THE MARITIME FOUNDATIONS OF ANDEAN CIVILIZATION: A RECONSIDERATION OF THE EVIDENCE

J. Scott Raymond

Moseley's contention that coastal Peruvian civilization was founded on a maritime subsistence economy is challenged, and the evidence that he used to substantiate his claim is re-examined. It is argued that: (1) the number of calories represented by the faunal remains in the late preceramic sites of the central coast is too few to have supported more than a simple hunter-gatherer society; (2) the potential productivity of the agricultural food plants present in the preceramic sites has been grossly underestimated; (3) biases in the preservation of sites and of food remains in the sites have not been considered sufficiently in drawing conclusions from the data; and (4) when considered in relation to the hydrology of the Peruvian coast, the distribution of the late preceramic sites indicates a dependence on flood-plain agriculture.

IT IS ALMOST A PLATITUDE in anthropological theory that efficient agriculture is a precondition for the rise of civilization. That assumption has a long and respectable history among anthropologists stretching back at least to the nineteenth century. Childe (1951:59–87), for instance, saw the "Neolithic Revolution" as a universal stage in the beginnings of urbanism and the evolution of civilization. Anthropologists studying the rise of Andean civilization accepted this as a given. Early theories of development presumed an early, incipient agricultural stage prior to the start of craft specialization, temple building, elaborate art, and the other diagnostic characteristics associated with complex societies in ancient Peru (cf. Strong 1948; Steward 1948; Mason 1957). However, the data accumulated from archaeological research on the coast of Peru over the past three decades seem to undermine the credibility of such hypotheses. Lanning was the first to express doubts. In discussing the first evidence of temples, pyramids, altars, formal art styles, and elaborate burials he says: "Remarkably these developments took place among people who were not primarily farmers, but rather shore-dwelling fishermen. To the best of my knowledge, this is the only case in which so many of the characteristics of civilization have been found without a basically agricultural economic foundation" (Lanning 1967:59). Others have since expressed a similar view (cf. Patterson 1971a, 1971b; Patterson and Moseley 1968; Moseley and Willey 1973; Moseley 1968, 1972, 1975). Of these Moseley has presented the most forceful and compelling case.

Cultures on Peru's Central Coast were, no doubt, on the threshold of civilization by 2000 B.C. The size, complexity, and architectural quality of El Paraíso, Río Seco, Las Haldas, Aspero, and other late preceramic sites reveal a highly organized society with corporate management of labor. Textiles, carved gourds, wood and bone carvings, and baked clay objects portend the development of the craft industries for which Peruvian civilization is renowned. Differential treatment of the dead, some accompanied by elaborate grave goods, suggests social stratification.

The sites do not bear evidence of an elaborate fishing technology. The most sophisticated fishing tools are nets and shell fishhooks. As yet, there is no evidence of boats. But, as Moseley (1975) points out, the shoreline environment is rich in seafood resources and, perhaps, could have provided nearly all of the dietary needs of the people who occupied these sites. Only a simple

J. Scott Raymond, Department of Archaeology, University of Calgary, Calgary, Alberta, T2N 1N4 Canada

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technology is required. Indeed, the Peruvian coast, bathed by the cool Humboldt Current, is one of the world's richest fishing areas, particularly the stretch bordering the Central Coast (Osborn 1977). Sea fowl, fish, molluscs, and sea mammals can be taken from shore without great effort.

The huge middens associated with the ancient sites consist mainly of marine products. Mollusc shells constitute the bulk of these middens; bones of sea birds, sea mammals (seals, sea lions, porpoises, and whales), fish, crabs, and tunicates occur in smaller quantities. Vegetal remains are also occasionally preserved: seaweeds, wild tubers from marshy coastal environments, and a variety of cultivated plants. However, plant residues constitute but a negligible part of the food remains (Moseley 1968, 1975).

The sites seem to be situated almost always near good fishing stations, and many are distant from arable land. Particularly notable in this respect are Las Haldas and Río Seco, both of which exhibit monumental architecture and are believed to have housed sizeable populations. El Paraíso (or Chuquitanta), situated a couple of kilometers above the mouth of the Chillon River, is one of the few exceptions.

The evidence in favor of the maritime economic base is weighty. Perhaps it "blatantly" implies, as Moseley says (1975:4-5), that coastal Peruvian civilization was born essentially in the context of a simple fishing technology without significant dependence on agriculture. Nevertheless, I believe that the data and assumptions on which the maritime hypothesis rests deserve further scrutiny.

The following are the main underpinnings of the maritime hypothesis as I understand it: (1) The contents of the middens of the late preceramic sites attest to the primary importance of seafood, mainly shellfish. (2) Evidence of reliance on agriculture is negligible. (This is supported by the contention that there were no staple crops and that water management technology was not advanced sufficiently during late preceramic times to allow cultivation of large tracts of land.) (3) The distribution of the late preceramic sites is indicative of a marine-based economy. (The proximity of the sites to rich fishing resources and, conversely, their distance from arable land and other potential terrestrial food resources is used to support this contention.)

An implicit assumption is that the sites and their contents are reasonably free of any significant bias of preservation.

In the following I shall examine the evidence on which these assumptions rest and suggest that it does not deny the importance of agriculture nor clearly imply the primary dietary importance of seafood. (In an article published as this was going to press, Wilson [1981] reaches similar conclusions based on his calculations of the carrying capacity of the Peruvian coastal waters.) I use the same chronological phase and period designations as Moseley (1975): The Cotton Preceramic period refers to the period between ca. 2500 and 1750 B.C. and is subdivided into the following phases: Pampa, 2500-2300 B.C.; Playa Hermosa, 2300-2100 B.C.; Conchas 2100-1900 B.C.; Gaviota 1900-1750 B.C. The Initial period succeeds the Cotton Preceramic. (The calendrical dates are based on uncorrected radiocarbon ages as interpreted in Patterson and Moseley [1968] and Patterson [1971a].)

MARITIME FAUNAL RESOURCES

One means of investigating the dietary habits of ancient peoples is to study the food residues in archaeological sites. The technique, of course, is not without its pitfalls, and one must take full account of these in order to avoid making gross errors. The most obvious source of error is that food residues are rarely, if ever, preserved in proportion to their relative dietary importance. Bones and shells, for example, stand a far greater chance of surviving the ravages of time than do seeds and roots. For that reason a quantitative study of food remains is likely to be biased in favor of meat products. Plant remains are frequently preserved on the coast of Peru where cool, dry conditions prevail year-round. Nevertheless (see Cohen [1972-1974]; Begler and Keatinge [1979]), the preservation of food plants is capricious, and bias is unlikely to be corrected by even the most sophisticated sampling strategies. For that reason I use food residues only to estimate the dietary contribution of meat and introduce a different procedure to estimate the possible caloric contribution of agricultural produce.

Table 1 gives estimates of the calories (technically kilocalories) represented by the estimated total of the mollusc, fish, bird, and mammal remains contained in five of the principal Cotton Preceramic sites in the Ancón-Chillón area (El Paraíso and the Yacht Club site are not included because of a lack of quantified data). My calculations are based on bone and shell values given by Moseley (1968: Appendices I, J). To avoid slighting the importance of seafood, I have sometimes been extravagant when quantifying the evidence. Where there was a range of values to choose from, I have selected the highest value. Therefore, the values in Table 1 are likely to be close to the maximum number of calories which could possibly be derived from the quantified data.

Biased sampling of each of the sites is a possible source of error. In Moseley's small field project he could not have been expected to obtain a statistically sound representative sample of the refuse from each of the sites, nor did he intend his samples to be manipulated statistically. But, by implication, in deducing the dietary patterns at each site from his excavations he must necessarily have regarded each of his samples as representative of the site as a whole; therefore, I have been obliged to do the same.

In calculating the cal/m^3 for the Tank site, I averaged the values of all three cuts, but at other sites for which there was more than one cut I have used the value for the cut with the greatest proportion of faunal remains. The effect of this should be to give the highest possible estimate of seafood remains. In calculating the volume of each site, I have multiplied the average depth of the preceramic midden (Moseley 1968) by the maximum horizontal dimensions. Again this should give a generous estimate.

Because mollusc shells preserve well in almost any environment, they are likely to give a more accurate estimate of food value than any of the other food remains. In the Ancón-Chillón area, more than eight species of bivalves and five species of gastropods were exploited by the preceramic peoples. Moseley (1968:Appendix I) gives a count of hinge and hinge fragments for the bivalves and of the whole shells or spires for the gastropods. From these data I calculated a minimum number of individual molluscs for each excavation by halving the sum of the bivalve shells and adding the quotient to the sum of the gastropod shells. This is probably a liberal estimate when translated to meat value, since a portion of the rock-perching species may have been empty when collected (Bailey 1975:51).

Lacking information on the average size, meat weight, and caloric value of Peruvian shellfish, I have had to rely on data collected on molluscs from elsewhere in the world (Cook 1946; Cook and Treganza 1947; Munson et al. 1971; Parmalee and Klippel 1974; Bailey 1975). Since these values vary considerably among molluscs according to species and relative age, this may be a source of considerable error in my calculations; but again I have tried to err on the high side. Munson et al. (1971:420) use a weight average of 56 g per mussel; Bailey's (1975:50) oysters range from 2.5 g to 7 g per specimen; and Parmalee and Klippel's (1974) calculations average to 40.3 g with a range

Table 1. Estimates of Calories from Faunal Remains.*

Site	Molluscs ΣCal. (x10^3)	Fish ΣCal. (x10^3)	Birds ΣCal. (x10^3)	Mammals ΣCal. (x10^3)	Total ΣCal. (x10^3)
Tank site	1,270,321	466,200	655,200	1,614,600	4,006,321
Punta Grande	329,605	1,457	19,089	7,432	357,583
Pampa (North)	547,588	21,522	130,722	63,989	763,821
Pampa (Central)	13,480	113	113	113	13,819
Banco Verde	4,527	209	209	1,005	5.950
Camino	13,977	164	747	105	14,993
Total	2,179,498	489,665	806,080	1,687,244	5,162,487

* Based on preceramic occupations only, as reported in Moseley (1968).

between 99 and 7 g for 36 species of freshwater mussels. Considering that there was a wide range in size of the molluscs from the Ancón-Chillón sites (Moseley [1968:163] reports that roughly 1,000 *P. purpuratus* valves are equal in volume to 60 *M. donacium* valves) and that there were high percentages of small molluscs in most of the stratigraphic levels, the value of 100 g per specimen, which I have used in my calculations, should give an exaggerated estimate of the total meat weight, unless, of course, Peru has Texas-sized shellfish. To translate meat weight to calories, I used 100 cal/100 g, a value which exceeds by 30% the highest caloric value which Parmalee and Klippel (1974:Table 4) report for freshwater mussels.

In estimating the meat weight from the fish, fowl, and mammal bones, I have followed the procedure of Cook and Treganza (1956:245–246). Using their figure of 5:100 as the ratio of dry bone weight to fresh carcass weight, I multiplied the bone weight by 20, doubled this figure (again following Cook and Treganza) in an attempt to take account of bone attrition, and then used that value directly as an estimate of the edible meat without subtracting the weight of inedible parts. Chaplin (1971:69–70) and Casteel (1976:119–122) have criticized this technique, but I had no alternative since Moseley reported only the weight of the bones. I used a value of 250 cal/100 g of meat (Cook 1975). That value is high for the fish and fowl (see, e.g., Parmalee and Klippel 1974:Table 4), but the difference should be offset by the sea mammal meat which may be richer in calories.

When converted to meat weight and calories, the faunal data do not bear out Moseley's interpretations. While molluscs overall were the single, most important source of meat during the Cotton Preceramic period, as Moseley asserts (1975:44–45), they actually constituted less than half of the calories (42%) available from meat. Sea mammals, the hunting of which Moseley regards as a minor activity, produced 32% of the meat calories. But at the Tank site, the largest and presumably the most populous of these communities, the caloric value of sea mammals (40%) was apparently greater than that of molluscs (32%). Fish and sea fowl, which Moseley (1975:44) lists as main resources, together constituted a lesser portion of the diet (25%) than did sea mammals. While it is probably correct that the bones of large mammals are more likely to be preserved than are those of birds and fish, thus biasing the sample, such bias should be partly offset by the fact that the 250 cal/100 g meat weight used to estimate calories is liberal for fish and fowl but conservative for sea mammals.

Table 3 converts calories to population estimates. To arrive at these estimates, I used a figure of 2,000 cal as the daily requirement of an individual, multiplied by 365 days to get the annual requirement (730,000 cal), and divided that into the total calories per site to get the man-years. Stretching the seafood resources evenly over the full length of the Cotton Preceramic, 750 years, and assuming that they were the only source of calories, an average population of 9.5 individuals could have been supported per year.

This figure, if accurate, indicates a relatively small caloric contribution made by seafood; however, it is unlikely that the population remained stable throughout this time, so I have attempted to estimate (Table 3) the population that could have been supported entirely by these resources for the final phase of the Cotton Preceramic Gaviota. To do this I have used the information provided by Moseley (1968, 1975) regarding the span of occupation at each of the sites. I have tried to arrive at estimates that favored the largest possible populations during the latter part of the period. For example, I guessed that two-thirds of the preceramic midden at the Tank site and one-half of the Punta Grande midden were deposited during the Gaviota phase. Despite this effort to exaggerate the seafood residues during the time when monumental architecture was first constructed, the paltry annual figure of 26.3 individuals is indicated.

Table 4 turns the question around and gives estimates of the percentage of the diet that could have come from seafood. The population estimates are taken from Patterson (1971a), Moseley (1975), Engel (1967), and Cohen (1977a) (see Table 2). Patterson's estimates are the most detailed and are broken down according to the cultural phases for the Ancón-Chillón area. Cohen's estimates take into account assumed populations in the river valleys, as do Patterson's to a lesser extent. In Table 4 I have made the same assumptions of caloric requirements and length of occupation as in Table 3.

Table 2. Chronology of Cotton Preceramic of Central Coast of Peru and Associated Population Estimates.

			Population Estimates			
Phases	Date* B.C.	Sites	Moseley (1975)	Engel (1967)	Patterson** (1971a)	Cohen** (1977a)
	1750					
		Tank site	750–2,000			
		El Paraíso		1,500		
Gaviota		Punta Grande	150–450			
		Yacht Club				
		Pampa (Central)				
	1900				Σ for Phase: 1,500 (2,000)	3,000–6,000
		El Paraíso				
Conchas		Tank site				
		Punta Grande				
	2100				Σ for Phase: 500 (800)	
		Banco Verde				
Playa Hermosa		Yacht Club				
		Camino				
	2300				Σ for Phase: 300 (400)	
Pampa		Pampa				
	2500				Σ for Phase: 100 (175)	200–300

* Uncorrected, from Patterson 1971a

** Cohen's estimates and Patterson's in brackets take into account Chillón Valley population not represented by any known site(s).

Table 3. Population Calculable from Caloric Estimates of Sea Fauna Remains.

Phase	Total Calories (x10^3)		Mean Annual Calorie Requirement (x10^3)		Years of Occupation		Population Size
Gaviota:*	2,876,846	÷	730	÷	150	=	26.3
All Phases:	5,162,487.8	÷	730	÷	750	=	9.5

* Based on two-thirds of Tank site, one-half of Punta Grande and 100% of Pampa (Central) middens.

These figures are strikingly low. Using the more conservative estimates of Patterson (1971a), seafood fell from a high of 5.2% during the Pampa phase to a low of .1% in the succeeding Playa Hermosa phase and climbed back to 1.8% during the Gaviota phase. However, it must be pointed out that both Cohen's and Patterson's estimates take into account the sizeable population that is supposed to have occupied El Paraíso during Gaviota (in excess of 1,000), the seafood remains from which have not been taken into account in my calculations. But, using the low end of Moseley's (1975:Table 5.1) range of population estimates for the Tank site (750–2,000) and Punta Grande (150–450), seafood comprised no more than 3.3% and 1.1% of the diet, respectively, at each of the sites.

These figures do not bespeak a civilization relying mainly on the sea for its daily bread. Rather, they fit better with the economy of a hunting and gathering people who obtained only part of their livelihood from the sea. Cohen (1971:167) calculates 360 km^2 for the area of the Ancón-Chillón region. This includes a 10-km strip of land north along the coast, 29 km from the mouth of the Chillón (290 km^2), and a section of the Chillón Valley to a point 14 km from the mouth. Assuming a population of 26 during Gaviota (Table 2) and using only the area of the coastal strip (290 km^2), as estimated by Cohen, the poplation density was ca. .09/km^2, a low figure even for hunters and gatherers (cf. Lee and Devore 1968:11).

The most obvious source of bias in these calculations is the lack of information from known but incompletely reported sites: the Yacht Club site and El Paraíso. The Yacht Club site is relatively small, so that even if the seafood remains are more abundant than at any of the sites for which there are quantified samples, it would probably not seriously alter the figures. However, El Paraíso, the largest of these early Peruvian settlements, covering 50 to 60 ha, would significantly increase the caloric estimates were it shown to have an extensive midden rich with sea faunal remains. Engel (1967), who excavated at El Paraíso, reported the existence of shellfish and sea mammal remains together with remnants of land game as well as wild and domesticated plants in the refuse, but he did not quantify these data. However, the site consists of eight or nine architectural complexes; mounds of refuse appear to be composed mainly of stones from the crumbled walls of these units. The middens are shallow, not at all comparable to the deep heaps of garbage in evidence at the Tank site or the other sites along the coastline. Moseley (1975:26) comments on the "surprisingly small" midden in proportion to the size of the site and suggests that much of the architecture served nonresidential purposes.

However, estimates of the population at El Paraíso range from 1,500 (Engel 1967:58) to 4,000 (Cohen 1971:179). If Engel's conservative population estimate is correct and the food remains are as sparse as they seem to be, the amount of seafood on the daily menu of the inhabitants of El Paraíso must have been far below that at the Tank site. Thus it seems safe to guess that adding the quantity of seafood from the middens at El Paraíso and the Yacht Club site to the sum calculated from the other coastal sites would not significantly inflate the figures in Table 1. There may, of course, be other sites, as yet undiscovered or lost to the ravages of time, which I have not taken into account, but these are more likely to be in the Chillón Valley where the river and several thousand years have had a chance to cover them over or carry them away. In any case they would likely bear witness against the case for a maritime economy.

Table 4. Caloric Contribution of Seafood to Annual Diet.

Phase	Site	*Calories Estimated $(x10^3)$	Mean Annual Calories $(x10^3)$	Percent Contribution Based on Population Estimates: Patterson (1971a)	Moseley (1975)	Cohen (1977a)
	Tank site	2,684,235	17,895		3.3%	
Gaviota	Punta Grande	178,791	1,192		1.1%	
	Pampa (Central)	13,819.7	92			
	Total	2,876,845.7	19,179	1.8%		.9%
	Tank site	1,322,086	3,526			
Conchas	Punta Grande	178,791	478			
	Total	1,500,877	4,004	1.1%		
	Banco Verde	5,950.5	47.6			
Playa Hermosa	Camino	14,993.3	119.9			
	Total	20,943.8	167.5	.1%		
Pampa	Pampa (North)	763,821.3	3,819	5.2%		2.6%

* Two-thirds of Tank site and one-half of Punta Grande middens assigned to Gaviota phase; remainder to Conchas.

It would be desirable to have a quantitative estimate of the sea urchins, tunicates, crabs, and other species for which there are no numerical data, for they would no doubt swell the caloric count somewhat. But according to Moseley (1975:44), pinnepeds and sea urchins were only of minor importance. Tunicates were the second most important invertebrate after molluscs (Moseley 1968:162), but in their greatest concentration (Camino level 1) their occurrence was only $20/m^3$ compared to $755/m^3$ for molluscs.

It could be argued that fish and bird bones stand less chance of being preserved than do seashells. By doubling their weight I have probably not compensated sufficiently for their under-representation in the samples. If small fish, such as anchovies, were consumed in quantity, the size of this error could be significant. Also, as mentioned above, my procedure can be challenged on the basis of probable bias in sampling. It is true that a more sophisticated sampling strategy, perhaps a stratified random sampling, would significantly change the quantified data, give greater assurance that they are representative of the occupations as a whole, and thereby at least give the feeling of greater precision in counting the calories. The resulting figures, however, might easily be less than the current ones. In any case the error would have to be of high magnitude to change the proportion of seafood in the diet significantly. For example, if the current estimate of fish remains were too little by a factor of 100, it would only push the percentage of seafood in the diet during Gaviota phase to 12% (using Patterson's low population estimate of 1,500).

PLANT FOODS

Because plant remains are far less likely to be preserved in an archaeological site than are the bones and shells of animals, their importance to a diet is more difficult to appraise (Cohen 1971; Begler and Keatinge 1979). In this case, if the size of the projected populations is correct, then plants were the main source of calories constituting, perhaps, more than 95% of the diet during the Gaviota phase.

In estimating the pre-agricultural population of the Ancón/Chillón region, Cohen (1971:175) has commented on the extreme poverty of the land in comparison to other coastal and riverine environments where the aquatic resources are complemented by rich terrestrial flora and fauna. In coastal Peru the plant foods are found almost exclusively in the river valleys. Ferreyra (Cohen 1971:17, 1978:25) has estimated that wild vegetation may once have covered an area equal to the modern irrigated zone in the Chillón Valley. As Cohen (1978:25) points out, this would no doubt have constituted a rich resource base for the pre-agricultural populations, but mostly at a considerable distance from the sea. With existing data we are not able to say exactly which species lived in these plant communities, nor specify their relative abundance nor estimate their contribution to the diet. But it is unlikely that the deficit of calories could have been made up simply by collecting wild plant foods, although that possibility cannot be ruled out altogether.

Seaweeds are another possible source of wild plant food. Kelp was found in quantity at the Camino site. However, since seaweeds are poor in calories (Lueng et al. 1952:Table 3), they could not have satisfied the requirements of a staple.

Without a heavy reliance on agriculture, then, what were the 1,500-plus inhabitants of the Ancón/Chillón region living on during Gaviota times? This question becomes all the more puzzling if it is asked with particular reference to the supposed 750 sedentary inhabitants of the Tank site who lived 10 km from the nearest section of river valley.

The inference that agriculture was of minimal importance during the Cotton Preceramic is based partly on the contention that there were no staple crops (Moseley 1972:32, 1975:55; Cohen 1977b:260). In a study of plant remains from several sites on the Peruvian coast Pickersgill (1969:52) concluded:

> The plants widespread in cultivation during the preceramic stage did not include any crops fitted to serve as a staple. Beans, squash, achira, chili peppers and guava constituted useful additions to, rather than basic items in, the diet; and throughout the preceramic, people relied on seafood rather than on agricultural

products for their subsistence. However, during the Initial period at least one plant which was capable of developing into a staple spread extensively on the coast; this was maize.

This conclusion rests on two assumptions: (1) that none of these crops could have been a staple, and (2) that during the Initial period maize became a staple among the coastal Peruvians.

The notion that maize was a staple of ancient Peru is rooted in the common belief of archaeologists and anthropologists that any civilized New World society was dependent on maize as its main source of calories. Bronson (1966) has shown that there is reason to doubt this for the Pre-Hispanic Maya, and Murra (1960) has made the point that it was potatoes, not maize, that sustained the highland civilizations of Peru and Bolivia. Maize was important to the Incas, but mainly as a ritual crop, not as a staple. There is little recorded in the chronicles about the agricultural practices of the Pre-Hispanic inhabitants of the Peruvian coast, for the systems did not survive long after the conquest. What little has been recorded is unclear with respect to the staples. Maize and four root crops—manioc, sweet potatoes, achira, and jicama are attested both historically and archaeologically. Jicama is probably too poor in calories to have been a staple. But both manioc and sweet potatoes can match or exceed maize in caloric production per hectare and, as will be shown below, achira is a starch-rich crop and cannot be dismissed as a possible staple.

If the staple during the Cotton Preceramic was a root crop, this would help explain the low frequencies of farmed produce in the middens. Just as the remains of plant foods in general are apt to make a poor showing in comparison to bone and shell, so are root crops likely to be outnumbered by the seed crops in middens in spite of the fact that they might have been far more important. That root crops are fleshy and decay rapidly, that they are usually consumed completely, and that they are often harvested only as they are needed make them poor survivors in comparison to the seed crops with their hardy rinds and shells. Maize, in particular, has achieved immortality by bearing its fruit on inedible cobs which rarely slip the notice of the most near-sighted archaeologist.

Achira, *Canna edulis*, is possibly the most underrated of all the New World root crops. Despite the fact that it commonly occurs with greater frequency than any other tuber in the prehistoric middens of coastal Peru (see, e.g., Cohen 1972–1974:53, 1978:32; Bird 1948:24), it is often forgotten in lists of the food crops and never mentioned as a staple. Of the four root crops noted above, only achira is well documented for the preceramic stage, first occurring at the beginning of the Cotton Preceramic (Cohen 1978:325). Sweet potatoes occur in small quantities during the Gaviota phase at the Tank site and jicama is reported by Engel (1967:62), but not confirmed by a botanist, at El Paraíso. Manioc does not occur at any site until the Early Horizon (ca. 1000 B.C.).

Two species of Canna, *edulis* and *coccinea*, are cultivated today in the West Indies, Australia, South America, tropical Asia, and the Pacific Islands. Mukherjee and Khoshoo (1971:36) report that they are "hardy, easy to grow, require not much care and are more or less free from diseases and pests," qualities which would make them well suited as cultigens for incipient cultivators. In one of the few published agricultural studies of *Canna edulis*, Chung and Ripperton (1924:6) report that in the Waimea district, Hawaii, the average yield is 18–20 tons per acre. It is tolerant of a wide range of soils, thrives at altitudes from sea level to 850 m, and is drought-resistant but can withstand excessive amounts of water in well-drained soils (Chung and Ripperton 1924:3).

Mukherjee and Khoshoo (1971) distinguish a diploid and triploid variety of *Canna edulis* and calculate that the diploid variety yields 3.35% starch and the triploid 12%. Assuming that the studies of Chung and Ripperton are accurate and halving their production figures to be conservative, i.e., 10 tons per acre, we find that the diploid variety would produce about 760 kg of starch/hectare, which converts to about 3.3×10^6 calories per hectare.

Engel (1967:58–59) estimates that 240 ha in the immediate vicinity of El Paraíso could have been farmed with very simple water management techniques. Moseley accepts this estimate but doubts that this is sufficient land to sustain a very large population (Moseley 1968:255, 1972:40, 1975:26). Assuming that the ancient Peruvians were cultivating a strain of achira comparable to the less starchy of the two modern strains and that the land near El Paraíso could produce half the yield of the fields in modern Hawaii, these 240 ha could have produced about 792×10^6 calories. This is enough to meet the annual caloric needs of about 1,085 people and would have supplied 36% of the caloric needs of the Gaviota phase population estimated by Cohen for the Ancón/Chillón area. Assuming further that the area of cultivation could be extended by using flood-plain zones further up the Chillón and through the use of simple water-table farming techniques such as those described by West (1976, 1979), the production of achira might have been considerably larger.

To my knowledge no one has yet made a systematic attempt to estimate the extent of the natural flood plains of any of the coastal Peruvian rivers. But if Ferreyra (Cohen 1971:17, 1978:25) is correct in his speculation that a broad area of the Chillón Valley was forested, there is good reason to suspect that many hundreds of hectares could have been cultivated through simple irrigation and water-table farming, and that a drought-resistant crop like achira would have been well suited to such farming. Moreover, if Singh's (1970:439) guesses prove true, achira would have been particularly tolerant of the saline soils of the coastal river deltas.

Patterson (1971a:320) suggests that maize was present in the Chillón area during the latter part of the Cotton Preceramic. Cohen (1977b:260) and Moseley (1972:32) dispute this, claiming that the earliest evidence for maize does not occur until the end of the Initial period. Despite the lack of direct evidence I am inclined to believe that maize was indeed among the cultigens during the Gaviota phase. It has been documented at sites of comparable age in the Supe, Huarmey, and Culebras valleys to the north, and it seems unlikely that it would take 800 years to diffuse 150 km. However, there is no evidence that it was a staple crop. Maize is more temperamental than achira. It is not tolerant of drought or saline soils. To be productive it requires regular watering and rich soils. It is more easily stored than achira, but more vulnerable to diseases and pests. It is my guess that it was never produced in any quantity in coastal Peru until water management systems were well developed, which, according to Moseley (1975:50), was not until the end of the Initial period in the Chillón Valley.

Cohen (1978:33–34) reports that seven cobs from late Initial and Early Horizon period contexts at the Tank site average 53 mm in length. If these cobs are typical of those grown at that time, maize would not have been a very productive crop. According to Kirkby's study (1973:127) in Oaxaca, which shows that there is a correlation between cob length and productivity, maize with cobs of 53 mm would produce about 234 kg/ha, just above the minimum yield that Oaxacans consider worth harvesting. If these maize plants were grown on the 240 ha next to El Paraíso, they would produce a total of 56 metric tons, enough to sustain about 118 people for a year. This far exceeds the number that could have been supported by seafood but is less than one-tenth of those who might have been supported by achira.

These seven cobs from the Initial period are apparently not atypical of prehistoric maize from the Chillón area. Cohen (1978:33–34) reports that 30 cobs from the Early Intermediate period average to 42 mm long, and 25 from the Late Intermediate period average only 46 mm. These are small samples and ought not be regarded as representative; nevertheless, they do not lend support to the idea that maize was a major food crop. Thus, it seems possible that some of the coastal peoples, like their highland neighbors, used maize primarily as a ritual crop and relied mainly on root crops to fill their bellies. If that is so, the absence of maize in the excavated plant collections from the Ancón/Chillón preceramic sites may be a result of its limited use and not of its absence altogether. Larger samples, taken with a more sophisticated sampling strategy, then, may yield maize cobs. Such evidence may one day be found in the middens at El Paraíso, a likely center for ceremonial activities.

If the lack of a suitable staple was a main factor limiting the dependence on agriculture during the Gaviota phase, what tipped the balance in favor of agriculture during the Initial period? Maize and manioc do not appear in the archaeological record until the end of the Initial period; yet the shift in the pattern of residence from the littoral zones to the valleys at the onset of the Initial period has been attributed to the ascendancy of farming and a desire to reside near arable lands (Moseley 1975:36–37).

LOCATION OF SETTLEMENTS

On the well-founded assumption that people tend to live nearest their principal resources, Moseley (1972, 1975) and Cohen (1977b:260) have interpreted the settlement patterns as further evidence of a marine-based economy. Most of the early sites are situated within a few hundred meters of the shore, and some, most notably the Tank site, Río Seco and Las Haldas, are situated several kilometers from the nearest river valley (Figure 1). Osborn (1977) has taken the locational argument still further and attempted to demonstrate an isomorphic distribution between the sedentary late preceramic settlements, a section of the Humboldt current which is particularly rich in marine life, and the zone periodically affected by the El Niño counter-current. However, no one has attempted to take variations in land forms into account.

The late preceramic sites for which sedentism is claimed lie along the stretch of coast between the Chicama and Omas valleys (8°-13° S). Otuma and other shellmounds have been reported from the region to the south of this, but these are regarded as impermanent settlements (Engel 1957). Likewise, those discovered by Richardson (1968) in the Talara region do not qualify as sedentary communities. The larger of these sites and, presumably, those with the greatest populations, lie in a more restricted section: south of Chimbote (9° S) and north of Lima (12° S) (Moseley 1975:61, Figure 1.1). According to Osborn, the concentration of these settlements in this zone is accounted for by the combined distributions of: (1) phosphorus and plankton-rich waters (7°-15° S); (2) waters with ideal salinity for high marine productivity (6°-13° S); (3) a broad continental shelf (6°-14° S); (4) a zone of ecological instability caused by the El Niño current. The plankton, salinity, and continental shelf combined to create a uniquely bountiful sea, allowing large sedentary populations. He further argues that the sites exhibiting complex architecture were built for the storage and redistribution of goods made necessary by the periodic collapses in the ecosystem brought on by the El Niño.

There are several aspects of Osborn's model which I believe deserve further consideration. First, he provides no direct evidence to show that these favorable offshore conditions did indeed support a fauna in the littoral zone which was rich enough to sustain the projected human populations. Second, he does not show that the productivity of this zone was of sufficiently greater magnitude than that of the adjoining offshore zones north and south to account for such a dramatic difference in population density between these zones. Third, it would appear from his map and his description of the zone that the isomorphism between the boundaries of these propitious conditions and the distribution of the late preceramic settlements is less than perfect: the offshore zone extends 2° N and 1° S of the coastal section where the archaeological sites are found. Why did these people not exploit the resource zone to its full extent?

Fourth, Osborn's model does not seem to explain satisfactorily the complexity of the architecture at some of these sites. To explain El Paraíso as a storage facility built as a hedge against recurring ecological disasters, it would seem that disasters recurred frequently; yet, according to Murphy (1923:71), "extraordinary uniformity is, after all, the outstanding hydrographic feature of the Peruvian littoral," and cataclysmic disturbances such as those caused by El Niño are rare, particularly as far south as the Chillón Valley. Moreover, Osborn does not say what may have been stored at El Paraíso or how it could have been preserved for so long.

There is a closer correspondence between variations in land forms and the distribution of the sites. The section of the coast between the Chicama and the Omas valleys where the settlements have been found coincides almost exactly with that part which has no coastal plain (Figure 1). Composed of alluvial sediments believed to be of Tertiary age, the coastal plain begins at the Ecuadorian border, reaches its greatest width at Punta Aguja, and ends at the Viru Valley. From the Viru Valley south to the Cañete Valley, the foothills of the Andes reach clear to the coast. At Cañete the plain begins again and continues south into Chile, with a short break between the Yauca and Chaparra valleys (Robinson 1964:154-159). From the standpoint of human settlement, the most important aspect of the coastal plain is its effect on the hydrology of the different river valleys which are the source of all irrigation waters.

More than 50 rivers cut across Peru's desert. These vary tremendously in their size, in their

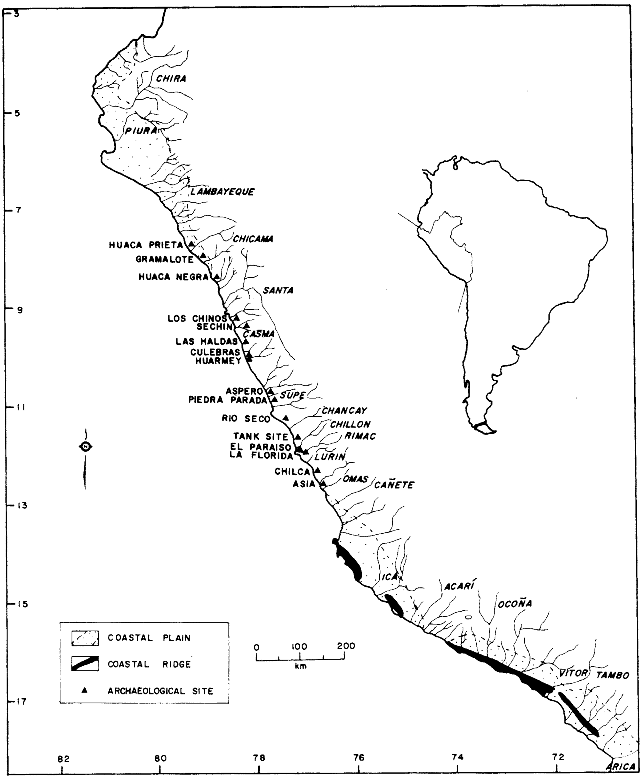

Figure 1. A map of the Peruvian coast, showing the late preceramic archaeological sites in relation to the river valleys and the coastal plain (after Moseley [1975:Figure 1.1] and Robinson [1964:161, 166, 167]).

seasonal flow, and in their drainage patterns. To the south of the Paracas Peninsula the coastal plain becomes progressively higher, reaching an altitude of nearly 1,500 m south of Ocoña. The coastward edge of the plain is rimmed by a low mountain range which plunges into the sea at Paracas. The rivers in this region have cut narrow, steep valleys; they have small, poorly developed floodplains; and the irrigated lands are well inland from the valley mouths. This section comprises 41% of Peru's coastline but contains only 15% of the irrigated land on the coast. Forty-seven percent of that lies in the middle sections of the Ica and Nasca valleys. If the amount of self-irrigating floodplain between this and the rest of the coast were to be compared, the contrast would be still more dramatic. If floodwater farming was an important economic aspect of the late preceramic peoples in coastal Peru, it is little wonder that no substantial sites have been found along this southern part of the coast.

North of Viru lie several river valleys with broad sections of irrigated land. In this region, where the coastal plain is broad but relatively low, the floodplains begin to broaden along the middle courses of the rivers, and the widest and best watered parts are often a good distance from the coast. For example, the Piura, with the largest area of irrigated land, has too little water to irrigate adequately the extensive farmland along its lower course (Robinson 1964:173). The pre-irrigation hydrology of these valleys needs further study, but this present evidence suggests that early agriculturalists would be more likely to settle inland beside the rivers and not near the shore. The effect of this phenomenon would have been greater north of the Chicama Valley where the coastal plain broadens.

The only section of the coast, then, where floodplain farmers might be expected to have lived near the shore is along that part between Chicama and Cañete where orographic conditions favor the development of larger floodplains at the valley mouths. Within this zone the size, character, and location of their settlements can be expected to have responded to hydrological, hydrographical, and geomorphological variables of the sea and the rivers as well as to variations in the character of the shoreline. The interplay of these phenomena is no doubt complex, and much more research is necessary before a locational study can be attempted. But indicative, perhaps, of the potential of such a study is the fact that the Santa Valley, with excellent nearby fishing resources but a negligible floodplain, has no known significant late preceramic settlement, while El Paraíso, the largest of the sites, lies next to the broadest delta.

BIASES IN THE SETTLEMENT DATA

To interpret the distributions of sites, the inadequacies of existing surveying strategies must be taken into account. In coastal Peru there is no doubt that more thorough surveys will turn up additional evidence of late preceramic settlements. The recent discovery of a large preceramic site on the south side of the Supe Valley illustrates this well (Moseley 1975:81). I have already emphasized the wide differences in the expected rates of preservation of animal and plant remains and of different kinds of plant remains. But even greater biases in the data stem from variations in the probable survival of prehistoric settlements themselves.

Cohen (1971:173–174, 1977a:162) and Patterson (1971b:194–197) have both attempted to take into account the probable existence of undiscovered sites in the Chillón Valley dating to the late preceramic period. Cohen estimates that the populations in the Chillón Valley at that time would have been equal to those on the coast. Such reasoning seems sound and ought to be used in interpreting the settlement data from other valleys.

Under even the best conditions for preservation and given the possibility that the importance of agriculture outweighed the importance of fishing, the fishing settlements discovered through archaeological survey can be expected to far outnumber the farming settlements. Situated near the rivers and particularly favoring areas that are likely to be flooded annually, the farming villages would have been lucky to have escaped being washed away or buried. And, as Bennett (1946:74) noted more than 30 years ago, those that survived would likely be destroyed by the expansion of the cultivated area through artificial irrigation or by later and more substantial settlements built right on top of them. Aceramic settlements with houses built of wattle and daub would leave few traces under such circumstances. Even El Paraíso might have been lost had it not been situated on an island of unirrigable land in the vast Chillón-Rimac delta. It is possible that another site equivalent in size or larger than El Paraíso, but not as well protected, lay along the shores of the lower Rimac or the Chancay valleys. Also, the possibility that such a site may underlie later sites, such as La Florida and Garagay, which have yet to be thoroughly excavated, cannot be dismissed. In the smaller valleys, such as the Culebras and Supe, where the edges of the valleys are nearer the floodplain and the chances of torrential floods are less, sites built along the hillsides would stand a better chance of surviving. This fact may account for the survival of Aspero, Piedra Parada, and Culebras.

On the other hand, the fishing villages, built on the rocky headlands or along the beaches in this area of tectonic uplift, would have been subject only to the erosion of the wind and the occasional deluge brought on by an El Niño. The refuse of shells and bones would have accumulated rapidly into a low, dark hill remaining as a monument to the abandoned settlement. It is little wonder that so many have been identified.

CONCLUSION

In the foregoing I have examined the evidence which has been used to support the hypothesis that Andean civilization was built on a maritime economic foundation. The hypothesis, in my opinion, has not stood up well to this scrutiny.

The contents of the midden, when analyzed quantitatively, do not support the conclusion that large sedentary populations were supported by seafood. The caloric values given in the tables are clearly imprecise measures of the calories consumed by the prehistoric peoples. However, I have endeavored to make them as accurate as the data would allow and have aimed at deriving exaggerated caloric estimates. These exaggerated estimates would have to be increased nearly 100-fold to argue from direct evidence that seafood sustained more than a small, nonsedentary, band-level society. This suggests that in coastal Peru, as has been demonstrated elsewhere (cf. Bailey 1975), shells, because they preserve well and are bulky, give a misleading impression of the relative dietary importance of shellfish when they occur in quantity in a midden.

The argument in favor of the primary importance of seafood could still be sustained if one were to assume, as I have done with respect to plant foods, that much of the data has not been preserved. That seems a valid argument were one to assume that vast quantities of small fish were consumed.

To evaluate the accuracy of the estimates of the calories which might have been derived from floodwater farming, it is necessary to know more about the pre-irrigation hydrology of the Chillón Valley and about the productivity and caloric value of prehistoric strains of achira. Still, even taking the probability of error into account, the data indicate that a far larger population could have been supported by agriculture than by exploiting the littoral resources. The estimates are conservative and one would have to reduce them many times to argue otherwise.

The locations of the late preceramic settlements seem, at first, to provide powerful evidence in favor of a marine-based economy. But, when studied with reference to the whole of the Peruvian coast and the distribution of self-irrigating farmland, and when considered in the light of probable biases in the preservation of sites, the settlement pattern data seem to weigh more heavily on the side of agriculture.

While fishing was probably never the mainstay of the Peruvian subsistence economy it was probably a critical ingredient and was no doubt significant in shaping the development of the coastal civilization. When harnessed with an agrarian economy, fishing would have contributed an important array of foods rich in protein and other essential nutrients to complement the calorie-rich plant foods.

To speculate briefly about the implications of the data, I would suggest that as farming systems expanded in the coastal valleys, with a corresponding growth of population and intensification of labor activities, the relative availability of seafood and other meat resources diminished, increasing their economic value. This, in turn, stimulated an intensification of fishing. Once a reliable network for the distribution of farm goods was established, the fishing villages increased in size and were located near the best fishing areas, even if this meant that they may have been several hours away from the nearest farmlands. Paralleling the evolution of the economy, an elite class emerged and gradually co-opted the authority for the redistribution of goods. The elite might be expected to have consecrated their status through the construction of temples, palaces, and monuments. The lower classes, i.e., the farmers and fishermen, dwelt in less conspicuous abodes. If this process began as early as 2500 B.C. on the central coast of Peru, it is not surprising that elite centers on the scale of El Paraíso, Aspero, Las Haldas, Piedra Parada, and Río Seco were built by the beginning of the second millennium B.C. Sites like Huaca Prieta, Cerro Prieto, and the Tank site were probably occupied by people of lower status. The flimsy houses of the farmers, built along the river shores, were soon eradicated by the ravages of time, erasing their presence from the archaeological record.

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