EVIDENCE FOR ENVIRONMENTAL CHANGE AT A COASTAL ARCHAIC SITE, OSTRA, PERU

Elizabeth J. REITZ*

Summary

Vertebrate remains from the coastal Peruvian site of Ostra Base Camp (4550-3050 BC) suggest the marine environment has changed since the site was occupied. At other preceramic coastal Peruvian sites the vertebrate remains are primarily fishes typical of the warm-temperate zone predominate today; however, the Ostra Base Camp collection includes a large number of warm-tropical or estuarine species. This suggests a warm embayment was present near the site in the past, although today the nearest such embayment is 400 km north of the site. Either the coastal waters were warmer than they are today or waters were temporarily entrapped in an embayment and warmed.

Résumé

Mise en évidence des changements environnementaux dans un site côtier archaïque, Ostra, Pérou.

Les restes de Vertébrés mis au jour à Ostra Base Camp, site côtier péruvien (4550-3050 BC) témoignent des modifications survenues dans l'environnement marin depuis que le site a été occupé. Dans d'autres sites côtiers pré-céramiques du Pérou, les restes de Vertébrés sont avant tout des poissons typiques de la zone tempérée chaude qui domine de nos jours, alors que l'échantillon de Ostra Base Camp comprend un grand nombre d'espèces tropicales chaudes ou d'estuaire. Cela laisse supposer la présence d'une baie chaude à proximité du site par le passé, alors qu'aujourd'hui, la baie de ce type la plus proche est à 400 km au nord du site. Les eaux côtières étaient peut-être plus chaudes qu'elles ne le sont de nos jours, ou bien les eaux ont été temporairement retenues dans une baie où elles se sont réchauffées.

Zusammenfassung

Der Nachweis von Umweltveränderungen in einer archaischen Küstensiedlung, Ostra, Peru.

Wirbeltierreste aus der peruanischen Küstensiedlung Ostra Base Camp (4550-3050 BC) belegen, daß sich die Meeresfauna während der Besiedlung gewandelt hat. In anderen präkeramischen Küstensiedlungen Perus stammen die Überreste der Wirbeltiere überwiegend von Fischen, die für die gemäßigte Zone, wie sie auch heute besteht, typisch sind. Hingegen enthält das Inventar vom Ostra Bay Camp eine große Zahl von Arten der Flußmündungen und der tropisch-warmen Breiten. Dies zeigt, daß in der Nähe der Siedlung eine warme Lagune bestanden haben könnte, wobei sich aber heute die nächste 400 km nördlich der Station befindet. Entweder waren die Küstengewässer tatsächlich wärmer als heute oder das Wasser erwärmte sich in Lagunen.

Key Words

Peru, Preceramic, Environmental Reconstruction, Coastal Resources.

Mots clés

Pérou, Pré-céramique, Reconstitution environnementale, Ressources côtières.

Schlüsselworte

Peru, Präkeramikum, Umweltrekonstruktion, Ressourcen.

Although the relationship between humans and their surroundings is complex, faunal assemblages can provide information important to studies of environmental change. An example of this is found in the vertebrate record from Ostra Base Camp, an early Peruvian coastal site. Although today the site is located on an exposed warm-temperate coast, geological and archaeomalacological studies suggest the area was once characterized by a warm-tropical bay (Sandweiss *et al.*, 1983; Sandweiss, 1986). Of particular interest is the presence in the Ostra assemblage of a warm-tropical molluscan complex which is not found near the site today, but is found 400-500 km north of the site (Sandweiss *et al.*, 1983). The vertebrate assemblage to be presented here is also composed largely of warm-tropical species not found near the site today.

Environmental reconstruction is difficult because archaeological deposits reflect both human and non-human responses to a number of factors (Grayson, 1981; Reitz, 1994). Fundamentally, alterations in the distribution of economically important species should be reflected in human

* *Museum of Natural History, University of Georgia, Athens, GA 30602-1882, U.S.A.*

behavior and, therefore, in archaeological assemblages. If trade or domestication are not considered likely mechanisms explaining a species' presence, it seems probable that natural conditions near the site were able to support that species. If conditions near the site cannot support the species today, then it is probable that the environment has changed.

At the same time, humans are not passive in the face of environmental change and archaeological sites are not faithful mirrors of environmental conditions. Archaeological sites reflect the choices made by humans as they select which resources to use or ignore; determine where to live and when; schedule resource use in terms of daily, seasonal, and annual cycles; develop the technologies to acquire and process resources; distribute resources; consume them; and dispose of the unwanted residue. These patterns obscure the relationship between the recovered faunal assemblage, human use of local resources, and the original resource base. However, many patterns of animal use do reflect the environment in which they occur and alterations in long-established cultural patterns may suggest a change in the local environment.

In the following paper, the modern distribution of warm-temperate and warm-tropical vertebrates will be summarized. Then archaeofaunal collections with a warm-tropical complex will be contrasted with those containing warm-temperate animals. These data indicate that the animals used at Ostra are not found near the site today and are uncommon in other preceramic coastal Peruvian collections. This finding will be considered in terms of cultural and environmental explanations.

Resource area

The Peruvian coast is today a cool, barren desert as far north as 5° S. Climate is governed by the north-trending Peru Current, prevailing winds, and the rain shadow of the Andes. During the austral winter, a coastal fog may condense between 200 and 800 meters elevation (Guillén, 1980: 193). Rain normally does not occur on the coast except when associated with recurrent southern oscillations of the Equatorial Counter Current, known as El Niño (Guillén, 1980; Santander, 1980; Handler, 1984). The desert is virtually devoid of plants and animals except where seasonal fog oases, or *lomas*, form during the austral winter, or in coastal river valleys. Most coastal rivers flow only when they are fed by rainfall in the upper valleys. Freshwater fishes are scarce (Eigenmann, 1921). In contrast, a diverse number of marine organisms are supported by nutrients brought to the ocean surface when cold benthic waters rise from the ocean floor due to the interaction of prevailing winds and currents (Briggs, 1974: 137; Santander, 1980).

Estuaries are rare on the Peruvian coast. The narrow coastal plain, steep drop in the continental shelf, and lack of permanent freshwater streams probably limits their formation. Elsewhere, estuaries are characterized by brackish waters, mud flats, oyster bars, salt marshes, and tidal creeks as well as by sounds fed by rivers draining the adjacent coastal plain (Odum, 1971: 352-362). They are dynamic environments in which physical, chemical, and biological features are variable and can change within a few hours (Odum, 1971; Hackney *et al.*, 1976). Estuaries are usually more productive than offshore waters because they trap nutrients and often have year-round photosynthesis (Odum, 1971: 51-52, 354, 357). Hence the role of estuaries as nurseries for many fishes (Schelske and Odum, 1961; Odum, 1971: 356). Commonly, adult fish spawn in the ocean with tidal currents carrying larvae back into the estuary. Juveniles stay in the estuary until mature and then return to the ocean to spawn. Adults of some species may return to the estuary after spawning although adults of other species do not. Some adults live offshore most of the year, but enter estuaries to spawn and their young remain in the estuary until mature. Adults and juveniles of many typical estuarine species may therefore also be found offshore and offshore species may be found in estuaries during at least part of the year because few species spend their entire lives in estuaries.

Today the Peruvian/Ecuadorian coastline (fig. 1) is divided into the warm-temperate Peru-Chilean Province and the warm-tropical Panamanian Province at 3°S or 4°S, in the Gulf of Guayaquil, Ecuador (Briggs, 1974: 42), although others divide the provinces at 6°S (Ekman, 1953: 38). The boundary is formed where the cold, north-flowing Peru Current meets south-flowing warm-tropical waters, deflecting the Peru Current westward away from the South American continent. The Peru-Chilean Province is characterized by warm-temperate waters with localized nutrient upwellings. The Panamanian Province is characterized by tropical waters, mangrove swamps, and extensive estuaries. These provinces correspond with two extensive fishing areas (Chirichigno, 1982). Area 87 corresponds to the Peru-Chilean Province and the Panamanian Province is designated as Area 77. Of specific interest here are Subarea 77C, which extends from 1°38'N to 5°S, and Subareas 87A and 87B. Subarea 77C is primarily the Ecuadorian coast extending down to Paita, Peru. Subarea 87A extends from Paita to Punta Aguja at 6°S. Subarea 87B includes the rest of the Peruvian coast down to 18°20'S while Subarea 87C extends southward along the Chilean coast.

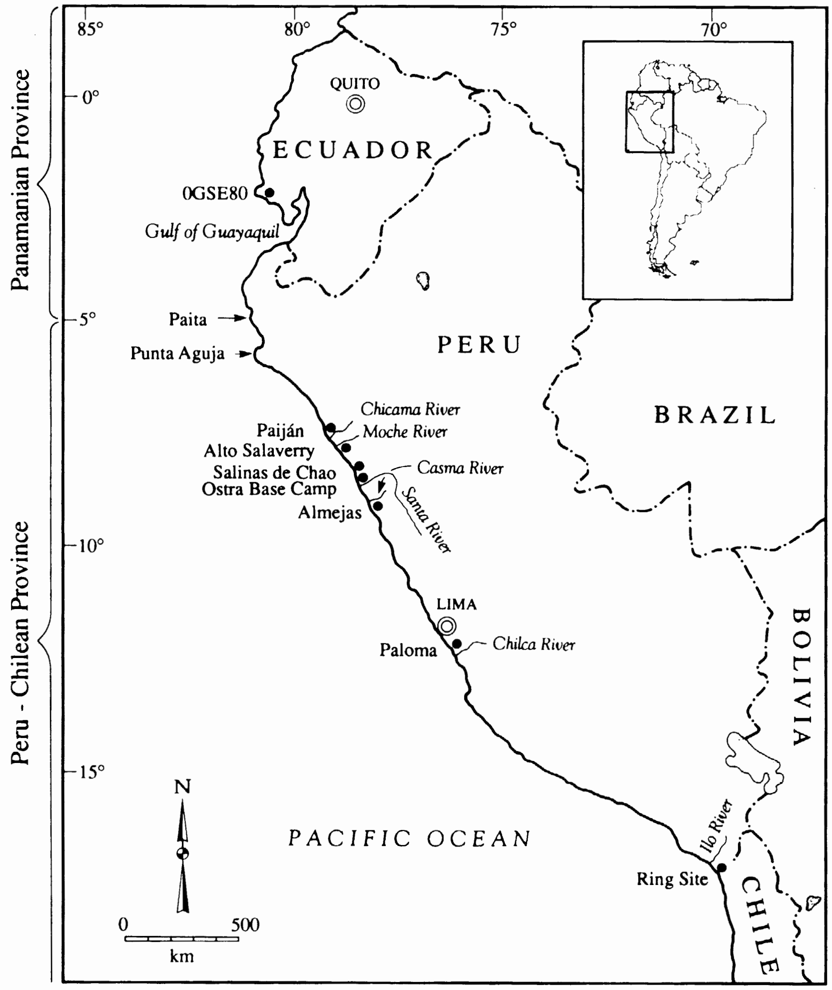

Fig. 1: Map of region.

Table 1: Warm-temperate versus warm-tropical vertebrates, percent MNI, organized by latitude from southern Peru to Ecuador. Note: data are from Sandweiss *et al.* (1989); Reitz (1988a, 1994); Pozorski and Pozorski (1979); Wing (1986) and Byrd (1976). Mixed includes terrestrial mammals, birds, and lizards, as well as marine mammals, birds, sea turtles, sharks, rays, and bony fishes with varied habitat preferences.

	TEMPERATE	TROPICAL	MIXED	MNI	DATE
Ring Site	68%	2%	29%	436	8625-3110 BC
Paloma (Prob. Samples)	83%	1%	15%	132	5750-3050 BC
Ostra Base Camp	30%	53%	17%	144	4550-3050 BC
Alto Salaverry	86%	6%	8%	64	2500-1800 BC
Paiján	0.5%	14%	85%	761	8550-6050 BC
OGSE80	4%	37%	59%	56	6500-5000 BC

Materials and methods

Based on a number of sources (Fowler, 1945; Hildebrand, 1945; Schweigger, 1964; Chirichigno, 1982), vertebrates found in these archaeofaunal assemblages were classified as warm-temperate, warm-tropical, or mixed habitat forms. [See Reitz (1994) for a more extensive discussion]. The most abundant warm-temperate forms are penguins (*Spheniscus humboldti*), boobies (*Sula* sp.), herrings (Clupeidae), anchovies (Engraulidae), and some species of grouper (*Paralabrax* sp.), grunt (*Anisotremus scapularis*, *Isacia conceptionis*), drum (*Paralonchurus peruanus*, *Sciaena deliciosa*, *S. gilberti*), and mackerel (Scombridae). Bonefishes (*Albula vulpes*), sea catfishes (Ariidae), some species of grouper (*Epinephelus* sp.) and grunt (*Conodon* sp., *Haemulon* sp., *Orthopristis* sp.), lisas (*Mugil* sp.), and puffers (*Spheroides* sp.) are the most common warm-tropical taxa in these collections. Several other taxa are typical of warm-temperate waters, but may also be found in warm-tropical settings. These variable species were classified as mixed. Terrestrial animals were also included in the mixed category. None of these species is absolutely restricted to the water condition in which it is classified here.

Ideally a further distinction among warm-temperate, Peru Current, warm-tropical, and estuarine forms would be made. However, three factors make such a distinction overly precise. First, most faunal identifications are to the level of genus only, although most organisms show preferences for specific habitats at the species level. Further, even if we had identifications at the level of species, the lack of life history data for most of these animals precludes drawing precise boundaries. Finally, many species actually may be found in several different water types. For example, although lisa live most of their lives in estuaries, they spawn in open waters and hence may be found both in offshore as well as estuarine waters. At this point only a broad distinction will be made between warm-temperate/Peru Current species and warm-tropical/estuarine species.

All but one of the preceramic sites surveyed are in the warm-temperate region (fig. 1, tab. 1). The Ring Site is located in southern Peru, in a region with only intermittent streams today (Sandweiss *et al.*, 1989) and excavated by D. H. Sandweiss and J. B. Richardson III. Paloma is a village located in the Chilca River Valley (Benfer, 1984). Probability samples from the site were recovered by R. Benfer (Reitz, 1988a, 1988b). Ostra Base Camp is located in the Santa River Valley, formed by one of the largest permanent Peruvian rivers. The Base Camp was excavated by Sandweiss (Sandweiss *et al.*, 1983; Reitz, 1994). Alto Salaverry, in the Moche River Valley, was excavated by S. and T. Pozorski (1979). A group of sites in the Chicama River valley are part of what is thought to be an early hunting complex known as Paiján (Chauchat, 1988). Vertebrate remains from the Paiján sites were excavated by C. Chauchat and studied by E. S. Wing (1986). The closest of the Paiján sites to the present coastline is 14 km and the furtherest is 36 km. In order to contrast the archaeological faunal assemblages from these warm-temperate sites, a vertebrate assemblage from a warm-tropical setting is included. The site of OGSE80, on the Gulf of Guayaquil, Ecuador was excavated by K. Stothert (1985) and the faunal assemblage studied by K. Byrd (1976).

Archaeofaunal evidence for environmental change

There is a strong affiliation of warm-temperate vertebrates with preceramic coastal sites. Warm-temperate taxa comprise between 68 and 84 percent of the individuals from the Ring Site, Paloma, and Alto Salaverry (tab. 1). A distinct and characteristic group of animals dominated by herrings (Clupeidae), anchovies (Engraulidae), and drums (*Paralonchurus peruvianus*, *Sciaena deliciosa*, *S. gilberti)* is found in these preceramic collections. This complex is highlighted by comparison with the Ecuadorian site OGSE80, in which warm-tropical vertebrates, primarily sea catfishes (Ariidae) and lisas (*Mugil* sp.), are much more common than warm-temperate herrings, anchovies, and drums.

The only exceptions to this pattern are the Ostra Base Camp and Paiján assemblages. The Paiján data are complicated by the fact that 74 percent of the individuals were terrestrial reptiles such as snakes and the cañán lizard (*Dicrodon* sp.); fishes constituted only 16 percent of the Paiján assemblage. However 97 percent of these fish were warm-tropical animals, primarily sea catfish and lisa. In the Ostra collection, warm-tropical animals constituted half of the individuals and were primarily bonefish (*Albula vulpes)*, sea catfish, lisa, and puffer (*Spheroides annulatus*). These are estuarine fishes which are usually very minor components of Peruvian faunal assemblages, although members of these families are often abundant in archaeofaunal assemblages where estuaries are common (Wing and Reitz, 1982; Cooke, 1992).

Discussion

The warm-temperate animals common in the Ring Site, Paloma, and Alto Salaverry collections are either very rare in the Ostra Base Camp assemblage or absent altogether. The differences among Paiján, Alto Salaverry, and Ostra, which encompass an approximately 150 km coast line, may indicate there were cultural as well as environmental changes between 6355 BC and 2500 BC. After that time humans turned their attention to warm-temperate taxa for cultural reasons or warm-tropical animals were less common, as the limited modern fisheries data suggest (Chirichigno, 1982).

Among the cultural explanations are the possibility that people at the camp intentionally did not use warm-temperate fish. In particular, cultural evidence related to seasonality, settlement patterns, and technology must be more closely examined. Fishes such as sea catfishes and lisa are likely to have been taken from shallow waters with mass capture techniques such as trot-lines for the catfish and cast nets for lisa. Many of the warm-temperate taxa were more likely taken in deeper waters with more substantial gear, or with gill or seine nets. This change in technology could be related to substantial changes in social organization and division of labor. If we knew more about the seasonal habits of Peruvian fishes, the change from warm-tropical to warm-temperate taxa might indicate a change in the seasonal pattern of exploitation, which in turn might be related to a change in settlement pattern. The difference between the Paiján lizard-hunting complex and the coastal fishing complex in the Ostra materials is particularly intriguing. It is possible that new ethnic groups occupied each site in the chronological sequence described here, each with different dietary preferences, seasonal exploitation patterns, and fishing technologies.

An equally valid possibility is that warm-temperate fish were either so rare that exploiting them was not energetically worth-while or that they were largely absent in the local setting prior to 2500 BC. It is clear that conditions once existed near Ostra Base Camp in which estuarine species such as bonefish, sea catfish, and lisa could be taken in large numbers, a condition which does not exist today.

There are two models reconstructing the coastal environment near Ostra Base Camp. Sandweiss and his colleagues propose a warm, relatively shallow bay with permanent warm water both in the estuary as well as adjacent to it when the camp was occupied (Sandweiss *et al.*, 1983; Rollins *et al.*, 1986). Lowered sea levels influenced the offshore currents such that the cold, northward flowing Peru Current may have turned westward south of the Santa River, leaving warm-tropical waters a persistent feature of the coast 400 km further south than they are today. The warm-tropical fauna associated with these waters shifted north to their modern location when these warm-tropical waters shifted northward and were replaced by warm-temperate waters about 3000 BC. Ostra itself was abandoned before this occurred when a coastal uplift closed the bay. The Ostra faunal materials do not reflect the change from warm-tropical to warm-temperate species but rather testify to the persistence of warm-tropical conditions in this area prior to the uplift (Sandweiss *et al.*, 1983; Sandweiss, 1986).

An alternate explanation is that warm-tropical animals may only represent locally distinct, isolated populations (DeVries and Wells, 1990). According to this model, although bay waters were locally warmed; offshore waters were cold, as they are today. Warm-tropical animals may have reached the area as an intrusive fauna borne along by the occasional southward oscillation of the Equatorial Counter Current, and been trapped in the bay. The bay supported these thermally-anomalous populations because its shallow waters were warmed by the sun while the bay was isolated from the open ocean by beach ridges which did not permit cold waters to intrude.

Although the Paiján-Ostra-Alto Salaverry sequence probably means that over the course of four millennia, estuarine-like settings between 8°S and 9°S slowly were infilled, uplifted, or otherwise became rare, these data do not necessarily indicate that the adjacent coastal waters were permanently warm. The Paiján data clearly indicate that warm-tropical vertebrates were not restricted just to the bay near Ostra. However, some members of the warm-tropical complex, such as sea catfish, manage even today to live as far south as the Chilean border, where the coastal waters are not tropical. Further, many members of the warm-tropical group move in and out of estuaries as part of their life cycle and consequently might be found in limited numbers in less-than-ideal water conditions.

The sequence could mean that coastal waters did gradually cool, either as part of the process by which estuarine-like settings were lost or independently. There is some evidence suggesting that coastal as well as estuarine waters did cool at an embayment at Salinas de Chao, 15 km north of the Santa valley (Sandweiss *et al.*, 1983). The earliest site associated with this bay, Site B, has a series of dates which range from 2770 to 1975 BC, roughly contemporary with Alto Salaverry. Site B was probably occupied before the Chao bay was uplifted; but the invertebrate assemblage has only cold-water molluscs typical of the species found in the area today. Thus, a warm-temperate invertebrate complex, rather than a warm-tropical one, was present at a site with an active bay about 500 years after Ostra Base Camp was abandoned. A change in coastal water temperatures is also suggested by the dominance of warm-temperate vertebrates at Alto Salaverry even though a bay was also present there.

A stronger case could be made for warmer coastal waters during the early part of the preceramic sequence if a warm-tropical complex is found at a preceramic site at the mouth of an intermittent river drainage where an estuarine-like setting was either lacking or not well-developed. This would further suggest that warm-tropical animals were at one time more common in this area rather than locally abundant in pockets of warm bay waters. It would also be useful to examine vertebrate remains from sites where a bay was present but the invertebrates suggest warm-temperate conditions, such as Chao Site B. However, we must remember that some warm-tropical animals may be found in warm-temperate waters, albeit in lower numbers. Whatever explanations for these changes in marine resource use must also accomodate evidence that the terrestrial desert environment does not appear to have altered considerably over this period of time.

Conclusions

Recent weather patterns in North America remind us that the consequences of the Equatorial Counter Current's oscillations are not confined to the Peruvian coast. In some cases many of the brief changes associated with El Niño are on the same order of magnitude as the consequences of global warming predicted for the coming century. It is, therefore, important to determine if the warm-tropical waters associated with the Equatorial Counter Current recently occupied a more southerly location for a prolonged period of time. It is also important to explore the consequences of that phenomenon, not only along the Peruvian coast, but throughout the hemisphere. Whatever the explanation, the archaeofaunal record from the Peruvian coast does document a substantial change in resource use during the preceramic period. This change was not so much a shift from terrestrial hunting to marine fishing, as some have suggested, but a shift from using a warm-tropical to a warm-temperate marine complex.

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