Documenting 12,000 Years of Coastal Occupation on the Osmore Littoral, Peru

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The history of coastal settlement in Peru beginning ca. 12,000 years ago provides insight into maritime adaptations and regional specialization. We document the Late Paleoindian to Archaic occupational history along the Osmore River coastal plain near Ilo with 95 radiocarbon dates from eight sites. Site distribution suggests that settlement shifted linearly along the coast, possibly in relation to the productivity of coastal springs. Marine foods, raw materials, and freshwater were sufficient to sustain coastal foragers for over 12 millennia. Despite climatic changes at the end of the Pleistocene and during the Middle Holocene, we found no evidence for a hiatus in coastal occupation, in contrast to parts of highland northern Chile and areas of coastal Peru for the same time period. Coastal abandonment was a localized phenomenon rather than one that occurred across vast areas of the South Central Andean littoral. Our finds suggest that regional adaptation to specific habitats began with initial colonization and endured through time.

Introduction

One of the world's richest marine habitats stretching along the desert littoral of the Central Andes contributed significantly to the early florescence of prepottery civilization (Shady Solis 2004), but there is debate about the antiquity of maritime adaptations. One argument is that fishing and desert farming arose concurrently around 3000 B.C. (Haas and Creamer 2006). Alternatively, maritime adaptations arose at the end of the Pleistocene with fishing constituting the oldest enduring profession in the Andes (Moseley 2006; Richardson 1978, 1981). The hypothesis of continuity has been challenged by the idea that parts of southern Peru and northern Chile experienced coastal abandonment because of a lack of water during an episode of extreme drought in the Middle Holocene, ca. 6000–1800 CAL. B.C. (Sandweiss 2003).

We evaluate these hypotheses with the evidence from the occupational history of the Osmore River region in southern Peru. This region was not a center of civilization in preceramic or subsequent times, but the seaboard was colonized in the Late Pleistocene and has a long archaeological record. The Central Andean coast is adjacent to one of the richest marine habitats in the world. Occupation of the southern coast near Ilo, Peru began in the Late Pleistocene and continued for several millennia. Previous syntheses of data from the region considered the nature of coastal settlement (Wise 1999a, 1999b), human adaptation, migration (Aldenderfer 1999), environmental catastrophes, flooding (Keefer, Moseley, and deFrance 2003), and the nature of paleoenvironmental data in comparative perspective (Sandweiss 2003). An issue of considerable importance is whether marine resources could have sustained populations through time, and if not, whether limited resources, climatic changes, or fluctuations in resource availability necessitated changes in forager strategy (deFrance 2008) or abandonment of the coast.

The temporal periods used in this study include the Late

Paleoindian period, roughly 11,000–9000 CAL. B.C., also known as the proto-Archaic (Dillehay 2000). The Early Archaic or Early Preceramic ranges from ca. 9000–6000 CAL. B.C. The Middle Archaic spans ca. 6000–4000 CAL. B.C., and is followed by the Late Archaic which ranges from ca. 4000–1000 CAL. B.C. (Aldenderfer 1998; Wise 1999a). The Pleistocene-Holocene transition occurs at approximately 9000 CAL. B.C. The Middle Holocene ranges from ca. 7000–4000 CAL. B.C., encompassing the Middle Archaic cultural period.

In southern Peru, climatic fluctuations during the Terminal Pleistocene (ca. 11,000–9000 CAL. B.C.) consisted of climatic shifts and eustatic sea level rise. The Early Holocene included an active El Niño Southern Oscillation (ENSO) regime with periods of relatively stable marine and climatic conditions followed by a Middle Holocene period of more perturbed conditions (ca. 7000–4000 CAL. B.C.). In the northern coastal areas, the intensity and periodicity of ENSO declined and the productive cold water fisheries were reduced as a result of elevated sea surface temperatures (SST) particularly north of Lima (10°s latitude and northward) (Sandweiss 2003; Sandweiss et al. 1996; Sandweiss et al. 2001; Sandweiss et al. 2007). The intensity and periodicity of ENSO in southern Peru also seems to have decreased markedly during the Middle Holocene (ca. 9000–6000 years ago) (Keefer et al. 1998; Keefer, Moseley, and deFrance 2003). Carré and his colleagues (2009) argue that the Middle Holocene decline in ENSO activity near Tacna, south of the Osmore region, was accompanied by increased marine productivity and greater moisture for desert vegetation (*lomas*, or patch vegetation sustained by coastal fog condensation), thus allowing permanent coastal settlement at the site of Quebrada de los Burros (see also Fontugne et al. 1999; Lavallée et al. 2000).

In addition to marine habitats, highland rainfall and surface water influence life in the coastal study area. The driest place on earth, roughly 700 km to the south, is the Salar de San Pedro de Atacama region in the uplands of north central Chile. Here, a stark decline in Middle Holocene archaeological presence of people is termed the *silencio arqueológico*, or archaeological silence (Grosjean and Núñez 1994; Núñez 1992, 1999; Núñez, Grosjean, and Cartajena 2001, 2002). Although drought was initially thought to have induced total abandonment, it is now evident that people concentrated in reduced numbers around scant high altitude springs where water remained available (Grosjean et al. 2003; Núñez, Grosjean, and Cartajena 2001, 2002). When survey and excavation of early coastal sites north of the Camaná River around Quebrada Jaguay, 180 km north of the Osmore River, did not identify Middle Archaic remains (ca. 6000–1600 CAL. B.C.), Sandweiss (2003: 7) proposed that the *silencio* extended to the region near Quebrada Jaguay where ephemeral streams were adversely affected by declines in highland rainfall. If the Atacama episode of extreme aridity extended north through the Titicaca Basin into the sierra (Gehy et al. 1999), potable water could have been lacking along the southern Peruvian desert littoral. Small, seasonally intermittent rivers, such as the Osmore River, may have discharged little to no water near the sea; however, other investigators have observed that subsurface runoff sustaining coastal springs may have provided sufficient potable water for continued seaboard settlement (Aldenderfer 1989; Wise 1999a, 1999b). Significantly, springs are unevenly distributed and may be more common in certain geographic areas. Independent of highland water, surface water at low- to mid-elevations in southern Peru may have been available from condensation of fog banks (*garuá*), generated by cold offshore winds blowing across the coastal desert, particularly during the Middle Holocene when ENSO was reduced and cold upwelling currents dominated (Fontugne et al. 1999).

To understand settlement on the arid littoral, we examine Late Paleoindian to Late Archaic (ca. 12,000–1000 CAL. B.C.; Terminal Pleistocene to Late Holocene) occupation in the Ilo region of southern Peru on the Osmore coastal plain. Understanding the diachronic nature of coastal habitation requires absolute dates, preferably chronometric, in addition to site identification and excavation, since many of the sites dating to the initial settlement and subsequent Archaic period contain relatively few temporally sensitive artifacts. We document coastal settlement spanning from ca. 12,000–900 CAL. B.C. using 95 radiocarbon dates from eight sites. The archaeological contexts include specialized procurement locales, dense shell middens with habitation areas, and burial sites. While radiocarbon dates cannot be used to infer settlement or occupation density (Rick 1987), these dates are significant because they demonstrate that there is no time when the coast was devoid of occupation. Although no sites were occupied continuously during this time, the temporal placement (i.e., dates of occupation) and site locations indicate that occupation shifted along the coast. We also use the radiocarbon dates to argue that a coastal economy was viable even during periods of climatic instability at the end of the Pleistocene and during the Early and Middle Holocene. Our data suggest coastal abandonment was a localized phenomenon rather than one that occurred across vast areas of the South Central Andean littoral. We explore cultural and hydrological explanations for why this coastal region demonstrates continuity in occupation.

The Osmore River Coastal Plain

The study area is bordered by a deep, offshore tectonic trench. Strong, cold, upwelling currents support a productive near-shore fishery. Behind the shoreline, the low Coastal Cordillera rises to average heights of ca. 1000 meters above sea level (masl). The Pacific escarpment is steep and conducive to the growth of lomas. Near the littoral, coastal plain formations are intermittent, short (less than 5 km in width), and often dominated by a series of Pleistocene terraces at roughly 25, 50, and 100 masl. The eastern face of the Coastal Cordillera is not pronounced because it frames one side of a sediment-infilled basin between the coastal and the high Andean ranges. The other side of the basin is formed by the main Andean Cordillera, which rises to heights of more than 5000 masl before descending into the Titicaca Basin.

The lower half of the Pacific watershed is hyper-arid and potable water is a life-limiting resource that derives from seasonal rainfall above 4000 masl. Historically, the Osmore River flow reaching the coast, where Ilo is located, has lasted two months or less per year. Subsurface runoff is less ephemeral; it sustains springs and seep springs along the lower river course and in short, normally dry drainages called *quebradas* that descend along the Coastal Cordillera and transect an aquifer at ca. 100–150 masl. Spring flow fluctuates relative to the annual quantity of highland precipitation. A late prehistoric drought that lasted more than three centuries is associated with a >70% decline in coastal settlements (Satterlee et al. 2000). Although sensitive to climatic conditions, spring resources have also dried up periodically during Holocene, colonial, and modern times; settlement has shifted in response (Clement and Moseley 1991). Tectonically induced entrenchment of drainages in the Pacific watershed is a potential contributor to this long-term background dynamic (Keefer and Moseley 2004).

The city of Ilo occupies the region immediately south of the Osmore River (FIG. 1). From the Punta Coles peninsula south (for approximately 16 km), there are three staggered terraces at roughly 25, 50, and 100 masl. The lowest formation, the Pampa del Palo, is an uplifted marine terrace of great antiquity (ca. 300,000 B.P.) (Sandweiss et al. 1989: 51). The middle terrace, also an uplifted marine terrace, contains the ruins of the Ring Site (Sandweiss et al. 1989). Shell scatter associated with Archaic period sites occurs primarily on the upper and middle terraces (Aldenderfer 1989; Sandweiss et al. 1989). Survey of the southern end of the lower terrace indicates the presence of anthropogenic shell refuse devoid of pottery that presumably is Archaic in age (Adán Umire Alvarez, personal communication 2007). At roughly 100 masl, the high terrace is dominated by lomas habitat that extends inland some distance. Coastal quebradas south of the Ilo River are characterized by seasonal flows of water in the quebrada channels in contrast to the region north of the river where springs are the only source of potable water.

Methods

We discuss the occupational history of eight sites (TABLE 1), the types of excavations completed, and the range of site activities represented. In addition, we present 95 radiocarbon dates (TABLE 2); of these, 67 dates are from published sources. The remaining 28 dates are previously unreported assays from the sites of Quebrada Tacahuay, Huaca Luna, and Kilometer 4 (K4).

Several issues affect the calibration and interpretation of the radiocarbon dates. Two issues in the study region are the "old wood" problem and the marine reservoir effect when dating shells. Kennett et al. (2002) collected nine paired samples of charcoal and shell from a stratified midden at K4. After calibration of the radiocarbon dates, including correction for the marine reservoir effect, they found that the charcoal samples were 100–750 years older than the shell samples. The area surrounding K4 was a desert oasis with grasses and reeds but no trees. Wood for construction and fuel was most likely brought to K4 from the interior, near springs or along the Osmore River, and possibly reused several times (e.g., for construction) before being burned. Kennett et al. (2002) suggest that shell dates may be more reliable for ^{14}C dating at K4 because the ^{14}C date on charcoal may indicate when the tree was felled and not the date of final human use.

Mixing rates of ^{14}C in the deep ocean are slower than the atmospheric mixing rate, and the ^{14}C age of carbonate in deeper waters can be 1000 years older than at the surface. Local conditions of climate, wind, coastline shape, and ocean bottom topography can cause upwelling of the carbon-depleted deep water and shells at the surface can incorporate the older carbonate. When dated, these shells will appear to be older than they are; this is called the marine reservoir effect (Taylor 1987). A correction needs to be performed before comparing marine and terrestrial samples and, because of the upwelling water, a local correction value needs to be determined (Stuiver and Braziunas 1993). The mean calibration curve (ΔR) is calculated from ^{14}C dates of known-age shells. The Peruvian coast has significant variability in upwelling of deep water and Jones et al. (2007) found that the ^{14}C ages within individual shells varied by up to 216 radiocarbon years. The authors suggest caution when using dates obtained from shells in areas of variable upwelling.

The ΔR values for a location can also fluctuate over time. Owen (2002) investigated the variability in ΔR for

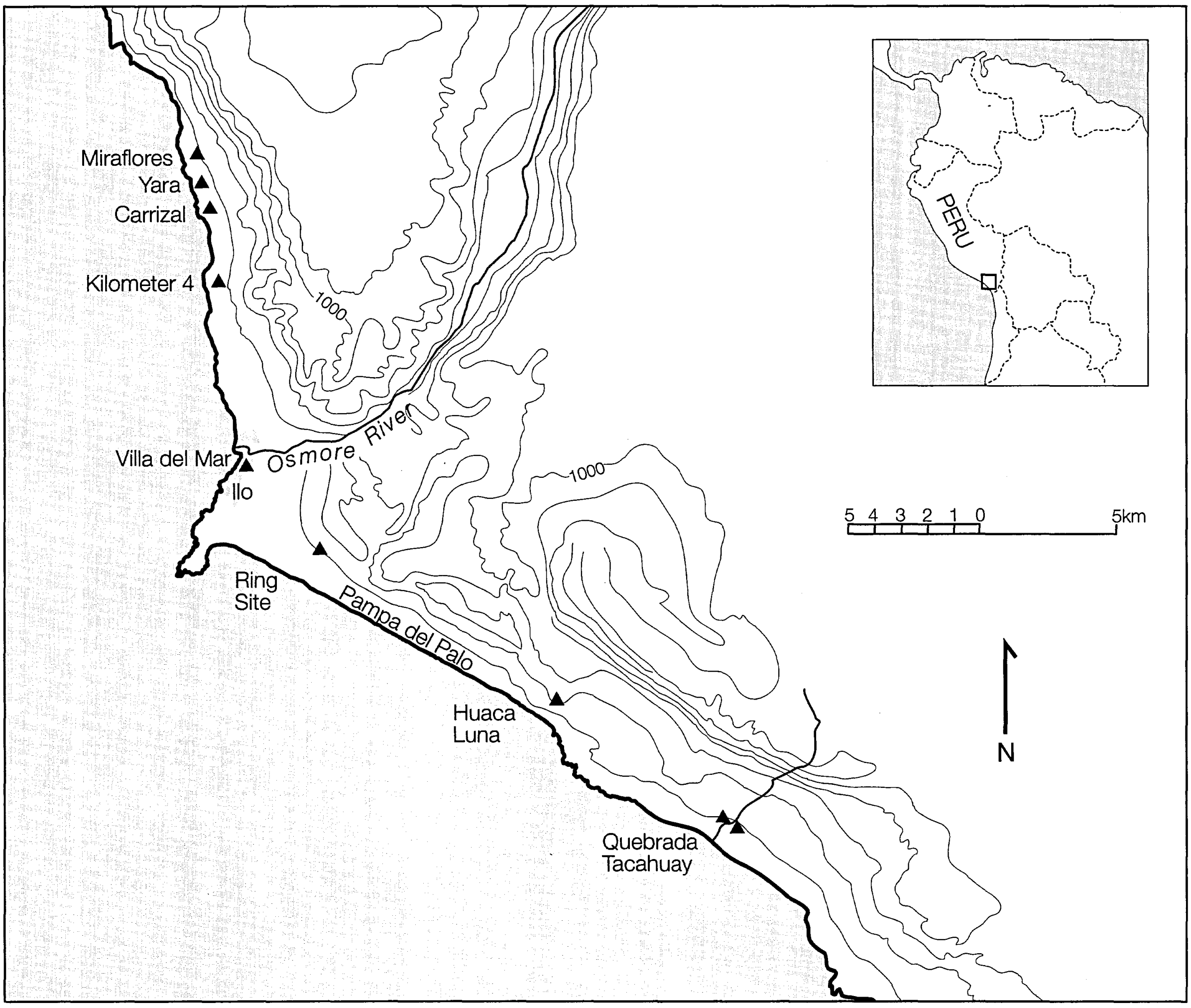

Figure 1. Location of study sites along the Osmore coastal plain, southern Peru.

the Ilo region using six pairs of marine and terrestrial plant samples from the site of Loreto Viejo, 13 km inland of Ilo. He concluded that the ΔR for Ilo is around CAL. A.D. 1280–1380, one standard deviation (1σ) was 382 ± 102, and one sample pair suggested a tentative ΔR estimate for around 1870–1680 CAL. B.C., (1σ) of 236 ± 65 (Owen 2002). These values are higher than the 190 ± 40 calculated by Stuiver, Pearson, and Braziunas (1986), and higher than the ΔR used in this paper: 205 ± 118. Due to these differences in ΔR values, we must exercise caution when interpreting ^{14}C calibrated ranges obtained from marine organisms.

We corrected the radiocarbon dates for isotopic fractionation as follows. Fifty two dates were corrected by lab measurement. Kennett et al. (2002) corrected 18 dates from K4 as part of an analysis of the effects of the carbon reservoir on radiocarbon dates. We corrected three dates through estimation of $\delta^{13}C$ values using the formulas supplied at the CALIB website (http://calib.qub.ac.uk/calib/manual/chapter5.html). The assumed $\delta^{13}C$ values are $^{-}25$ for charcoal and zero for shell (Stuiver and Polach 1977). We were unable to correct 22 dates for isotopic fractionation because it could not be determined from published data if the original measurements were $^{14}C/^{12}C$ ratios or $^{14}C/^{13}C$ ratios, information that is necessary to perform the $\delta^{13}C$ correction.

We calibrated the ^{14}C ages to calendar years B.C. using CALIB 5.0.1 (Stuiver and Reimer 1993) and calculated terrestrial dates using SHCal04.14C, the Southern Hemisphere terrestrial dataset (McCormac et al. 2004). Thirteen dates are older than the 11,000 CAL. B.P. age limit of the Southern Hemisphere dataset; therefore, they were calibrated with IntCal 04.14C, the Northern Hemisphere terrestrial calibration dataset (Reimer et al. 2004). In addition to the calibrated two sigma (2σ) date ranges, we present the median probabilities as calculated by CALIB. All cali-

Table 1. Site time periods, number of radiocarbon dates per site, and 2σ date ranges.

Site	*No. of ^{14}C dates*	B.C. *2σ date range*	*Time period*
Quebrada Tacahuay	18	11,120–6640	Late Paleoindian, Early and Middle Archaic
Huaca Luna	5	5700–1410	Middle and Late Archaic
Ring Site	7	10,110–3660	Late Paleoindian to Middle Archaic
Villa del Mar	3	7030–5010	Early to Middle Archaic
Kilometer 4	43	7290–1010	Early to Late Archaic
Carrizal	5	3650–1670	Late Archaic
Yara	10	7020–510	Middle to Late Archaic
Miraflores	4	8810–6410	Early Archaic

brated age ranges and median probabilities are rounded to the nearest 10 years.

We calibrated shell dates with the Marine 04.14C "global" marine calibration dataset (Hughen et al. 2004). To adjust for local differences in the marine reservoir age, the local marine reservoir correction (ΔR) needs to be calculated and then used in the Marine 04.14C calibration dataset. The local marine reservoir correction (ΔR) is calculated from ^{14}C dates from known-age shells. The ΔR value for Peru is published as 190 ± 40, calculated from three known-age shells (Stuiver, Pearson, and Braziunas 1986). We used the Marine Reservoir Database (Stuiver et al. 2005; Stuiver et al. 2006) to identify five local marine samples. These samples were from Peru and northern Chile and had ΔR values of 243 ± 49 (MapNo 363), 175 ± 34 (MapNo 364), 313 ± 76 (MapNo 365), 61 ± 50 (MapNo 366), and 670 ± 44 (MapNo 367). Additionally, four known-age shells for Peru were tested by Jones et al. (2007) and the ΔR values were calculated at 183 ± 18, 189 ± 23, 194 ± 23, and 165 ± 24. These ΔR values are not included in the Marine Reservoir Database. Paula Reimer from CALIB calculated a weighted average using the four shells in Jones et al. (2007) and the five shells from Peru and Chile from the Marine Reservoir Correction Database. The resulting ΔR value was 205 ± 118 (Paula Reimer, personal communication 2008); this was used as the ΔR value when calibrating shell samples from Ilo sites.

The Occupational History of the Osmore Coastal Plain

The parameters of the study area are primarily within the coastal region of the Department of Moquegua, though one of the sites, Quebrada Tacahuay, is located 1.7 km south of the departmental border. Systematic survey of a 90 km-long region from the coastal community of Ite north to the Pampa Dispensilla in the Department of Arequipa identified 335 preceramic and Archaic sites (Adán Umire Alvarez and Greg Zaro, personal communication 2007). The sites discussed here are from the area roughly 20 km north to 30 km south of Ilo where a total of 256 preceramic sites have been identified, eight of which have chronometric dates. Table 1 summarizes the number of chronometric dates by site and the temporal range of those dates. The eight sites described here are all located on the coastal plain; none occur in the lomas habitat or at inland settings (FIG. 1).

The K4, Carrizal, Yara, and Miraflores sites are located north of Ilo. Archaic sites consisting of coastal shell scatter have been identified north of Miraflores (Adán Umire Alvarez and Greg Zaro, personal communication 2007), but have not been systematically investigated. The Villa del Mar site is located south of the Ilo River, within the Ilo city limits. Also south of the river, but outside of Ilo, are the Ring Site, Quebrada Huaca Luna, and Quebrada Tacahuay (FIG. 1). Of the eight sites discussed here, only Huaca Luna and Miraflores have not been excavated. A mussel shell midden located south of the quebrada channel at Quebrada Tacahuay was minimally sampled. We describe the archaeological sites by location from south to north.

Quebrada Tacahuay

Quebrada Tacahuay is located approximately 30 km south of Ilo. Construction of the Ilo to Ite highway exposed deep archaeological deposits north and south of the quebrada channel. North of the quebrada is a Late Pleistocene marine bird processing area (deFrance 2005, 2008, 2009; deFrance and Keefer 2005; deFrance and Umire A. 2004; deFrance et al. 2001; Keefer et al. 1998). The earliest deposit contains abundant faunal remains, primarily seabirds, lithic artifacts, and one worked bone artifact. Several hearths were excavated, but neither structural nor mortuary remains are present. Thin pluvial deposits below the earliest cultural stratum suggest the presence of potable water; however, the modern spring is roughly 2 km inland. The earliest occupation dates to ca. 11,120–9380 CAL. B.C. and is buried under a debris flow 1 m deep from an ancient El Niño event (Keefer et al. 1998; Keefer, Moseley, and deFrance 2003). The site was reoccupied during the Late Paleoindian period, ca. 10,170–9290 CAL. B.C., and the Early Archaic, ca. 9240–7970 CAL. B.C. (TABLE 2). A series of

Table 2. Radiocarbon dates for Late Paleoindian and Archaic sites in the Osmore River coastal plain, arranged chronologically.

Lab no.	^{14}C *Age*	*Std. dev*	*Notes*	*Site*	*Context*	*Material type*	B.C. *2σ date ranges*	*Median probability*	*Source*
Beta-95869	10770	150	3	Q. Tacahuay	Profile 1, Unit 8, hearth	Charcoal	11,120–10,300	10840	Keefer et al. 1998
Beta-108692	10750	80	3	Q. Tacahuay	Profile 1, Unit 8, hearth	Charcoal	10,940–10,690	10810	Keefer et al. 1998
Beta-160706	10660	80	3	Q. Tacahuay	Block 3, Unit 8B, bajo	Charcoal	10,900–10,450	10770	deFrance 2008
Beta-172645	10690	60	3	Q. Tacahuay	Profile 1A, Unit 8 (1998)	Charcoal	10,900–10,470	10800	deFrance 2008
Beta-108860	10530	140	3	Q. Tacahuay	Profile 3A, Unit 8	Charcoal	10,870–10,110	10570	Keefer et al. 1998
Beta-122822	10420	110	3	Q. Tacahuay	Profile 1A, Unit 8	Charcoal	10,790–9900	10530	deFrance et al. 2001
Beta-122821	10510	50	3	Q. Tacahuay	Profile 3B, Unit 8	Charcoal	10,780–10,290	10380	deFrance et al. 2001
Beta-126968	10290	200	3	Q. Tacahuay	Profile 1A, Unit 8	Charcoal	10,750–9380	10120	deFrance et al. 2001
Beta-122820	10090	130	3	Q. Tacahuay	Profile 3B, Unit 5	Charcoal	10,170–9290	9730	deFrance et al. 2001
SI-6783	10575	105	1	Ring Site	Unit B, Level 16	Shell	10,110–9150	9560	Sandweiss et al. 1989
Beta-160707	10050	90	3	Q. Tacahuay	Profile 3C, Unit 5B	Charcoal	10,020–9320	9640	deFrance 2008
Beta-159921	9850	150	3	Q. Tacahuay	Block 3, Unit 5B	Charcoal	10,000–8810	9370	deFrance 2008
Beta-108859	9630	60	3	Q. Tacahuay	Profile 1, Unit 4	Charcoal	9240–8820	9010	Keefer et al. 1998
Beta-108858	9550	90	3	Q. Tacahuay	Profile 1, Unit 4, sheetflood	Charcoal	9230–8650	8950	Keefer et al. 1998
Beta-120721	9420	70	3	Miraflores	Lowest midden	Charred grass-like material	8810–8350	8630	Keefer et al. 2003
Beta-129709	9090	110	3	Q. Tacahuay	Mussel shell midden S-1c	Charcoal	8550–7830	8260	deFrance et al. 2001
Beta-203485	9100	50	3, 6	Q. Tacahuay	Mussel shell midden S-1c	Charred material	8420–7990	8230	unpublished
Beta-172615	9010	40	3	Q. Tacahuay	Block 2, Unit 4	Charcoal	8280–7970	8120	deFrance 2008
Beta-203486	9010	40	3, 6	Q. Tacahuay	Mussel shell midden S-1c	Charred material	8280–7970	8120	unpublished
Beta-127640	8770	50	3	Miraflores	Middle midden	Charcoal	7940–7600	7730	Keefer et al. 2003
Beta-120720	8690	50	3	Miraflores	Middle midden	Charcoal	7790–7570	7650	Keefer et al. 2003
SI-6931	8755	120	1	Ring Site	Unit B, Level 7	Shell	7580–6750	7220	Sandweiss et al. 1989
Beta-135387	8090	90	3, 6	Kilometer 4	Zone 4, Unit 301, Level 29	Charred wood	7290–6650	6940	unpublished
Beta-135327	8420	110	3, 6	Kilometer 4	Zone 4, Unit 301, Level 29	Shell	7220–6420	6800	unpublished
Beta-77947	8010	100	3, 6	Kilometer 4	Zone 2, Units 166 and 183, F94-48, Level 2	Charcoal	7140–6590	6860	unpublished
Beta-109354	7990	80	3	Q. Tacahuay	Profile 4, Unit 4-c3, midden	Charcoal	7060–6640	6840	Keefer et al. 1998
Beta-52799	7800	110	1	Villa del Mar	House 1, hearth (base)	Charcoal	7030–6400	6600	Wise 1995
Beta-135329	7930	40	3, 6	Kilometer 4	Zone 2, Unit 167 and 169, F94-50, Level 2	Charred wood	7030–6600	6730	unpublished
Beta-80971	7880	60	1	Yara	Hearth, Unit 120, 50-55 cmbs	Carbon material	7020–6480	6670	Rasmussen 1998
Beta-120719	7690	50	3	Miraflores	Upper midden	Charcoal	6600–6410	6480	Keefer et al. 2003
Beta-135333	7570	40	3, 6	Kilometer 4	Zone 6, Unit 805, Level 3, F96-4	Charred wood	6460–6250	6390	unpublished
SI-6930	7810	105	1	Ring Site	Unit B, Level 5	Shell	6430–5800	6120	Sandweiss et al. 1989

(contd.)

Table 2 (contd.)

Lab no.	^{14}C *Age*	*Std. dev*	*Notes*	*Site*	*Context*	*Material type*	B.C. 2σ *date ranges*	*Median probability*	*Source*
PITT-0142	7415	65	1	Ring Site	Test Pit 1, Level 16 (30–35 cm), above sterile soil	Charcoal	6390–6070	6050	Sandweiss et al. 1989
PITT-0147	7155	180	1	Ring Site	Unit L, Level L/M-12	Floated charcoal	6360–5650	5910	Sandweiss et al. 1989
SI-6784	7675	60	1	Ring Site	Unit B, Level 6	Shell	6250–5700	5980	Sandweiss et al. 1989
Beta-135334	7210	70	3, 6	Kilometer 4	Zone 6, Unit 800-803, Level 1, F96-9	Charred wood	6210–5890	6030	unpublished
Beta-203489	6740	40	3, 6	Huaca Luna	90 cmbs, mussel shell midden, main channel	Charred material	5700–5520	5600	unpublished
Beta-203491	6650	40	3, 6	Huaca Luna	50 cmbs, midden N, minor channel	Charred material	5620–5480	5540	unpublished
Beta-71133	6360	60	1	Villa del Mar	Burial 91-2 (Tomb 5)	Bone	5470–5070	5280	Wise 1995
Beta-77951	6270	70	3, 6	Kilometer 4	Zone 2, Unit 403, Level 14	Charcoal	5320–4970	5160	unpublished
Beta-52800	6280	60	1	Villa del Mar	House 1, hearth (superior)	Charcoal	5320–5010	5170	Wise 1995
Beta-135331	6150	40	3, 6	Kilometer 4	Zone 5, Unit 226, Level 3, F94-79	Charred wood	5210–4850	5020	unpublished
Beta-135322	5810	30	3, 6	Kilometer 4	Zone 4, Unit 301, Level 4	Carbon	4700–4500	4600	unpublished
Beta-89588	5570	70	1	Yara	Midden II, Unit 120, 35–40 cmbs	Charcoal	4520–4180	4370	Rasmussen 1998
Beta-57842	5540	60	1	Yara	Test unit, Unit 4, 20–25 cmbs	Charcoal	4460–4080	4340	Rasmussen 1998
Beta-135326	5340	150	3, 6	Kilometer 4	Zone 3, Unit 202, Level 14	Charred wood	4450–3770	4030	unpublished
Beta-89589	5450	80	1	Yara	Hearth midden II, Unit 199, 15–20 cmbs	Charcoal	4440–4000	4230	Rasmussen 1998
Beta-135323	5850	70	3, 6	Kilometer 4	Zone 4, Unit 301, Level 4	Shell	4370–3770	4100	unpublished
Beta-135325	5720	80	3, 6	Kilometer 4	Zone 3, Unit 201, Level 14	Shell	4260–3640	3950	unpublished
Beta-135332	5280	40	3, 6	Kilometer 4	Zone 5, Unit 204, Level 3, F94-78	Charred wood	4230–3960	3940	unpublished
Beta-135324	5200	70	3, 6	Kilometer 4	Zone 3, Unit 201, Level 14	Charred wood	4230–3720	3870	unpublished
CAMS-1783 6c	5060	80	2, 4	Kilometer 4	Railroad profile stratum XVIII, Level 150 cmbs	Charcoal	3960–3650	3800	Kennett et al. 2002
CAMS-1770 7c	5020	80	2, 4	Kilometer 4	Railroad profile stratum X, Level 74 cmbs	Charcoal	3960–3640	3760	Kennett et al. 2002
PITT-0144	5060	65	1	Ring Site	Unit J, Level 8	Charcoal	3950–3660	3800	Sandweiss et al. 1989
Beta-80970	5020	60	1	Yara	Burial 1, burial area, Unit 141, 10–15 cmbs	Bone	3940–3640	3750	Rasmussen 1998
Beta-80972	4920	80	1	Yara	Midden I, Unit 172, 130–135 cmbs	Organic sediment	3930–3780	3650	Rasmussen 1998
CAMS-1770 4c	4940	60	2, 4	Kilometer 4	Railroad profile stratum XXI, Level 175 cmbs	Charcoal	3890–3520	3680	Kennett et al. 2002
CAMS-1770 8c	4940	60	2, 4	Kilometer 4	Railroad profile stratum VIII, Level 53 cmbs	Charcoal	3890–3520	3680	Kennett et al. 2002
CAMS-1770 9c	4940	60	2, 4	Kilometer 4	Railroad profile stratum VII, Level 40 cmbs	Charcoal	3890–3520	3680	Kennett et al. 2002

(contd.)

Table 2 (contd.)

Lab no.	^{14}*C Age*	*Std. dev*	*Notes*	*Site*	*Context*	*Material type*	*B.C. 2σ date ranges*	*Median probability*	*Source*
CAMS-1772 2c	4930	60	2, 4	Kilometer 4	Railroad profile stratum XII, Level 95 cmbs	Charcoal	3890–3520	3680	Kennett et al. 2002
Beta-27417	4690	120	1	Carrizal	Midden, Unit 3, Stratum 10	Carbon	3650–3020	3390	Wise 1997
Beta-77949	4730	60	3, 6	Kilometer 4	Zone 5, Unit 204, Level 3 F94-78	Charred material	3640–3350	3170	unpublished
Beta-31074	4620	100	1	Carrizal	Midden, Profile 2, stratum 28	Carbon	3630–2930	3270	Wise 1997
Beta-27416	4620	100	5, 7, 8	Kilometer 4	Base of the railroad profile	Charcoal	3630–2930	3130	Wise, Clark, and Williams 1994
CAMS-1744 4s	5080	60	2, 4	Kilometer 4	Railroad profile stratum XXI, Level 175 cmbs	Shell	3530–2880	3220	Kennett et al. 2002
CAMS-1744 6s	5070	60	2, 4	Kilometer 4	Railroad profile stratum XVIII, Level 150 cmbs	Shell	3520–2880	3210	Kennett et al. 2002
CAMS-1772 3c	4620	60	2, 4	Kilometer 4	Railroad profile stratum XIII, Level 115 cmbs	Charcoal	3510–3030	2990	Kennett et al. 2002
CAMS-1744 3s	5050	60	2, 4	Kilometer 4	Railroad profile stratum XIII, Level 115 cmbs	Shell	3510–2870	3180	Kennett et al. 2002
CAMS-1744 8s	4990	70	2, 4	Kilometer 4	Railroad profile stratum VIII, Level 53 cmbs	Shell	3490–2770	3120	Kennett et al. 2002
CAMS-1744 7s	4990	50	2, 4	Kilometer 4	Railroad profile stratum X, Level 74 cmbs	Shell	3480–2830	3120	Kennett et al. 2002
CAMS-1744 9s	4980	60	2, 4	Kilometer 4	Railroad profile stratum VII, Level 40 cmbs	Shell	3480–2770	3100	Kennett et al. 2002
CAMS-1744 5s	4950	70	2, 4	Kilometer 4	Railroad profile stratum XXII, Level 190 cmbs	Shell	3440–2690	3070	Kennett et al. 2002
CAMS-1744 1s	4950	50	2, 4	Kilometer 4	Railroad profile stratum V, Level 25 cmbs	Shell	3380–2700	3070	Kennett et al. 2002
Beta-31073	4450	100	1	Carrizal	Midden, Unit 3, stratum 5	Carbon material	3370–2780	3070	Wise 1997
CAMS-1770 5c	4530	80	2, 4	Kilometer 4	Railroad profile stratum XXII, Level 190 cmbs	Charcoal	3360–2920	2950	Kennett et al. 2002
Beta-18920	4390	110	1	Carrizal	Midden, Unit 2, Stratum 8	Carbon material	3350–2640	2990	Wise 1997
CAMS-1770 1c	4500	60	2, 4	Kilometer 4	Railroad profile stratum V, Level 25 cmbs	Charcoal	3340–2920	2870	Kennett et al. 2002
CAMS-1745 2s	4890	60	2, 4	Kilometer 4	Railroad profile stratum XII, Level 95 cmbs	Shell	3340–2630	2990	Kennett et al. 2002
Beta-135328	4010	70	3, 6	Kilometer 4	Zone 2, Unit 401, Level 3	Charred wood	2830–2210	2450	unpublished
Beta-77948	3910	80	3, 6	Kilometer 4	Zone 1, Unit 69, Level 6, F94-85	Charcoal	2570–2040	2320	unpublished
Beta-52797	3760	80	7, 9	Kilometer 4	Zone 89-B, Unit 6, Center Level 7	Charcoal	2430–1880	2100	Wise, Clark, and Williams 1994
Beta-127639	3820	30	3	Yara	Lower midden	Charcoal	2290–2040	2180	Keefer et al. 2003
Beta-52796	3750	70	7, 10	Kilometer 4	Zone 89-B, Unit 6 N 1/4, Level 3	Charcoal	2290–1890	2090	Wise, Clark, and Williams 1994
Beta-203490	3770	40	3, 6	Huaca Luna	50 cmbs, mussel shell midden, main channel	Charred material	2280–1970	2100	unpublished
Beta-31075	3640	100	1	Carrizal	Trench 5, 26 cmbs, domestic terrace	Carbon material	2270–1670	1940	Wise 1997

(contd.)

Table 2 (contd.)

Lab no.	^{14}C Age	Std. dev	Notes	Site	Context	Material type	B.C. 2σ date ranges	Median probability	Source
Beta-77946	3690	70	3, 6	Kilometer 4	Zone 1, Unit 53, Level 6, F94-42	Charred wood	2200–1770	2010	unpublished
Beta-127638	3960	80	3	Yara	Lower midden	Shell	2120–1410	1750	Keefer et al. 2003
Beta-19549	3400	100	1	Huaca Luna	Lense of ash and shell	Carbon	1890–1430	1640	Aldenderfer 1989
Beta-135330	3220	140	3, 6	Kilometer 4	Zone 2, Unit 159, Level 5	Charred wood	1750–1020	1550	unpublished
Beta-77950	3320	70	3, 6	Kilometer 4	Zone 1, Unit 68, Level 7, F94-33	Charcoal	1740–1410	1440	unpublished
Beta-203492	3290	50	3, 6	Huaca Luna	50 cmbs, midden N, minor channel	Charred material	1630–1410	1510	unpublished
Beta-77943	3220	60	3, 6	Kilometer 4	Zone 1, Units 68 and 70, Level 3, F94-2	Charcoal	1610–1270	1430	unpublished
Beta-135335	3130	100	3, 6	Kilometer 4	Zone 6, Unit 812, Level 3, F96-21	Charred wood	1600–1010	1320	unpublished
Beta-122102	2930	50	3	Yara	Upper midden	Charcoal	1260–910	1060	Keefer et al. 2003
Beta-122101	3230	50	3	Yara	Upper midden	Shell	1200–510	860	Keefer et al. 2003

1. Dates not corrected for isotopic fractionation.
2. Dates corrected for isotopic fractionation by the author of the original reference (Kennett et al. 2002).
3. Dates corrected for isotopic fractionation by lab measurement.
4. A combination of the lab number and the sample number as given in the original reference (Kennett et al. 2002).
5. Lab number was incorrectly given as Beta-27417 in the original reference.
6. Date has not been previously published.
7. Dates corrected for isotopic fractionation using estimated values for ^{13}C.
8. Published date was 4620 ± 90 (before ^{13}C correction). Date given in the table is the ^{14}C age after correction for isotopic fractionation.
9. Published date was 3760 ± 70 (before ^{13}C correction). Date given in the table is the ^{14}C age after correction for isotopic fractionation.
10. Published date was 3750 ± 60 (before ^{13}C correction). Date given in the table is the ^{14}C age after correction for isotopic fractionation.

stratified debris flows and sheetflood deposits separate and overlay these more recent cultural deposits (Keefer et al. 1998; Keefer, Moseley, and deFrance 2003). The Early Archaic material consists primarily of faunal remains including a greater variety of marine fish than the earlier deposit and local lithic artifacts. Early Archaic deposits include thin scatters of marine mussel shell (*Choromytilus chorus*); there are no associated artifacts or vertebrate fauna. This discontinuous shell scatter suggests that there was little occupation north of the quebrada channel during the later Early Archaic or more recent periods. Potential evidence of more recent occupation, however, was affected by geomorphological changes in the quebrada that occurred after the deposition of the uppermost debris flow ca. 3300 CAL. B.C., when the channel downcut to its present level, thereby starving the site of additional sediment that could have stratified and preserved any younger occupation.

Deposits on the south side of Quebrada Tacahuay consist of a dense mussel shell midden that was also exposed during construction of the coastal highway. No artifacts are associated with this shell deposit. In order to determine the temporal placement of the mussel shell midden, three radiocarbon dates were obtained indicating that the deposit ranges in age from ca. 8550 to 7970 CAL. B.C. One sample from north of the channel and one from the south are identical in radiocarbon age (9010 ± 40 B.P. Beta-203486; Beta 172615) suggesting that occupation may have been extensive, but that denser refuse survives on the south side. It is unknown how much of this deposit was destroyed during highway construction; the spatial extent of the occupation is therefore indeterminable. There is abundant shell scatter inland from the coastal highway on the south side of the quebrada. This material is undated; however, the senior author observed numerous Archaic period projectile points on the surface. Although spring water is present inland in the quebrada channel, survey of the quebrada lomas and foothills did not identify any Archaic sites (Adán Umire Alvarez, personal communication 2007).

Quebrada Huaca Luna

Approximately 22 km south of Ilo, the wide Quebrada Huaca Luna contains an archaeological deposit buried by an undated debris flow capped by a recent debris flow from either the 1982–1983 or the 1997–1998 El Niño. This site was originally identified as Quebrada 1 in a survey conducted by Mark Aldenderfer in 1985 (Aldenderfer 1989).

Along exposures in the braided quebrada channel are cultural deposits consisting predominantly of mussel shell, false abalone, and chitons. The deposit varies in thickness from 0.35 m to a maximum depth of 0.75 m. No lithics or features were observed in the profiles. Although there is no obvious hiatus in site deposits, AMS dates indicate two periods of site occupation: an early Middle Archaic occupation dating from 5700 to 5480 CAL. B.C. and a Late Archaic occupation dating from 2280 to 1410 CAL. B.C. (TABLE 2). The exposed faunal remains and limited radiocarbon dating comprise all of the existing information on the site.

The Ring Site

The Ring Site is a Late Paleoindian through Archaic stratified shell midden located 7.5 km SE of Ilo and 0.75 m inland on a marine terrace above the Pampa del Palo. Late in the occupation the terrace was topped with shells to form a large ring 26 m in diameter (Sandweiss et al. 1989), which represents the earliest shell ring in the Americas. Excavations completed in the 1980s produced dates ranging from ca. 10,110 to 3660 CAL. B.C. (TABLE 2). The basal stratum produced a Late Pleistocene/Late Paleoindian date, but the majority of the deposits appear to represent the Middle Archaic. The site is identified as a residential base camp with long-term occupation. Although there are few dates from 8000–7000 B.C., the Ring Site has undated deposits that bracket the earlier and later dates with no indication of a hiatus.

The midden consists primarily of marine vertebrates and invertebrates; the only terrestrial animals are small mice. Few organic materials are present. The artifact assemblage consists of modified and unmodified lithics of local origin (Sandweiss et al. 1989). No domestic features or burials were identified, however, the excavations were limited in spatial extent. The site has been obliterated by modern use as a garbage dump for the city of Ilo and construction of the Ilo to Ite highway.

Villa del Mar

Villa del Mar is an Early–Middle Archaic site dating from ca. 7030 to 5010 CAL. B.C. (TABLE 2). Located along the south side of the Osmore River approximately 100 m from the ocean, the site originally covered at least 0.5 ha. Roads, development, and fences have since destroyed much of the site. Remaining deposits consist of domestic areas, including the remains of a house floor, midden deposits, and a cemetery (Guillén and Carpio 1999; Torres et al. 1990a, 1990b; Wise 1995). The cemetery contains 10 individuals buried in seven distinct tombs (Wise 1995). All are in extended position and one features the remains of a clay and shell mask, demonstrating a relationship with the Chinchorro tradition of northern Chile (see Allison et al. 1984; Bittmann 1982; Guillén 1992). Burial goods include shell beads, bone awls, the remains of twined textiles, and bird skin or feather cloaks from two tombs. There were few lithic artifacts.

Villa del Mar appears to have been a residential base camp with at least one associated cemetery. It contains a wider range of artifacts than were found at either the Ring Site or at Quebrada Tacahuay. The site is located in a prime setting for the exploitation of diverse marine and terrestrial resources. Although the faunal remains include numerous marine resources, terrestrial mammals are more common than at other Archaic sites in the region (Wise 1999a: 344). The plant remains identified by Heidi Lennstrom include taxa from the lomas habitat and the river valley (Wise 1999a).

Kilometer 4 (K4)

K4, located 9 km north of the Ilo River and 50 m from the ocean, documents long-term occupation spanning the Early Archaic through the Late Archaic. The site extends 10 ha across a relatively flat area to the coastal foothills. The remains of at least 75 domestic terraces are present, varying in size from 4 to 10 m across, as well as a midden area, and at least three separate cemeteries. The Middle and Late Archaic occupations, dating from ca. 7290 to 1010 CAL. B.C., are the best-studied deposits of these ages in the Ilo region (Wise 1999a, 1999b; Wise, Clark, and Williams 1994) (TABLE 2). Variation in refuse, burials, and artifacts suggests that K4 represents a Middle Archaic seasonal residential camp and cemetery, and a more permanently occupied Late Archaic settlement with segregated residential, mortuary, and midden areas. At the northeastern edge of the site are the remains of a small spring that is now dry. The presence of extensive Archaic remains but no material from later periods suggests that the spring dried up by the end of the Archaic, perhaps forcing an abandonment of the site.

The evidence for Early–Middle Archaic occupation of K4 consists of shell middens and domestic or processing areas in lower levels. The Late Archaic domestic features at K4 comprise remnants of small circular houses constructed on domestic terraces. Each terrace was built on fill composed of redeposited shell midden.

Three distinct cemeteries have been found at K4. The burial treatment and tomb styles include circular tombs with single flexed burials, a large circular common grave containing numerous individuals with Chinchorro-style mortuary treatment (i.e., extended burials, often face down, evidence for defleshing, exposed or reopened graves, and post-mortem manipulation of the remains), and a third area with extended burials of individuals wrapped in matting. Individuals were interred with varying quantities and types of matting, animal skins, bird skins, human hair, and cotton; other grave goods also vary (Wise, Clark, and Williams 1994). An isolated, flexed burial was excavated in an upper layer of one of the domestic terraces (Wise, Clark, and Williams 1994).

Ongoing analysis of faunal remains from K4 indicates a maritime economy, focused increasingly on small schooling fish (anchovy and herring) by the Late Archaic (Jean Hudson, personal communication 2008). Floral remains include a range of plants from the river valley, lomas, and springs during the Middle Archaic, but a restricted range of plants from the local spring and nearby lomas during the Late Archaic (Gilliam 1998). The lithic assemblage is typical of other nearby sites and features a few projectile points, scrapers, cobble-cortex tools, manos, and hammerstones. Bone artifacts include awls, net or fishing line weights, bird bone tubes, some decorated, small bird bone flutes, and bone beads. There are a few wooden artifacts and several cactus spine fishhooks.

Carrizal

Carrizal is a multicomponent site on the alluvial fan of the spring-fed Quebrada Carrizal located 15 km north of the Ilo River. The site slopes toward an oceanfront pebble beach. The terrain above the site is steep with sparse lomas vegetation in the distance. This location afforded inhabitants access to varied resource patches, including the pebble beach, rocky and sandy beaches within 2 to 3 km of the site, the spring-fed quebrada, and lomas patches 3 to 5 km away. The productivity of the modern spring is reduced since antiquity (Clement and Moseley 1991).

Occupation of Carrizal ranges from the Archaic to the colonial period, as indicated by artifacts from surface collections and shovel tests (Bawden 1989a, 1989b). Diagnostic pottery indicates that most of the late components are at the lower end of the site. In contrast, most of the Archaic components occur at the higher end of the terrace. Clement and Moseley (1991) argue that this settlement pattern follows the progressive drying of the spring, which caused the outlet to become lower through time. Formative (Bolaños 1987) as well as Late Intermediate through historical occupations (Reycraft 1998) have been defined, along with several Archaic components (Bawden 1989a, 1989b).

An important Late Archaic component lies north of the main quebrada branch, roughly 150 masl. This area covers 2.5 ha and consists of a shell midden and a series of domestic terraces located in the hills that rise beyond the quebrada. Small-scale excavations were focused primarily on the shell midden (Wise 1990, 1997). Five radiocarbon dates indicate that the site was occupied during the Late Archaic, ca. 3650–1670 CAL. B.C. (TABLE 2). The terraces at Carrizal appear to represent domestic areas. Charcoal recovered in excavations on one of the terraces produced a date of 1940 CAL. B.C. Additional excavations and dating are needed to determine when the terraces were constructed and whether they are contemporaneous with the shell midden. The layout of the site suggests a village and mortuary area similar to the Late Archaic site of K4 discussed above (Wise, Clark, and Williams 1994). One burial in the shell midden unequivocally dates to the Archaic (ca. 3650 and 2780 CAL. B.C.). The single interment consisted of a flexed individual wrapped in vegetal-fiber twined textiles and placed on an *estera* (woven fiber mat). The individual was buried wearing a basketry hat and accompanied by a single stone mano (Wise 1997).

Organic remains are well preserved at Carrizal. The faunal assemblage from the shell midden indicates a diet of primarily marine and coastal organisms, although some terrestrial mammal remains are present. Material collected from Carrizal includes faunal remains (fish, bird, marine mammal, terrestrial mammal bone, marine shell), and small amounts of feathers, possibly for ornamental purposes. Also present are floral remains (seeds, bits of grass and fiber, and the remains of textiles), lithic artifacts, and a few bone artifacts (Wise 1990).

Yara

Yara is an Early–Late Archaic residential camp located 17 km north of Ilo between the dry quebradas of Yara and Chololo on a low coastal terrace. The site lies 50–100 m below the remains of a spring and within several hundred meters of the lomas. Yara contains middens, mortuary areas, and possible domestic remains (Rasmussen 1998). It covers approximately 5 ha, although testing at 50 m intervals indicated that not all areas contain subsurface cultural remains.

Excavations revealed two distinct occupational layers, defined by Rasmussen (1998) as Midden I and II and by Keefer, Moseley, and deFrance (2003) as the lower and upper middens separated by a debris-flow deposit. In addition to the midden deposits, a small cemetery contains the remains of extended burials associated with the Chinchorro tradition. Although only one burial was excavated, researchers identified the intact but disturbed remains of at least eight additional individuals. A radiocarbon date places the burial in the Late Archaic (ca. 3940–3640 CAL. B.C.). Nine radiocarbon dates were obtained from Yara (TABLE 2). Dates for the two middens are from contexts excavated

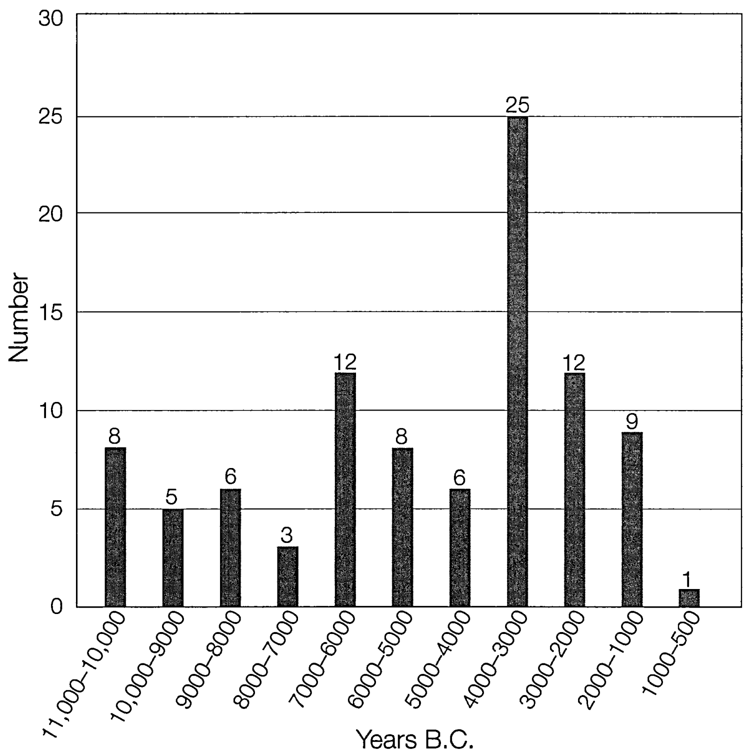

Figure 2. Frequency of radiocarbon dates by 1000-year increments using median probability dates.

by Rasmussen (1998) and the remainder come from charcoal and shell samples collected and reported by Keefer, Moseley, and deFrance (2003). The dates range from 6670 to 860 CAL. B.C. into the coastal Formative. Inconsistency between charcoal and shell dates reported by Keefer, Moseley, and deFrance (2003) is interpreted as reflecting the imprecision in the marine carbon reservoir correction for the upwelling habitats of coastal Peru. Regardless of date discrepancies, the site demonstrates reoccupation of the area following an ENSO-generated debris flow that occurred sometime between 2200 and 700 CAL. B.C. (Keefer, Moseley, and deFrance 2003). Rasmussen (1998) interprets Yara as a residential base camp that was reoccupied through time, but finds no definitive evidence that the site was a sedentary village.

Yara contains the only imported lithic identified from the sites discussed here. Rasmussen (1998: 134) recovered a Middle Archaic broken projectile point made of a highland-derived volcanic andesite in a highland form. No other non-local materials are present. Other recovered objects include a small number of lithic tools and fishing implements. Faunal remains, in order of abundance, consist of fish, birds, sea mammals, and land mammals (Rasmussen 1998). The mortuary remains include twined textiles and marine mammal pelts. Cotton is present in late contexts; however, the archaeobotanical remains contain no evidence of cotton cultivation.

Quebrada Miraflores

Approximately 20 km north of Ilo, the Miraflores Quebrada terminates in the largest basin and alluvial fan in the Osmore study region. Initial geoarchaeological investigations of the quebrada focused on massive ENSO debris flows (the Chuza and Miraflores flood events) that destroyed a Late Intermediate Period village (Satterlee 1993; Satterlee et al. 2000). Archaic debris flows and three relatively thin organic middens are also exposed in the quebrada fan and beneath the late flood deposits (Keefer, Moseley, and deFrance 2003). Investigation and characterization of the flood deposits by Keefer, Moseley, and deFrance (2003) generated Early Archaic dates (7730–6480 CAL. B.C.) for the two uppermost shell middens as well as an Early Archaic date (8810–8350 CAL. B.C.) for the deepest midden, an organic layer of charred material that is devoid of shell. Other than shell refuse in the upper middens, no artifacts, features, or other cultural materials have been observed within these deposits. The Archaic occupation at Miraflores awaits further archaeological study.

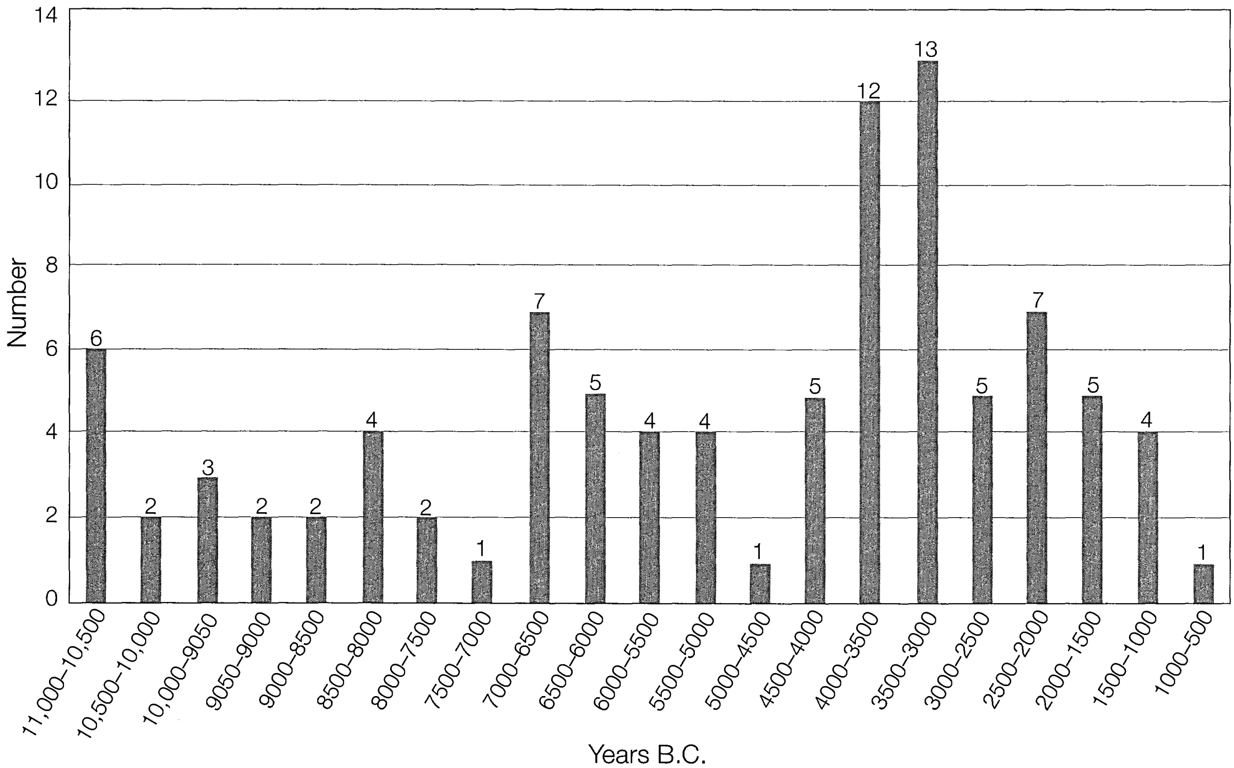

Figure 3. Frequency of radiocarbon dates by 500-year increments using median probability dates.

Discussion

The comparison of occupational history and radiocarbon dates from these sites on a millennial scale indicates that although no sites were occupied continuously from the Late Paleoindian to the Late Archaic, there is no hiatus in human occupation (FIGS. 2, 3). The time period with the least evidence for occupation spans roughly 8000 to 7500 CAL. B.C. This interval may, however, reflect the absence of chronometric dates from the Ring Site where dense, undated refuse brackets this time period (Sandweiss et al. 1989: 48). The dates presented here indicate that occupation shifted along the coast but it was never abandoned (FIGS. 4, 5). Settlement was not unidirectional through time; instead, people migrated north and south (FIGS. 4, 6). The earliest occupation is documented at the southernmost site of Quebrada Tacahuay. Early Archaic deposits are also present at Miraflores Quebrada (Keefer, Moseley, and deFrance 2003), the northernmost site, and Late Archaic occupation occurs across most of the study area with settlements at both Carrizal and Huaca Luna. Site location reflects the occupation of quebradas with varying types of coastal habitat and access to lomas patches. These data are significant because the eight sites represent only 2.7% of the preceramic/Archaic sites (n = 256) in the study region and only 2.1% of all sites (n = 335) in the total area surveyed.

Sites vary with respect to potable water, shoreline features, and the range of identifiable site activities. Although spring sources are no longer evident at all sites, the relationship of highland-charged springs to coastal occupation is strongly correlated at all three of the sites north of Ilo. South of Ilo, quebrada channels with springs are evident at Quebradas Huaca del Luna and Tacahuay. Shoreline configuration also appears to be a factor in site location. A combination of beach and rocky shorelines appears to have provided the greatest access to diverse marine resources, including finfish, marine birds, marine mammals, shellfish, and other invertebrates (e.g., octopus). Long-term site occupation is correlated with diverse occupation areas (e.g., houses, terraces). Cemeteries are found at both short-term occupation sites as well as at sites occupied for several millennia.

The location and occupational evidence at the Ring Site are anomalous. The site is located a greater distance from the shoreline than other sites and the nearest shoreline is dominated by sandy beach with few rocky outcrops. The upper elevated beach terrace allowed easy access to the lomas habitat, possibly for resources such as wood fuel. The

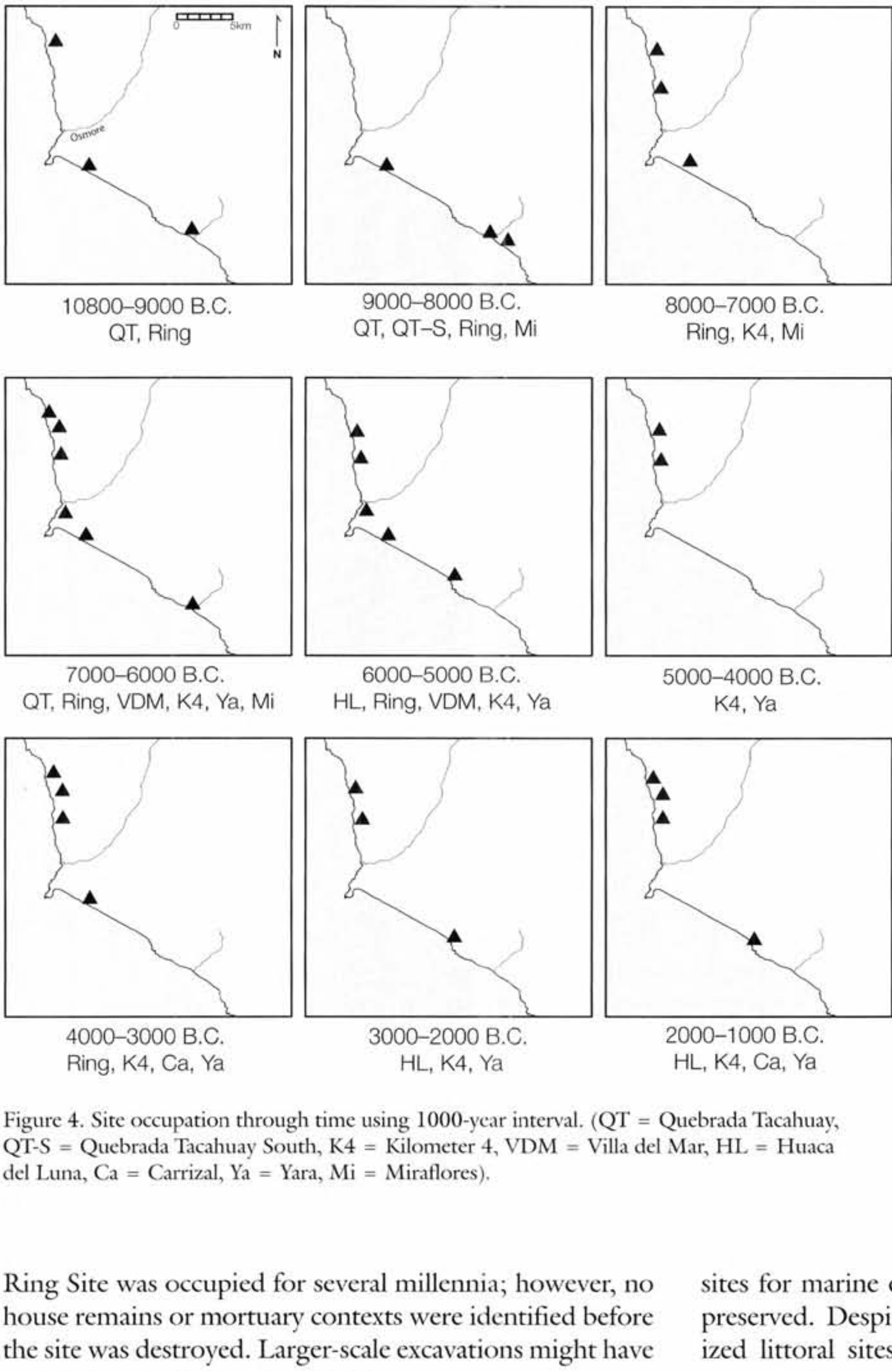

Figure 4. Site occupation through time using 1000-year interval. (QT = Quebrada Tacahuay, QT-S = Quebrada Tacahuay South, K4 = Kilometer 4, VDM = Villa del Mar, HL = Huaca del Luna, Ca = Carrizal, Ya = Yara, Mi = Miraflores).

Ring Site was occupied for several millennia; however, no house remains or mortuary contexts were identified before the site was destroyed. Larger-scale excavations might have revealed more diverse site activities.

Inhabitants of sites where dense refuse accumulated, such as the Ring Site and K4, presumably obtained marine products from specialized maritime sites; however, affiliations between habitation sites and specialized maritime extractive locales have not been identified. The early marine bird processing and cooking deposits at Quebrada Tacahuay provide evidence that highly specialized activities were a component of the earliest occupations; specialization did not develop over time. Other types of specialized sites for marine exploitation in the region have not been preserved. Despite the narrow continental shelf, specialized littoral sites probably were destroyed by shoreline transgression and erosion due to sea level rise. The earliest deposits at Tacahuay are intact because the site is located above a shoreline terrace and was buried and preserved by an El Niño-induced debris flow (deFrance and Keefer 2005; Keefer et al. 1998; Keefer, Moseley, and deFrance 2003).

Aside from one andesite projectile point from Yara, the Ilo sites are devoid of imported materials. There are no lithic materials obtained from regions beyond the Osmore coastal plain, nor are there exotic animal remains. Uniden-

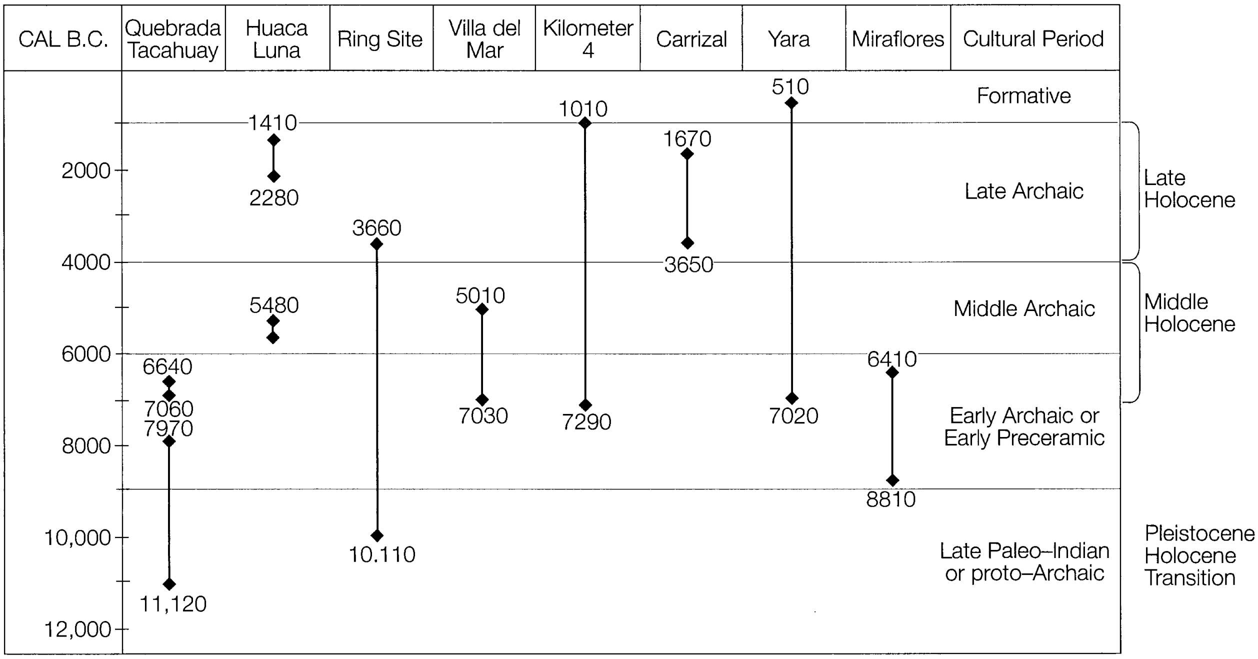

Figure 5. Date range for sites site using 2σ ranges.

tified bird feathers recovered from a few of the burial contexts may be of local origin; no feathers are definitively from exotic birds.

Interaction with other culture groups is indicated by burial styles and the late introduction of cotton farming. Contact with Chinchorro populations who originated in northern Chile is evident in burials at Villa del Mar, K4, and Yara. The late introduction of farming methods, including cotton cultivation and field terracing, demonstrates the exchange of information with people outside of the coastal plain. It is unknown whether domesticated crops and terrace systems were accompanied by the settlement of people from elsewhere or whether these innovations represent information exchange only.

There may have been local variation in paleoclimatic conditions. In the Osmore region, archaeobotanical remains, faunal evidence, and depositional contexts are comparable through time, indicating that local palaeoenvironmental and climatic conditions were relatively stable. Future research should investigate why some coastal areas to the north, e.g., near Quebrada Jaguay north of Camaná (Sandweiss 2003), necessitated coastal abandonment while the Ilo/Osmore region did not. It is possible that the distribution of local springs near Quebrada Jaguay and a decline in groundwater recharge from highland systems may have forced people to move to well-watered areas. Localized palaeoclimatic conditions may have contributed to coastal abandonment in some areas, rather than widespread increased aridity, changes in offshore or nearshore currents, or shifts in sea surface temperatures.

In contrast to highland regions of northern Chile where increased aridity forced people to abandon large areas and settle in geographically circumscribed, oasis-like settings (Grosjean and Núñez 1994; Núñez 1992, 1999; Núñez et al. 2001, 2002), coastal settlement in the Ilo region appears to have offered greater flexibility in response to Early and Middle Holocene climatic fluctuations. Shifting settlement location along the coast took advantage of different marine habitats and allowed maritime economies to continue for several millennia. A similar pattern of long-term Early to Late Archaic coastal occupation is documented at the site of Quebrada de los Burros, south of the Osmore region near Tacna (Carré et al. 2009; Fontugne et al. 1999; Lavallée et al. 2000).

Although a hiatus in ENSO activity is observed during the Middle Holocene, ca. 7000–3800 B.C., in the Osmore region (Keefer et al. 1998; Keefer, Moseley, and deFrance 2003), as well as in other areas of Peru (Carré et al. 2005; Fontugne et al. 1999; Sandweiss 2003; Sandweiss et al. 1996; Sandweiss et al. 2001; Sandweiss et al. 2007), coastal economic exploitation in the Ilo region was not affected. The faunal remains from the Ilo sites are all cold water upwelling fauna; there are no anomalous assemblages indicating elevated sea surface temperatures or other environmental perturbations before or after the hiatus. These data also suggest that annual highland rainfall was suffi-

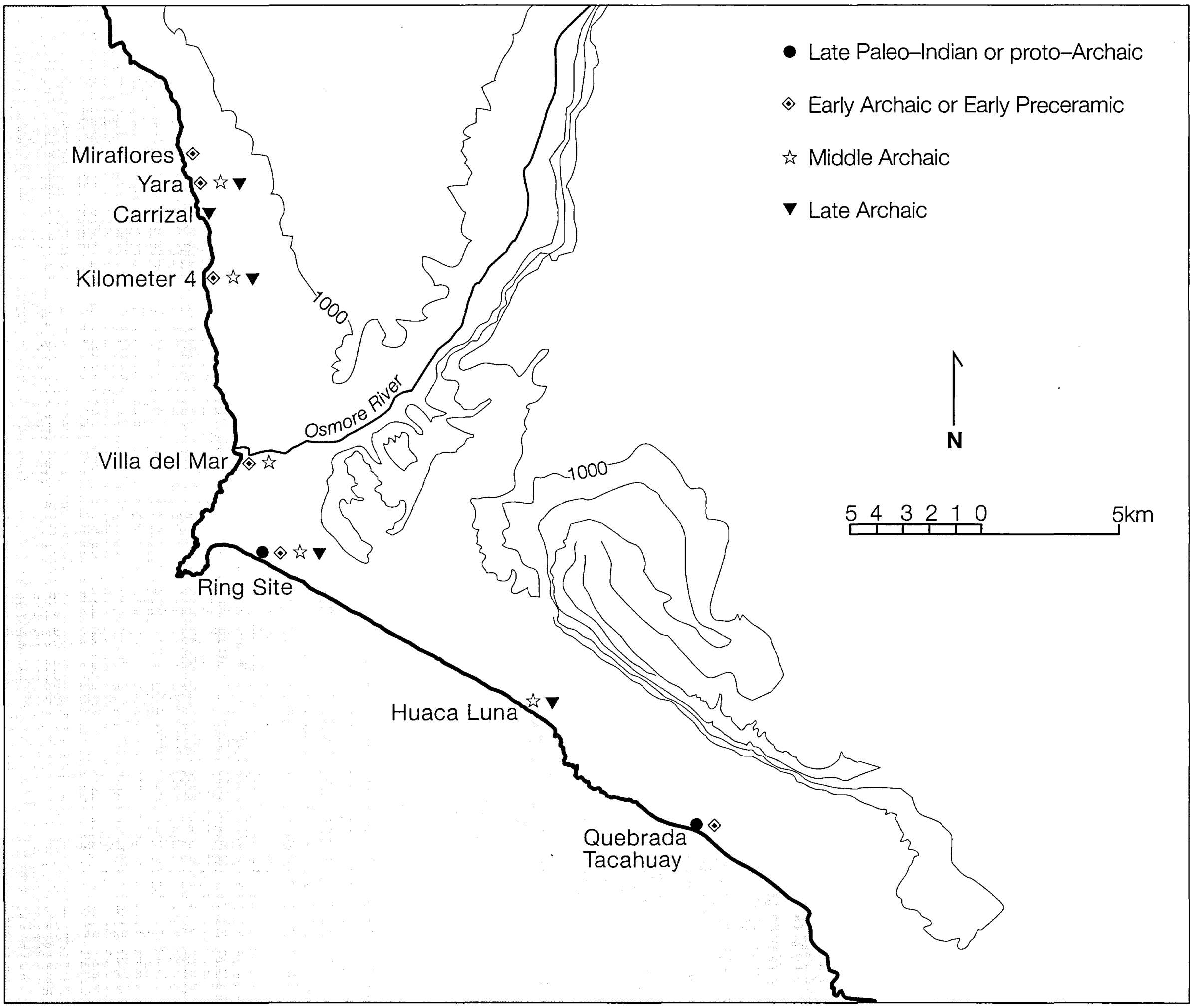

Figure 6. Occupational components at Osmore sites.

cient to recharge the coastal aquifer. The analysis by Fontugne and his colleagues (1999) at the site of Quebrada de los Burros indicates that fresh water was probably also available from condensation of heavy fog banks associated with cold upwelling currents, particularly during the Middle Holocene when ENSO activity was reduced and sea surface temperatures were colder. Stable isotope analysis of modern and archaeological surf clams (*Mesodesma donacium*) from Quebrada de los Burros indicates that sea surface temperatures during the Early and Middle Holocene were cooler and upwelling was stronger, thus suggesting greater marine productivity and thicker fog banks providing more surface water during the austral winter (Carré et al. 2005). Following the return or increase in periodicity of ENSO phenomena and sea level stabilization that occurred at approximately 3000 B.C., the sites in the Osmore region demonstrate continuity in coastal economic practices.

The Osmore coastal plain is circumscribed by a narrow coast and a low elevation mountain range. Travelling inland, the springs retreat underground and the Osmore River becomes a dry channel. There is no water for over 30 km until the lower Moquegua Valley where the surface channel of the Osmore (Ilo) reemerges as the Moquegua River. Overland travel was probably unappealing to ancient people due to the lack of water, plant, and animal resources. Marine foods and potable water made coastal settlement attractive. In order to test the hypothesis that water was a determining factor in settlement location, future research should focus on chronometric dating of coastal springs and more rigorous hydrological analysis to identify ancient fluctuations in spring productivity.

More radiocarbon dates on inland sites are also needed to determine if they are contemporaneous with coastal sites. Archaic sites are absent in the arid mid-valley, which begins at about 1200 masl. Archaic sites do not occur until highland elevations exceed 6400 masl (Aldenderfer 1998). These data strengthen the view that maritime economic and environmental specialization developed independently from highland economies at an early date, probably with initial settlement, and that they remained viable for over 12,000 years.

A single highland-style, andesite projectile point from Yara is the only exotic object identified in the study area. The absence of imported materials supports a scenario of regional economic specialization that did not involve seasonal migration from coast to highland nor significant trade in goods from one region to another. In this regard, the Osmore region differs from Camaná to the north where highland obsidian from the Alca source has been identified in the earliest, Late Pleistocene deposits and in more recent Archaic deposits at Quebrada Jaguay; however, it remains unknown if the obsidian at Jaguay arrived through down-the-line trade or if people originating in the Camaná region made the round-trip trek themselves (Sandweiss et al. 1998). The possible highland-to-coast trade routes are the subject of ongoing research (Kurt Rademaker, personal communication 2009).

Coastal abandonment in some regions may also be a result of sampling bias rather than a reflection of ancient human behavior; the Osmore coastal region is well studied. As researchers in other areas of the South Central Andes conduct more extensive surveys and obtain more chronometric dates we may be able to determine if people elsewhere also moved along the coast, possibly to different quebradas, but did not abandon the coastal region.

Conclusion

Beginning ca. 12,000 years ago, the occupational history of the Osmore coastal plain documents economic specialization focused on marine resources. Through time, people settled different parts of the coast, particularly near coastal springs and quebrada channels where potable water was available. Our analysis indicates that Late Paleoindian coastal forager occupation is evident beginning in the Late Pleistocene and human settlement continued for over 12,000 years through the Holocene into the Late Archaic with no evidence for periods of coastal abandonment. Radiocarbon dates and settlement data from eight sites indicate that people migrated along the coast. The migration consisted of movement both north and south. Although we cannot determine the density of human settlement using radiocarbon dates, and no single site was occupied from its initial settlement to the Late Archaic, there is no time when the coast was not inhabited. Cultural affiliations with the Chinchorro tradition of northern Chile are evident at three sites. Increased sedentism occurred with the introduction of industrial crops, including cotton (Rasmussen 1998), and food crops such as beans (Gilliam 1998). Marine food resources associated with cold, upwelling currents are important during all periods. There is some indication of food intensification over time involving the increased capture of small-sized fish (e.g., anchovies and sardines) (Rasmussen 1998); however, net technology is evident in the earliest deposits (deFrance 2005; Keefer et al. 1998). The scarcity of exotic materials and the absence of animals from other regions indicate that the coastal populations were largely self sufficient. Social networks apparently were not used for the circulation of subsistence goods or raw materials.

The Osmore data indicate that coastal abandonment may have been a localized phenomenon rather than a temporally correlated pattern that occurred across a vast area of the South Central Andean littoral. The study region contrasts with the Quebrada Jaguay area north of Camaná where there is coastal abandonment during the Middle Holocene (Sandweiss 2003). This pattern is also identified in the Atacama Desert (Grosjean et al. 2003; Núñez et al. 2001, 2002). The local conditions of coastal circumscription, springs, and high marine productivity combined to make the Osmore coastal plain a viable locale for human settlement for over 12,000 years. The degree and duration of marine exploitation suggest that regional specialization, rather than generalized forager behavior, was a characteristic of the earliest coastal settlement and endured through time.

Acknowledgments

We thank the following individuals for information on various phases of this research: Jean Hudson, David K. Keefer, Ana Miranda, Michael E. Moseley, Adán Umire A., and Greg Zaro. Susan Duser of Academic Technology, University of Florida produced the final figures. The following institutions provided support for investigations in the region that were supervised by either deFrance or Wise: Southern Peru Copper Corporation (SPCC), the Asociación Contisuyo, the American Philosophical Society, the Margaret Cullinan Wray Trust through the American Anthropological Association, the H. John Heinz III Charitable Trust, the Taylor Science Fund of the Los Angeles County Museum of Natural History, the Weiler Foundation, the Arco Foundation, the University of Florida Humanities Scholarship Enhancement Fund, FERCO (Foundation for Exploration and Research on Cultural Origins), the National Geographic Society, and the U. S. Geological Survey. In addition, all of Wise's field research in the Ilo area of southern Peru was generously supported by friends, collaborators, including local citizens and SPCC families, students, and teams of researchers, without whom the investigations would not have been possible. We also thank David K. Keefer, Daniel S. Sandweiss, Kary L. Stackelbeck, and one anonymous reviewer for their critical and helpful comments.

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