kilometer offshore. Beginning sometime between 6000 and 5000 BC, sea-level rise eventually resulted in inundation of the lands between Gull Island and the point. This would have caused shellfish living in the intertidal and shallow subtidal zones to become very abundant and a significant attraction to prehistoric settlement.

Keywords: Archaeology, prehistory, Santa Cruz Island, Punta Arena, chronology, environmental change, radiocarbon dating, sea-level rise, *Haliotis rufescens*.

INTRODUCTION

Several important cultural changes occurred in the Santa Barbara Channel region during the period of prehistory between 4300 and 3800 BC (5500 to 5000 radiocarbon years before present). First, stone mortars and pestles began to be used to process foods, implying that diet breadth expanded to include foods that earlier were not important or not utilized. Second, beginning sometime around 3800 BC, flaked stone projectile points that probably tipped darts or spears were much more frequently used than before, even though the importance of hunting does not appear to have increased. Third, beginning perhaps as early as 4300 BC, marine animals, including fish and sea mammals became more important to the diet. At this point, however, we have only a vague understanding of the relationship of these changes to such aspects of culture as subsistence systems and social organization. These changes appear to reflect the rise of a new form of cultural system that set the stage for future cultural development while maintaining strong affinities with the past. Correlating with these changes is a relatively abrupt rise in frequencies of dated sites, implying that regional population numbers increased from relatively low levels prior to 4300 BC (Glassow, in press).

The changes just summarized have been documented primarily through excavations of coastal mainland sites. On the Channel Islands, sites dating to this period typically contain large quantities of red abalone shells (Glassow 1993), but so little is known about these sites that it is unclear whether changes seen on the mainland also occurred on the islands. On Santa Cruz Island, site deposits containing quantities of red abalone shells (*Haliotis rufescens*), or "red abalone middens," typically are midden strata only about 20 to 30 cm thick with no earlier midden deposits directly below, and if deposits occur above, they date to much later periods of time and are of a different soil texture.

It was against this backdrop of information that I undertook investigations in 1997 at site CA-SCRI-109, located at Punta Arena on the south coast of Santa Cruz Island (Figures 1 and 2). This is a site at which research carried out in 1974 revealed that earlier deposits were separated from a red abalone midden by dune sand. Two radiocarbon dates obtained from the 1.5-m thick red abalone midden in 1974 indicated that it dated ca. 3600 to 3000 BC, and an underlying midden stratum, separated from the much thicker red abalone midden stratum by a nearly sterile accumulation of dune sand, yielded a date of ca. 5800 BC. The stratigraphic separation of the earlier and later deposits, as well as a red abalone midden that was considerably thicker than that of

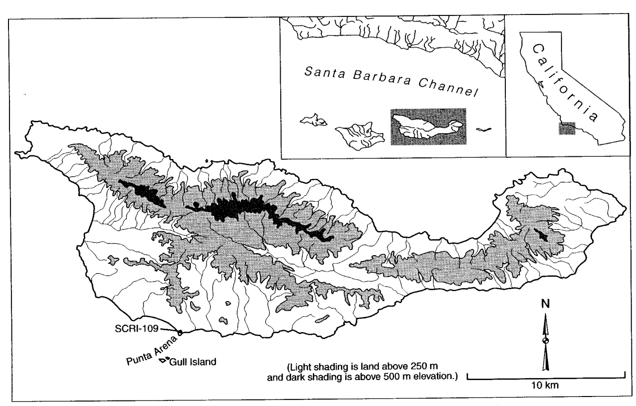

Figure 1. Map of Santa Cruz Island showing location of archaeological site CA-SCRI-109.

Figure 2. Oblique air photograph of Punta Arena. The main portion of site CA-SCRI-109 is in the center of the frame, and immediately to the right of it is the ravine that cuts through the site deposits. This photograph was taken at low tide, and much of the intertidal zone of Tertiary conglomerate is exposed around the margins of the point. A perennial stream runs in the small canyon seen in the upper right of the frame.

any other known red abalone midden, seemed an ideal situation for investigating not only the cultural changes that occurred sometime between ca. 5800 and 3600 BC, but also any changes that might have occurred during the time interval represented by the red abalone midden. As a result, site CA-SCRI-109 was the focus of fieldwork undertaken during the summer of 1997 as part of a research program designated the Red Abalone Midden Project.

The work of the Red Abalone Midden Project is ongoing, but chronological, soil stratigraphic, and geomorphological information are now available for reconstructing the depositional history of the site and its relationship to changes in the topography of Punta Arena and the shape and position of the coastline. The objectives of this paper, therefore, are to establish a baseline of chronological and environmental information to serve as a basis for the eventual interpretation of data derived from the archaeological collections.

DESCRIPTION OF SITE CA-SCRI-109

The midden deposits of CA-SCRI-109 cap a promontory of land elevated above sea level by about 17 m. The southern face of the site descends to a low marine terrace about 5 m above sea level that forms the tip of Punta Arena. The west side of the site has been affected by extensive erosional gullying, while the east side is bisected by a deep ravine. The gullying and the entrenchment of the ravine are undoubtedly a product of historic livestock grazing, as historic photographs reveal that the heads of lateral tributaries of the ravine began to infill with eolian sand at about the time livestock were removed from the island in the 1980s. The northern margin of the site merges into the exposed surface of fanglomerate bedrock, and this fanglomerate formation appears to form the spine of the promontory of land on which rests the central portion of the site deposits.

The fanglomerate underlying the central portion of the site deposits is a tongue-shaped extension of a broad bedrock formation extending inland to the base of the Sierra Blanca Ridge, 450 m north of the site. At the location of the site, the fanglomerate is 1 to 5 m thick. Underlying it is approximately 15 m of compact sand, undoubtedly an eolianite, the upper portion of which contains regularly spaced illuvial clay lamellae. Underlying the eolianite at the mouth of the ravine bisecting the site is a conglomerate formation apparently of Tertiary age, which is also exposed in the intertidal zone surrounding Punta Arena. This lower bedrock formation extends inland from the beach but is obscured by the overlying eolianite. Although similar in lithology, it is more resistive than the fanglomerate above the sand. On either side of the ravine the fanglomerate overlying the eolianite is largely absent, and site deposits rest directly on the eolianite. Only near the head of the ravine are site deposits resting on an extensive exposure of the fanglomerate. The fanglomerate is also visible at scattered spots along the western margin of the site. Although geologists have not yet studied in detail the bedrock formations in the immediate vicinity of Punta Arena, it is obvious that the fanglomerate and the underlying eolianite date well into the Pleistocene and appear to have formed long before any prehistoric occupation took place at Punta Arena.

Freshwater seeps occur below the southeastern edge of the site, just above the high tide. They are seeping from the base of the sand overlying the conglomerate. The reliability of these seeps is unknown. Regardless, a clearly perennial small stream is only 250 m northeast of the site.

The overall dimensions of the site, excluding a segment to the east of the ravine, are 80 by 140 m. Prior to historic erosion, the west side of the midden sloped gently away from the central axis of the promontory, and the east side sloped down to an apparently relatively shallow swale, where the ravine is now located. Only the southern margin was a steep slope, as it still is today. Comparatively little vegetation covers the site today, consisting of coastal goldenbush (*Isocoma menziesii* var. *vernonioides*), silver lupine (*Lupinus albifrons*), and scattered silver beachbur (*Ambrosia chamissonis*). These plants are low-growing and occur as clumps on an otherwise exposed shell midden surface, and they were absent when livestock grazing took place in the vicinity. That these clumps of vegetation are catching sand blown onto the site from the west implies that prior to livestock grazing the site probably was covered with much denser vegetation growing on a mantle of dune sand. The dune sands filling the heads of the lateral tributaries of the ravine are covered with a thin cover of grasses mixed with scattered coastal goldenbush and silver beachbur. This cover of vegetation is thick enough to stabilize the dune surface.

Along the sides of the ravine and its tributaries are extensive vertical profiles of the site deposits, giving insight into the depositional structure of the midden. For the most part, the midden deposits are 1.0 to 1.5 m thick and are comprised of broad lenses generally less than 20 cm thick of marine shell fragments in a matrix of dune sand varying in color from light tan to dark brown. The extent and contents of the lenses is quite variable. In some cases the boundaries of a lens are very distinct, but in others they are difficult to discern. Significantly, no house floors have been observed anywhere along the few hundred meters of vertical midden exposure, and only a few concentrations of fire-affected stones are present that may be either hearths or the cleanings from hearths. There are, however, small, discrete lenses largely composed of one species of shellfish.

Shell fragments are the principal constituent of the midden deposits. California mussel (*Mytilus californianus*) is by far the most prevalent, but red and pink abalone (*Haliotis rufescens* and *H. corrugata*) are relatively abundant as well, their complete shells being scattered through the midden and sometimes concentrated in one discrete lens. Other species of shellfish occurring commonly in the midden are wavy top (or wavy turban, *Lithopoma undosum*), Pismo clam (*Tivela stultorum*), black abalone (*H. cracherodii*), and purple sea urchin (*Strongylocentrotus purpuratus*) (See Sharp 1999, this volume). Bones of dolphins, pinnipeds, sharks, and bony fish also occur commonly, although their bulk is significantly less than that of the shell fragments. Rows of fish and dolphin vertebrae sometimes occur, implying that the prehistoric inhabitants of the site discarded segments of the spine of these animals, which became buried rapidly enough to be preserved intact. Flakes and cores of basalt and other volcanic rocks also occur in the midden, the source of the stone being cobbles in the local fanglomerates. Also present in the midden are flakes of chert, probably all derived from outcrops in the El Montañon vicinity and other localities near the eastern end of the island.

1997 TEST EXCAVATION

Test excavation took place at CA-SCRI-109 in summer 1997. Only two test units were excavated, each placed along the wall of a lateral tributary of the ravine bisecting the site. The units were 1.5 m long (along the face of the tributary) and 0.25 m wide (from the plumbed vertical face inward). The units were placed approximately 30 m apart and were designated North Unit and South Unit. Each was excavated in stratigraphic levels, North Unit having 18 defined strata and South Unit having 20 (later revised to 18). Midden deposits in North Unit extended to a depth of 170 cm below surface, but in South Unit they extended to a depth of 245 cm.

All excavated soil from each stratum of a unit was sifted through eighth-inch mesh screens and all material caught by the screens was retained for laboratory analysis. After completion of the unit excavations, 25 x 25 cm column samples were taken from the wall of each completed unit. The columns also were divided into the strata, and all soil and its contents from each stratum were retained for flotation recovery of macrobotanical remains.

Prior to washing the materials from the unit excavations as the initial step in laboratory processing, whole shells and large fragments were extracted, and some of these were selected for radiocarbon samples. As well, a charcoal sample was selected from the small carbonized wood fragments sorted from the materials of a unit stratum. This charcoal sample was paired with a shell sample from the same stratum to begin an investigation into the comparability of radiocarbon dates from shell and charcoal.

SITE CHRONOLOGY

At the beginning of the Red Abalone Midden Project, the two radiocarbon dates from the approximately 1.5 m accumulation of red abalone midden indicated an age of ca. 3600 to 3000 BC, which is consistent with dates from other red abalone middens on the island. However, the dates came from nearly the same location in the deposits, and the discrepancy between them was perplexing. Consequently, an objective of the dating program connected with the Red Abalone Midden Project was to refine this chronology. In particular, the initial and terminal dates of the occupation that produced the red abalone midden, as well as the degree of continuity of occupation between these dates, had to be established. Furthermore, because one of the 1974 dates indicated that the site also was occupied more than two thousand years earlier, at ca. 5800 BC, the prospect of intervening periods of occupation had to be assessed.

Twelve additional radiocarbon dates obtained in 1998 are generally consistent with the three obtained in 1974 (Table 1; Figure 3). However, certain discrepancies are not

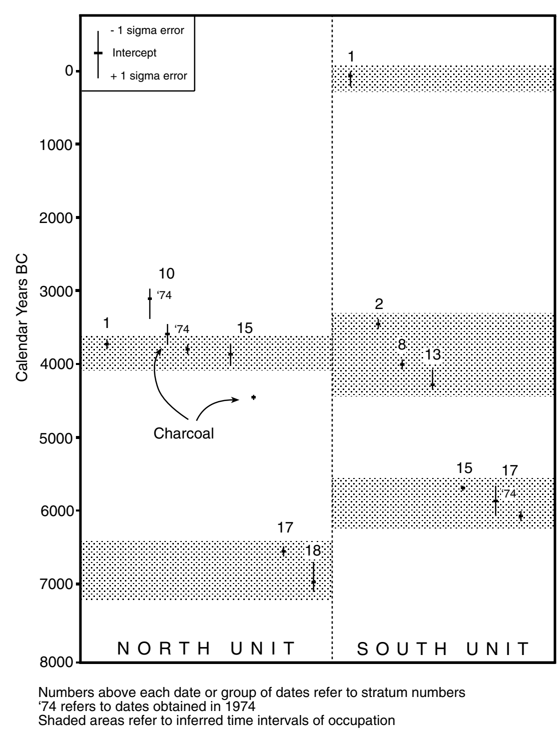

Figure 3. Distribution of calibrated radiocarbon dates from CA-SCRI-109. Shaded areas are the periods of occupation indicated by the distribution.

Table 1. CA-SCRI-109 radiocarbon dates.

Unit	Stratum	Intercept	1σ Range	Conventional Age BP[a]	Material	Lab No.
South	1	55 BC	165-35 BC	2620±70	Shell	Beta 119188
South	2	3355BC	3480-3300 BC	5210±70	Shell	Beta 119189
South	8	3950 BC	4010-3885 BC	5740±70	Shell	Beta 119190
South	13	4195 BC	4275-4050 BC	5940±70	Shell	Beta 119191
South	15	5610 BC	5675-5565 BC	7370±60	Shell	Beta 122001
South	17	6000 BC	6110-5940 BC	7780±80	Shell	Beta 119192
South	17	5804 BC	6000-5597 BC	7570±210	Shell	UCR 390
North	1	3660 BC	3730-3615 BC	5480±60	Shell	Beta 119183
North	10	3760 BC	3845-3685 BC	5580±60	Shell	Beta 119184
North	10?[b]	3628 BC[c] 3562 BC 3544 BC	3705-3370 BC	4790±150	Charcoal	UCR 201
North	10?[b]	3088 BC	3337-2891 BC	5030±150	Shell	UCR 209
North	15	3780 BC	3915-3685 BC	5600±80	Shell	Beta 119185
North	15	4350 BC	4445-4330 BC	5520±70	Charcoal	Beta 119186
North	17	6490 BC	6580-6425 BC	8270±70	Shell	Beta 122000
North	18	6878 BC	7007-6658 BC	8520±90	Shell	Beta 119187

[a] Shell dates reported by Beta Analytic are corrected for $^{13}C/^{12}C$ fractionation. Because fractionation corrections had not been obtained for the three UCR dates, they were corrected by assuming an average Santa Barbara Channel fractionation correction of +430 yrs.

[b] UCR 201 and UCR 209 were obtained from the general vicinity of North Unit at depths below surface of 100-104 cm and 100-108 cm, respectively. These depths are approximately that of Stratum 10.

[c] UCR 201 intercepted the calibration curve at three different dates because of the curve's flatness in the vicinity of this calibrated date.

easily explained. The two 1974 dates obtained from samples collected from the vicinity of North Unit at the approximate depth of Stratum 10 are both younger than any of the 1998 dates pertaining to this unit. Similarly, the 1974 date pertaining to Stratum 19 of South Unit is younger than the 1998 date pertaining to this stratum. This discrepancy between the 1974 and 1998 dates may be due to either of two causes: 1) differences between the two laboratories in procedures used to produce the two sets of dates or 2) discrepancies between the estimated $^{13}C/^{12}C$ fractionation correction applied to the 1974 dates and the actual corrections, had these been obtained.

In addition, the two pairs of charcoal and shell dates pertaining to Strata 10 and 15 of North Unit are not consistent, the charcoal date being more than 500 years older than the corresponding shell date in both pairs. This difference may be a product of the charcoal coming from wood that was 500+ years old when it was collected prehistorically, but this seems unlikely. Another possibility is that the ΔR reservoir correction for dates falling into the time interval of these two pairs is much less than the 225 ± 35 years normally applied to shell dates pertaining to sites in the Santa Barbara Channel region. It should be noted, however, that the pair pertaining to Stratum 10 are the two dates obtained in 1974. The 1974 charcoal date actually is quite close to the 1998 shell date from this stratum. As just mentioned, however, the 1974 dates appear to be systematically younger than the corresponding 1998 dates, so the similarity of the two dates may be fortuitous.

Without a substantially larger suite of radiocarbon dates, the reasons for the discrepancies among the 15 existing dates cannot be identified. It seems wise, therefore, to ignore the 1974 dates and the 1998 charcoal date in attempts to identify chronological patterns of site use. Significantly, all the shell dates obtained in 1998 are in proper stratigraphic order.

The 1998 shell dates reveal that the bulk of the midden in the vicinity of North Unit was deposited over an interval of time not much longer than 100 years. The lowermost two strata in North Unit, however, are about 2000 years older than the deposits above. In contrast, the red abalone midden deposits in South Unit above the dune sand strata span a period close to 900 years long, which includes the period represented in the North Unit deposits. The uppermost stratum of South Unit, which is stratigraphically quite distinct from the deposits directly below, dates much later in time, within the first century BC, and this stratum is associated with a distinct lobe of deposits visible on the site surface. Similar to the situation at North Unit, the basal strata of South Unit, including the lowermost stratum and one of the strata bounded by light-colored dune sand, are substantially older than the red abalone midden deposits above, the difference being about 1400 years.

In summary, the radiocarbon dates indicate four discrete periods of occupation: 6900 to 6500 BC, 6000 to 5600 BC, 4200 to 3300 BC and ca. 50 BC (Figure 3). The period dating between 4200 and 3300 BC accounts for most of the deposits in the vicinity of the two units and presumably throughout the site, but the earlier and later dates reveal that the history of occupation at the site is relatively complex. Indeed, it is likely that the two units do not include all the intervals of time when the site was occupied. Nonetheless, the stratigraphic relationship between the basal strata of the two units and the strata directly above imply that occupation either was very sporadic or did not occur between ca. 5600 and 4200 BC.

The difference in the time-spans represented by the red abalone middens between North and South Units is also of interest. Even though these units are only 30 m apart, it appears that use of the site was concentrated in the vicinity of South Unit between 4200 and 3300 BC and that it expanded northward only during the period between roughly 3800 and 3700 BC This difference may be due to South Unit's location being farther down the crest of the promontory, a position that would have afforded more protection from prevailing winds from the west.

HOLOCENE COASTLINE EVOLUTION AT PUNTA ARENA

Explanations of why the archaeological deposits at Punta Arena have particular characteristics and why changes in the utilization of particular taxa of flora and fauna as food resources changed through the periods of occupation of the site require that the nature of environmental change in the vicinity of the site be understood. In light of the site inhabitants' dependence on a variety of shellfish, an important aspect of environmental change is the manner in which Holocene sea level rise affected the characteristics of the intertidal and shallow subtidal zones near the site. In recent decades, the bedrock shelves forming the intertidal zone surrounding Punta Arena have been very productive of California mussel and black abalone. California mussel lives in dense beds in the middle to lower intertidal zone, and black abalone was so dense the middle to upper intertidal zones, until it was decimated in the early 1980s by the disease manifested as the withering foot syndrome, that individuals frequently were living on top of others (based on personal observations of the sea floor since 1966). Such conditions may not necessarily have existed at all times during the site's various periods of occupation.

To reconstruct the change in the coastline and the character of the intertidal and shallow subtidal zones in the vicinity of Punta Arena, two bodies of information are needed: a bathymetric map of the ocean bottom near the point and a curve showing change in sea level during the Holocene. Continental Shelf Data Systems (1967) has published a bathymetric map including the nearshore waters in the vicinity of Punta Arena. This map shows depths of the ocean bottom at one-fathom intervals to a depth of 50 fathoms except in areas of relatively steep slopes, in which case the contours are at five-fathom intervals. The map also indicates whether the ocean bottom is rocky or sandy. To use this map, depths given on curves of Holocene sea level rise had to be converted from meters to fathoms.

Selecting an appropriate curve of Holocene sea level rise is problematic. There is wide variation among the various Holocene sea level curves published during the past 40 years, and there is little basis for judging which is likely to be most applicable to Santa Cruz Island. Archaeologists working in coastal California often have used Curray's 1960 curve as presented by Inman (Inman 1983:9; e.g., Erlandson 1994:34), a curve that Inman believed was most applicable to the southern California coast. However, Curray later published another curve that differs in some respects from his earlier one (Curray 1965). Seemingly one of the most sensitive curves is that produced by Fairbanks (1989) on the basis of a sequence of reef-crest coral deposits off the coast of the island of Barbados. This curve has the same shape as Curray's 1965 curve, but it shows progressively greater depths below current sea level from the present to the beginning of the Holocene (compensating for the fact that Fairbanks' curve begins about three meters below current sea level). To use any of the curves, their chronology must be converted from radiocarbon years to calendar years, considering that radiocarbon dates currently are reported in calendar years.

Applying a sea-level curve to a particular locality requires that the chronology of land uplift or submergence be known. In the case of the Punta Arena vicinity, land apparently has been uplifting no more than 10 and 20 cm per thousand years, given that the marine terrace along the southwestern coast of Santa Cruz Island is firmly dated at 125,000 years (Pinter et al. 1998:717). Consequently, the maximum amount of uplift that would have occurred since the earliest dated occupation is somewhat less than two meters. Considering that the amount of error in the bathymetric contour lines is probably at least two meters vertical elevation and that the sea-level curve has this much error as well, this amount of uplift is essentially negligible.

For present purposes, sea level is reconstructed for three dates, each representing a time interval during which Punta Arena is known to have been occupied: 6900 BC, 6000 BC, and 3500 BC (Table 2). Although Curray's 1960 curve differs in significant respects from his 1965 curve, they are close to overlapping or intersecting during these three dates. Fairbanks' 1989 curve is between 1.0 to 3.5 m lower than Curray's curves. Figure 4 shows the position of the coastline at the three dates with respect to Curray's sea level curves. The general characteristics of the coastline at the three points in time would not have differed significantly had Fairbanks' curve been used instead.

Figure 4 shows that the coastline in the vicinity of Punta Arena underwent some dramatic changes over the course of time. At 6900 BC Gull Island and Punta Arena were part of a broad promontory of land 1.0 to 1.5 km in breadth. Directly west was a bay protected by an seaward extension of Morse Point as well as the Punta Arena/Gull Island promontory. This bay probably resembled those currently at Willows and Coches Prietos anchorages farther east on the south coast of Santa Cruz Island. Its margins probably were sandy beach, except near the tip of the Punta Arena/Gull Island promontory. The ocean bottom descended much more abruptly around the perimeter of the promontory than is the case in the vicinity of Punta Arena today. Indeed, the slope off the southwestern and southeastern side of the promontory descended into the deep submarine canyon known as Santa Cruz Canyon. As a consequence, the intertidal zone would have been relatively narrow; that is, it would not have had the broad, nearly horizontal shelves that surround Punta Arena today. Most likely the intertidal zone near the tip of the promontory was exposed bedrock.

By 6000 BC the promontory would have become much narrower, but the bay still would have existed between Morse Point and Punta Arena. The bay still would have been surrounded by sandy beach, and the tip of the Punta Arena/Gull Island promontory would have had a narrow intertidal zone of exposed bedrock. By 5000 BC the promontory undoubtedly had separated into a series of at least three islets, including Gull Island and another island between Gull Island and Punta Arena. Both of these islands would have been much larger than the present-day Gull Island. At this time the flat-lying bedrock probably formed a very extensive intertidal zone and shallow subtidal zone. Prehistoric occupation has not yet been documented at Punta Arena at this time.

The coastline at 3500 BC would have been relatively close to the present-day coastline. Punta Arena would have protruded seaward a few hundred meters more than it does today and would have been broader. Gull Island would have been larger, and bedrock prominences might have been visible at low tide between Gull Island and Punta Arena. The flat-lying bedrock forming the intertidal zone around Punta Arena would have been more extensive than it is today.

As the characteristics of the coastline were changing from 6900 BC onward, so was the nature of communities of intertidal invertebrates. At 6000 BC and earlier, the relatively narrow and steep rocky intertidal zone near the tip of the Punta Arena/Gull Island promontory would have been an appropriate habitat for California mussel, but it would not have been an ideal habitat for abalone. The intertidal zone at this time probably resembled that found along much of the north coast of Santa Cruz Island, where today California mussels are abundant and abalone are rare. However, as more of the flat-lying bedrock became inundated and cleaned of any sediment accumulation, the intertidal and shallow subtidal zones would have broadened significantly and would have been ideal habitats for abalone. This

Table 2. Sea-level depths during periods of prehistoric occupation at CA-SCRI-109.

	Depths Below Current Sea Level in Meters (M) and Fathoms (f)		
Source of Curve	**6900 BC**	**6000 BC**	**3500 BC**
Curray 1960 & 1965 (Inman 1983)	16.0 m/8.7 f	10.5 m/5.7 f	3.5 m/1.9 f
Fairbanks 1989	19.5 m/10.6 f	12.0 m/6.6 f	4.5 m/2.5 f

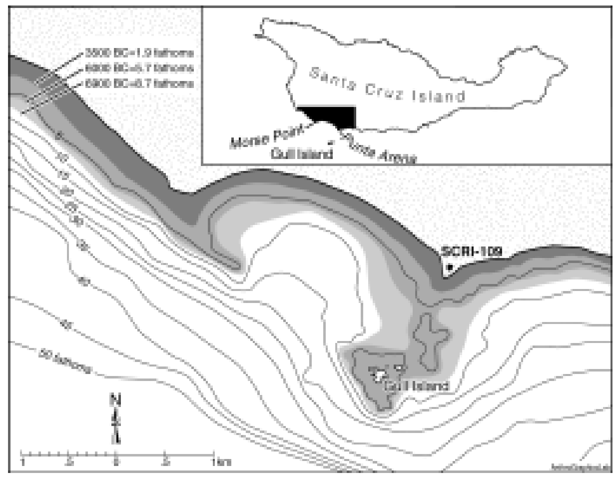

Figure 4. Map showing bathymetric contour lines in the vicinity of Punta Arena and Morse Point. Depicted on the map is position of the coastline at three dates during the prehistory of CA-SCRI-109.

process surely began sometime between 6000 and 5000 BC, and the intertidal and shallow subtidal zones near Punta Arena may have reached their maximum extent sometime during this time interval. By the time that inhabitants at the Punta Arena site began to create the red abalone midden deposits, ca. 4200 BC, the intertidal and shallow subtidal zones still were considerably more extensive than they are today, and this may be the reason why these deposits are much more substantial than at other Santa Cruz Island sites with red abalone middens dating to approximately the same time.

Considering how extensive the land of the promontory was prior to 6000 BC, when Punta Arena was connected to Gull Island, one might speculate that prehistoric habitation occurred at spots on this promontory that later were inundated. Indeed, there may have been occupation on this promontory dating earlier than 6900 BC, considering that Daisy Cave on San Miguel Island has yielded dates associated with habitation deposits as early as ca. 8000 BC (Erlandson et al. 1996; Erlandson et al. 1997). Because the archaeological deposits would have been destroyed by erosion caused by wave action, this possibility cannot be verified. Nonetheless, remnant archaeological deposits may have survived on Gull Island that would lend credence to the possibility. No archaeological reconnaissance has yet taken place on Gull Island to determine whether such deposits are present.

There is reason to believe, however, that a large proportion of the occupation during the Holocene did take place at the present Punta Arena, even if it also occurred on lands destroyed in the course of Holocene sea level rise. Punta Arena always would have been a prominent, well-drained landform that would have been attractive for habitation, and because it is relatively close to Sierra Blanca Ridge, it would have close to perennial water in the unnamed stream located 250 m east of the site. Punta Arena would have remained the closest prominent landform to this water source through the Holocene.

CONCLUSION

To summarize, currently available radiocarbon dates pertaining to the Punta Arena site indicate that it was occupied as early as 6900 BC, although the main occupation of the site occurred between 4200 and 3300 BC. The site also was occupied briefly around 50 BC. While people lived at the site, they collected and consumed shellfish, primarily California mussel but including a wide variety of other species as well. Between 4200 and 3300 BC, red and pink abalone and wavy top were among the more commonly collected species. Bathymetric data and reconstruction of Holocene sea-level rise reveal that at the time of the earliest known occupation, ca. 6900 BC, Punta Arena was at the inland end of a broad promontory of land that extended approximately 1.5 km seaward to include the present-day Gull Island. In addition, a protected bay existed west of this promontory. A narrow intertidal zone surrounded the outer portion of the promontory at this time, but as sea level rose after ca. 6000 BC, the intertidal zone became very broad and probably remained broader than today's during the time of the main occupation of the site.

Because the position of the coastline and the nature of the intertidal and shallow subtidal zones changed dramatically as sea level rose, the distribution and abundance of shellfish and other marine resources occupying these zones also changed. Generally speaking, the diversity and abundance of intertidal and shallow subtidal invertebrates would be expected to have increased significantly after 6000 to 5000 BC, making the Punta Arena site more attractive to people interested in collecting and consuming marine resources from the intertidal and shallow subtidal zones.

While the extent of the intertidal and shallow subtidal zones was changing, so too was water temperature, as indicated by the sea-water paleotemperature curve produced by J. Kennett and D. Kennett (Kennett 1998:123). Between 6500 and 5500 BC, sea water temperatures were significantly cooler than today's, as they were also at times between ca 3800 and 3200 BC (see also Glassow et al. 1994). These water temperature fluctuations would have affected the distribution of certain species of shellfish, particularly red abalone. This species would have become prevalent in the intertidal zone during intervals when water temperature was cooler than present (Glassow 1993).

Of special interest is the gap in occupation between ca. 5600 and 4100 BC, seen in the South Unit date sequence and encompassed by the longer gap seen in the North Unit sequence. This is roughly the same the period of time during which radiocarbon date frequencies are lower than before or after in most regions of the southern California coastal mainland, a pattern that is probably the result of lower population densities (Glassow, in press). The climatic interval known as the Altithermal occurred during this same period, and its aridity presumably lowered the productivity of many terrestrial plants and animals upon which prehistoric populations depended (Glassow et al. 1988). In the stratigraphic profile of South Unit, this period is associated with the accumulation of dune sand containing much less evidence of occupation, the sands being a clean tan color in comparison to the organically stained sands of the red abalone midden above. The reduced occupation during this time interval apparent at Punta Arena indicates that coastal settings on the Channel Islands were affected as well, although not necessarily in the same way as was the mainland coast.

The research results reported here reveal that an understanding of the chronology of occupation of a site such as that at Punta Arena requires a substantial number of radiocarbon dates to elucidate fully. Coastal locations such as Punta Arena were attractive during the early and middle Holocene, making the chronological sequence especially complicated. Furthermore, this research has shown that the dynamics of change in coastal topography brought about by early/middle Holocene sea level rise affected the character, distribution, and abundance of intertidal and shallow subtidal marine fauna, which in turn affected popularity of a locale such as Punta Arena for habitation and the relative importance of marine faunal taxa to the prehistoric diet.

ACKNOWLEDGMENTS

I gratefully acknowledge the financial support of the Red Abalone Midden Project by the National Science Foundation (award no. SBR-9707765). Dr. Lyndal Laughrin, Resident Director of the University of California Santa Cruz Island Reserve, facilitated in a variety of ways project logistics. I thank the staff of The Nature Conservancy for permission to use the facilities at Christi Ranch during fieldwork. David Sowle flew me over the island in his Cessna 210 so that I could photograph Punta Arena from the air (Figure 2). Donald L. and Diana Johnson helped interpret the Pleistocene stratigraphy of the Punta Arena locality. The Red Abalone Midden Project would not have been a success without the diligent work of my field and laboratory crews. Figures 1 and 2 were prepared by David Lawson and Dirk Brandts of the UCSB Department of Anthropology.

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