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FISHING ON THE FRONTIER: VERTEBRATE REMAINS FROM AMOTAPE, SICHES, AND HONDA PHASE OCCUPATIONS AT SITIO SICHES (PV 7-19), PERÚ

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FISHING ON THE FRONTIER: VERTEBRATE REMAINS FROM AMOTAPE, SICHES, AND HONDA PHASE OCCUPATIONS AT SITIO SICHES (PV 7-19), PERÚ

Elizabeth J. Reitz,[1] Daniel H. Sandweiss[2], and Nicole R. Cannarozzi[3]

ABSTRACT

This study provides zooarchaeological data and interpretations of cultural and environmental changes between ~10,700 and 5200 cal B.P. by comparing diachronic trends within a single coastal site (Sitio Siches) with synchronic trends across multiple coastal sites in different, adjacent ecological regions. Sitio Siches (PV 7-19), located at 4° 24.7' S on the Pacific coast of Perú, is a stratified site with an occupational sequence extending from the Early to the Later Preceramic period. Radiocarbon dates divide the occupation into three cultural phases: Amotape (9500–9000 ^{14}C B.P./~10,700–10,100 cal B.P.), Siches (7100–6000 ^{14}C B.P./~7900–6800 cal B.P.), and Honda (5150–4550 ^{14}C B.P./~5800–5200 cal B.P.). The total Sitio Siches assemblage contains 27,180 vertebrate specimens (NISP) and the remains of an estimated 2,759 minimum number of non-human vertebrate individuals (MNI). Marine vertebrate individuals dominate the assemblage. A temporal trend within the assemblage suggests changes in fishing strategies that may reflect changes in marine conditions. These measures are variable within the Siches-phase occupation, likely reflecting responses to environmental and cultural transitions between 7100 and 6000 ^{14}C B.P. Overall the results show that people living at the site during the Amotape phase experienced warm marine waters. During the Siches phase, coastal waters were even warmer, an interpretation consistent with isotopic values in sea catfish otoliths. Variations in fishing strategies during the Siches phase may be responses to sharper annual or seasonal fluctuations in Sea Surface Temperature than were experienced during the Amotape or Honda occupations. The Amotape collection from Sitio Siches offers a glimpse of an early fishing tradition on the northern coast of Perú. The Honda collection reflects modern conditions at the frontier between the Peru-Chilean and Panamanian provinces. A comparison of Sitio Siches with other vertebrate assemblages from within the Peru-Chilean province finds broad similarities among assemblages at similar latitudes throughout the province. This suggests that the patterns observed in these assemblages are not due exclusively to cultural dynamics, but also reflect larger environmental patterns influencing the economies of all human communities in the region.

Key words: Sitio Siches, Peruvian coast, climate change, vertebrate zooarchaeology, Preceramic period, fishing strategies.

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INTRODUCTION

Archaeological studies of early- and mid-Holocene coastal environments of Perú shows that this period was more dynamic than once thought (e.g., Sandweiss et al., 1996, 2007; Fontugne et al., 1999; Reitz, 2001; Reitz and Sandweiss, 2001; Andrus et al., 2002; Richardson and Sandweiss, 2008; Carré et al., 2014). This is particularly evident in archaeological materials excavated from sites south of 5° S latitude, in what is today a warm-temperate water regime dominated by the Peru Current and subject to occasional El Niño/Southern Oscillations (ENSO; Fig. 1; Tables 1–2). These studies also demonstrate that a regional economy based on marine resources flourished along the coast at least from the Late Pleistocene, that subsequent societal developments reflect ecological as well as cultural influences, and that the modern resource base prevailing today was established ca. 5000 ^{14}C B.P. (5700 cal B.P.).[1]

Although evidence for a regional economy and a dynamic early- and mid-Holocene environment is strong, zooarchaeological data are limited for stratified sites bridging the transition from the Late Pleistocene ecological regime to the modern one (ca. 10,000–5000 ^{14}C B.P. [11,400–5700 cal B.P.]). Sitio Siches (PV 7-19), located at 4° 24.7′ S on the Pacific coast of northern Perú, contains a stratigraphic sequence of archaeological materials deposited between 9500 and 4550 ^{14}C B.P. (~10,700–5200 cal B.P.). These materials offer the opportunity to: (1) study fishing strategies on the north coast during the early- and mid-Holocene

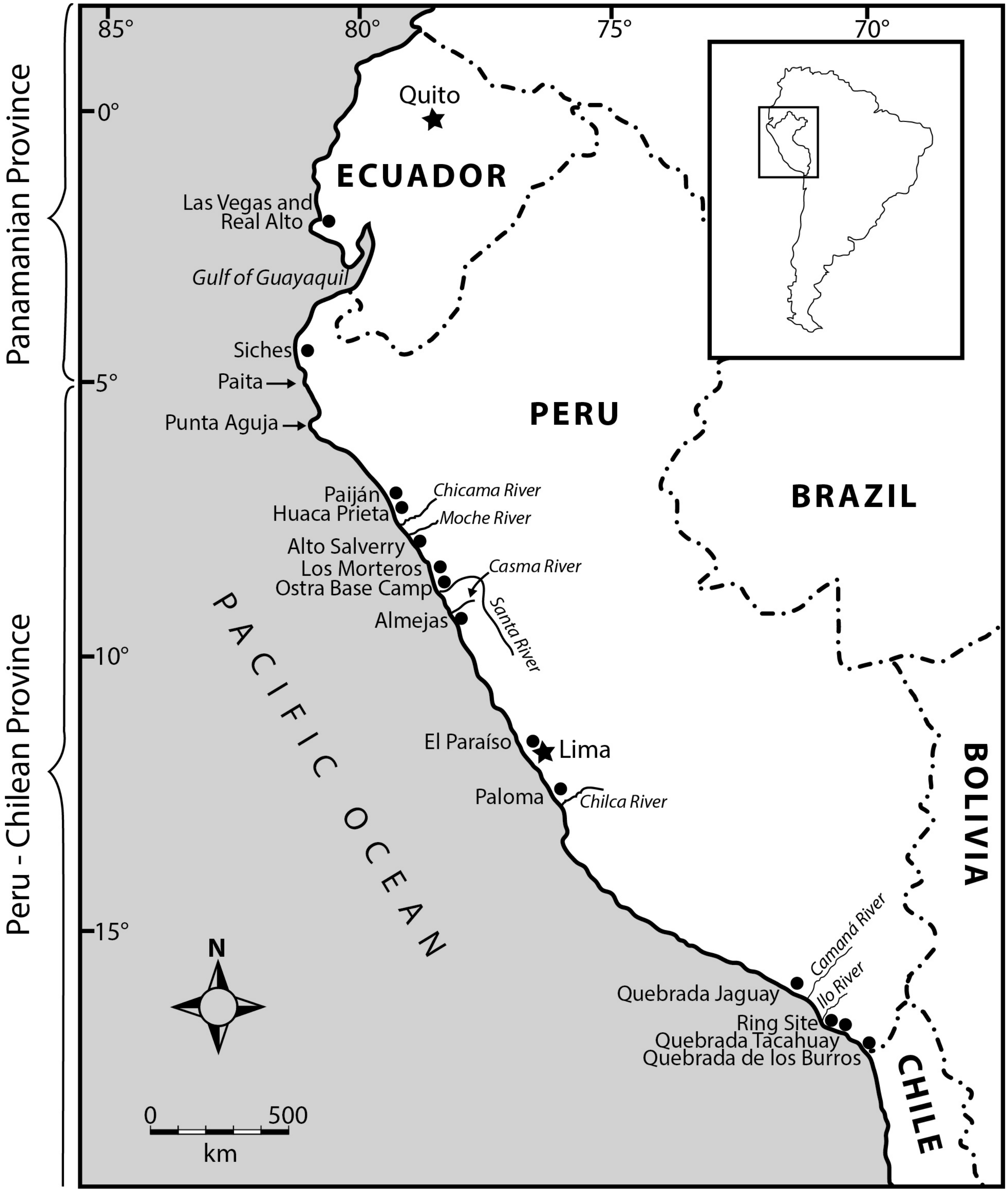

Figure 1. Map of study region. Stars denote modern cities, dots denote archaeological sites.

using vertebrate remains recovered from stratified deposits and (2) correlate these strategies with environmental and cultural transitions. We elaborate here on our previous assessments of fishing strategies and other aspects of cultural life in a changing environment using additional and revised data from Sitio Siches which strengthen our arguments for cultural and environmental dynamism

Table 1. Information about sites referenced in the text. No ^{14}C dates are available for Alto Salaverry, which is dated by association with similar sites and artifacts. The date for Las Vegas does not include earlier, Pre-Vegas deposits, which are not included in these faunal samples. Age ranges are from the means of oldest and most recent ^{14}C dates where available, discounting outliers rejected by the excavators. Calibrated dates were run using Calib 7.1 (Stuiver and Reimer, 1993), SHcal13 curve (Hogg et al., 2013), and rounded to nearest 100 years. The 10,575 date for the Ring Site is a shell date calibrated using http://calib.org/marine/.

Province and Site	Deposit dates, ^{14}C B.P.	Deposit dates, cal B.P.	References
Southern Peru-Chilean Province (17°–12° S)			
Quebrada Jaguay, Sector II (16° 30′ S)	10,867–10,250	12,700–11,900 (12,000 from short-lived samples)	Sandweiss et al., 1998; McInnis, 1999; Sandweiss, 2014; Jones et al., 2017; Reitz et al., 2017
Ring Site (17° 40′ S)	10,575 (marine); 8755–5060	9800–5800	Sandweiss et al., 1989; Reitz et al., 2015; Reitz et al., 2016; Reitz et al., 2017
Paloma (Probability samples) (12° 25′ S)	7735–4780	8500–5500	Benfer, 1984; Reitz, 1988a, 1988b, 2003
Northern Peru-Chilean Province (10°–8° S)			
Paiján (10° S)	10,380–8260	12,200–9200	Lumbreras, 1974:28; Chauchat, 1976, 1978, 1988, 1992; Wing, 1986
Almejas (6.35 mm fraction) (9° 40′ S)	7000	7900	T. Pozorski and S. Pozorski, 1984, Reitz, 1995; S. Pozorski and T. Pozorski, 2003
Ostra Base Camp (8° 55′ S)	6250–5450	7100–6200	Sandweiss et al., 1983; Sandweiss et al., 1996; Reitz, 2001; Reitz and Sandweiss, 2001
Alto Salaverry (8° 10' S)	4450–3750	5000–4000	Pozorski, 1976; S. Pozorski and T. Pozorski, 1979
Panamanian Province (4°30′–2° S)			
Las Vegas (OGSE80) (2° 14′ S)	10,000–6600	11,400–7500	Byrd, 1976, 1996; Chase, 1988; Stothert, 1988
S. Siches, Amotape Phase (4° 25′ S)	9500–9000	10,700–10,100	Richardson, 1973, 1978; Richardson et al., 1996; Sandweiss, 2003
S. Siches, Siches Phase (4° 25′ S)	7100–6000	7900–6800	Richardson, 1973, 1978; Richardson et al., 1996; Sandweiss, 2003
S. Siches, Honda Phase (4° 25′ S)	5150–4550	5800–5200	Richardson, 1973, 1978; Richardson et al., 1996; Sandweiss, 2003
Real Alto (2° 23 ′ S)	Middle Valdivia		Byrd, 1976, 1996

(Sandweiss et al., 1996, 1997; Andrus et al., 2002).

A dynamic relationship exists among humans as biological and cultural organisms, the environments in which they live, and archaeological deposits. Human economies reflect the environments in which they occur and alterations in long-established fishing habits at coastal sites may be evidence of cultural responses to changes in those environments. Cultures and environments change for many interrelated and complex reasons. Some of these changes may be stimulated primarily by human behavior. For example, a new technology might influence which resources are used or which resources are preferred or shunned. Likewise, non-anthropogenic factors, such as a change in coastal topography after a storm, may alter the availability and behaviors of economically important plants and animals. Evidence for these changes are recorded in archaeological assemblages, though it may be difficult to determine which is cause and which is a consequence. The case for environmental change is strengthened if a corpus of changes is observed in the biological remains recovered from a site over time or from several sites within a region.

In the case of Sitio Siches, changes in local use of fishes preferring warmer or cooler waters could indicate a cultural change or a change in fish availability due to altered coastal water conditions. A patterned shift among groups of indicator animals, instead of in just one or two species, is more likely to represent changes in availability than changes in human tastes or choices. A review of published data from the region shows changes in ecological groups of indicator vertebrates recovered from Peruvian and Ecuadorian coastal sites located between 17° S and 2° S latitude and occupied between 10,867 and 3750 ^{14}C B.P. (~12,700–4000 cal B.P., or 12,000–4000 cal B.P. using the most accurate Quebrada Jaguay dates; Figs. 1–2; Tables 1–2; Sandweiss et al., 1996; Reitz, 2001; Andrus et al., 2002; Reitz et al., 2015; Jones et al., 2017).[2]

Faunal assemblages from sites located between 17° S and 12° S latitude show a persistent focus on cool-water vertebrates. Vertebrate assemblages from sites located between 10° S and

Table 2. Percentages of the Minimum Number of Individuals (MNI) from warm-water and cool-water ecological groups as a percentage of MNI classified to these two groups; organized chronologically within each province.

Province and Site	% Warm-water	% Cool-water	MNI
Southern Peru-Chilean Province (17°–12° S)			
Quebrada Jaguay, Sector II (16° 30′ S)	0.5	99.5	210
Ring Site (17° 40′ S)	3.6	96.4	308
Paloma (Probability samples) (12° 25′ S)	1.8	98.2	112
Northern Peru-Chilean Province (10°–8° S)			
Paiján (10° S)	96.5	3.5	113
Almejas (6.35 mm fraction) (9° 40′ S)	53.5	46.5	86
Ostra Base Camp (8° 55′ S)	64.2	35.8	120
Alto Salaverry (8° 10′ S)	6.8	93.2	59
Panamanian Province (4°30′–2° S)			
Las Vegas (OGSE80) (2° 14′ S)	93.9	6.1	49
S. Siches, Amotape Phase (4° 25′ S)	83.3	16.7	12
S. Siches, Siches Phase (4° 25′ S)	87.7	12.3	701
S. Siches, Honda Phase (4° 25′ S)	82.6	17.4	258
Real Alto (2° 23′ S)	98.3	1.7	175

Note: See Table 1 for references and Figure 1 for site locations. MNI in this table does not include mixed-water or terrestrial individuals. For the total MNI in each assemblage see Table 4. Sitio Siches data exclude anchovies and Pozo II.

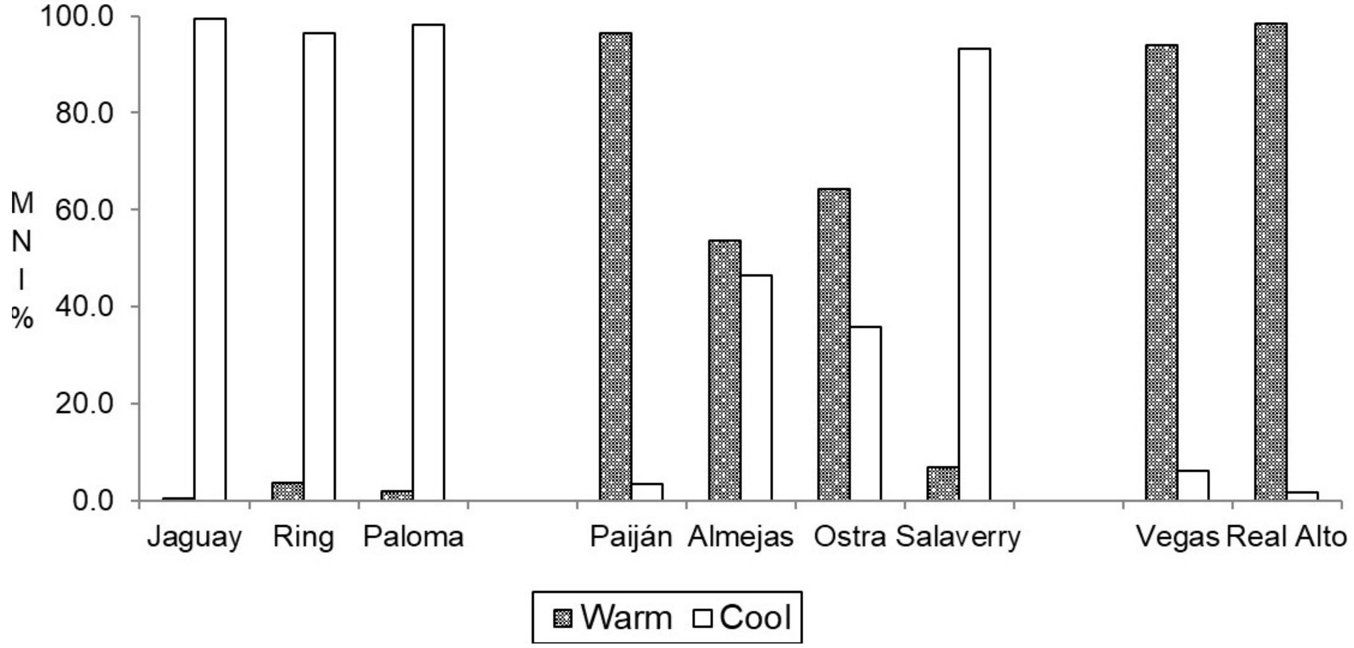

Figure 2. Percentages of vertebrate individuals (MNI) in warm-water and cool-water ecological groups in some coastal Peruvian and Ecuadorian zooarchaeological assemblages. Sites arranged chronologically within the southern Peru-Chilean Province, the northern Peru-Chilean Province, and the Panamanian Province reported in Table 1. See Figure 1 for locations.

8° S latitude show a shift from animals associated with warm waters to those preferring cool waters (Fig. 2). Vertebrates from Ecuadorian sites between 4°30′ and 2° S latitude suggest an early emphasis on warm-water animals persisted, perhaps intensifying over time. Based on the Sitio Siches data reported here, we propose a climate history for the Sitio Siches with two climatic transitions: an early transition between cooler and warmer conditions ca. 10,000–9,000 ^{14}C B.P. (~11,400–10,100 cal B.P.) and a later transition to mixed water conditions, trending to the cool side, occurred ca. 6000–5000 ^{14}C B.P. (~6800–5700 cal B.P.). The latter transition, at least, also seems to characterize sites between 10° S and 8° S latitude.

Several lines of evidence contribute to this study. The first line of evidence lies in the specific characteristics of the resource area, particularly modern biogeographical differences between a warm-temperate Peru-Chilean province and a warm-tropical Panamanian province (e.g., Briggs, 1974:42; Fig. 1). These differences are used to classify vertebrates found in archaeological contexts into terrestrial, warm-water, cool-water, and mixed-water ecological groups. These four ecological groups are described broadly in the text. Additional biological, ecological, and, when available, cultural aspects of these animals are summarized in Appendix 1. These ecological groups are used to summarize data from nine published, quantified zooarchaeological studies of coastal assemblages representing over 30 years of research in which zooarchaeological materials were compared to reference specimens of known identity (Tables 1–2). These studies constitute a large sample with good taxonomic resolution, allowing our study of Sitio Siches to sit within a regional corpus of similar studies. The review of these legacy zooarchaeological studies is followed by an introduction to Sitio Siches, the field methods used to excavate the site, the site's occupational sequence, and the zooarchaeological methods used in the Sitio Siches study. Finally, the results for each cultural phase at Sitio Siches are placed within the broader cultural and environmental context of life on the frontier between the warm-temperate Peru-Chilean and warm-tropical Panamanian provinces.

RESOURCE AREA

Today the Peruvian coast is a cool, barren desert as far north as 5° S latitude (Guillén, 1980; Santander, 1980; Handler, 1984). It seldom rains on the coast except during southern migrations of the warm Equatorial Counter Current associated with ENSO. The desert is virtually devoid of plants and animals except where seasonal fog oases (*lomas*) form during the austral winter and in coastal river valleys. Most coastal rivers flow only when it rains in the highland headwaters of the valleys, though some rivers are partially fed by glacial meltwater. Freshwater fishes and terrestrial vertebrates are scarce (Eigenmann, 1921; Grimwood, 1969; Eisenberg and Redford, 1999). Shallow warm bays with brackish waters are rare, but not unknown. In contrast, an abundant and characteristic group of marine organisms is supported by nutrients brought to the ocean surface by cold benthic waters rising from the ocean floor in response to prevailing winds and currents, the upwelling associated with the Peru Current (Briggs, 1974; Santander, 1980).

Biogeographers divide modern coastal waters into a warm-temperate Peru-Chilean province and a warm-tropical Panamanian province at 3° or 4° S latitude, just south of the Gulf of Guayaquil (e.g., Briggs, 1974:42; Fig. 1). Others place this boundary at about 6° S latitude, near Punta Aguja (e.g., Ekman, 1953:38). The boundary is formed where the cold, north-flowing Peru Current meets south-flowing, equatorial waters, deflecting the Peru Current westward away from the South American continent. Although technically referred to as "warm-temperate," the waters of the Peru-Chilean province are cold by comparison to the warmer waters of the Panamanian province. The Peru-Chilean province is characterized by localized nutrient upwellings that contrast with the mangrove swamps and extensive estuaries of the Panamanian province.

As with most biogeographical boundaries, this one is not impermeable and animals typical of one province are found in others, though often in lower numbers or only periodically (Chirichigno, 1982). Transition zones are frontiers between biogeographic provinces and characterized by gradients in environmental parameters such as temperature, dissolved oxygen, salinity, turbidity, and productivity (e.g., Scartascini, 2017).

DEFINING ECOLOGICAL GROUPS

Animal use by people is associated with many environmental and cultural factors operating on different scales (e.g., topography, seasonality, ecosystem productivity, social affiliations, trade, scheduling conflicts, technology), but one of these is local availability. A preference for using local resources facilitates interpreting temporal and spatial variability in the archaeological record from the perspective of environmental change at a specific site.

Analysis of animal remains from Sitio Siches relies on the modern distributions of warm-tropical (henceforth referred to as warm) and warm-temperate (cool) vertebrates derived from the biological literature (Table 3; Appendix 1; Fowler, 1945; Hildebrand, 1946; Schweigger, 1964; Chirichigno, 1974, 1982; Froese and Pauly, 2004). These vertebrates form one terrestrial and three marine groups that we use to summarize vertebrate data from nine coastal zooarchaeological assemblages and to establish a zooarchaeological context within which to consider these same ecological groups in the Sitio Siches assemblage.

The prevalence of habitat and niche preferences among animals represented in archaeological assemblages permits us to assign vertebrates recovered from archaeological sites to these groups (Table 3; Appendix 1; Kenward and Hall, 1997). Kenward and Hall (1997:665, italics in the original) define an indicator taxon as "*...one which reliably carries the implication of the occurrence of some event, activity, or ecological condition in the past*" and an indicator group as "*...a natural grouping of organisms selected because it includes a range of stenotopic species which together encompass a wide spectrum of ecological conditions or human activities relevant to the aims of the study being carried out.*" In the following pages four indicator groups, here referred to as ecological groups, are used: warm-water, cool-water, mixed-water, and terrestrial. Except for terrestrial animals, membership in each group is largely defined by preferences

Table 3. Classification of animals to ecological groups.

Vernacular name	Taxonomic name
Terrestrial taxa	
Opossum	*Didelphis* sp.
Anteater	*Tamandua tetradactyla*
Spider monkey	*Ateles* spp.
Rabbit	*Sylvilagus* cf. *brasiliensis*
New World rats, mice	UID Rodent, Sigmodontinae, *Akodon* sp., *Oryzomys* spp., *Phyllotis* sp., *Sigmodon* sp.
Viscacha	*Lagidium peruanum*
Fox and other canids	Canidae, *Lycalopex* cf. *sechurae*
Raccoon	Procyonidae
Weasel	*Mustela* sp.
Puma	*Puma concolor* (formerly *Felis concolor*)
New World camelid	Camelidae, Lamini, guanaco
Deer	Cervidae, *Odocoileus virginianus, Mazama* sp.
Pigeon, dove	Columbidae
Macaw, parrot	Psittacidae
Passerine bird	Passeriformes, Corvidae, Mimidae
Freshwater turtle	Emydidae
Lizard	Iguanidae, *Tropidurus* sp., Teiidae, *Dicrodon* sp., *Callopistes flavipunctatus*, Gekkonidae
Snake	Colubridae, *Boa constrictor* (formerly *Constrictor constrictor*), *Drymarchon corais*, Viperidae, *Bothrops* sp.
Frog, toad	Anura, Bufonidae, Ranidae
Warm-water taxa	
Ladyfish	*Elops affinis*
Bonefish	*Albula vulpes*
Sea catfish	Ariidae, *Bagre* spp., *Galeichthys peruvianus*
Toadfish	Batracoididae, *Batrachoides* sp.
Mullet	*Mugil* spp.
Snook	*Centropomus* spp.
Grouper, sea perch	*Epinephelus* spp., *Hemanthias peruanus*
Jack	*Caranx* spp., *Oligoplites* spp., *Selene* spp.
Snapper	Lutjanidae, *Lutjanus* spp.
Mojarra	Gerreidae, *Eucinostomus* spp.
Grunt	*Conodon* spp., *Haemulon* spp., *Orthopristis* spp.
Porgy	Sparidae, *Calamus brachysomus*
Drum	*Bairdiella* spp., *Cynoscion* cf. *analis*, *Cynoscion* cf. *stolzmanni*, *Larimus* cf. *acclivis*, *L.* cf. *effulgens*, *L.* cf. *pacificus*, *Micropogonias* spp., *Odontoscion* spp., *Ophioscion* spp., *Umbrina* cf. *xanti*
Pococho	*Nicholsina denticulata* (formerly *Xenoscarus denticulata*)
Sleeper	Eleotridae
Puffer	*Spheroides annulatus*

Table 3. Continued.

Vernacular name	Taxonomic name
Cool-water/Peru Current taxa	
Marine otter	*Lontra felina*
Great grebe	*Podiceps major*
Inca tern	*Larosterna inca*
Humboldt penguin	*Spheniscus humboldti*
Shearwater	Procellariidae, *Macronectes giganteus*
Diving petrel	Pelecanoididae, *Pelecanoides garnotii*
Booby	*Sula* spp.
Black-created buzzard eagle	*Geranoaetus melanoleucas*
Eagle ray	Myliobatidae, *Myliobatis* spp.
Anchovy	Engraulidae, *Anchoa* spp.
Herring	Clupeidae
Merluza	*Merluccius* spp.
Cusk eel	*Genypterus maculatus*
Cabrilla	*Paralabrax* spp.
Jurel	*Trachurus murphyi*
Sargo	*Anisotremus scapularis*
Cabinza	*Isacia conceptionis*
Drum	*Corvina deliciosa* (formerly *Sciaena deliciosa*), *Cilus gilberti* (formerly *Sciaena gilberti*), *Paralonchurus* spp.
Morwong	Cheilodactylidae, *Cheilodactylus* spp.
Wrasse	Labridae, *Bodianus* spp., *Pimelometopon* spp.
Rollizo	*Pinguipes chilensis* (occasionally *Mugiloides chilensis*)
Chalapo	*Labrisomus philippii*
Mackerel	Scombridae, *Euthynnus* spp., *Sarda* spp., *Scomber* spp., *Scomberomorus* spp., *Thunnus* spp.
Palmera	*Seriolella violacea* (formerly *Neptomenus violacea*)
Mixed-Water Taxa	
Sealion	Pinnipedia, Otariidae, *Otaria flavescens* (formerly *O. byronia*)
Whale, dolphin	Mysticeti, Delphinidae
Duck	Anatidae
Rail	Rallidae
Sandpiper	Scolopacidae
Gull	Laridae, *Larus* spp.
Sooty shearwater	*Puffinus* cf. *griseus*
Cormorant	*Phalacrocorax* spp.
Pelican	*Pelecanus* spp.
Heron	*Ardea cocoi*
Sea turtle	Cheloniidae
Shark, ray	*Rhiniodon typus*, Carcharhinidae, *Mustelus* sp., Rajiformes, *Rhinobatos* spp., Dasyatidae
Eel	Anguilliformes, Muraenidae
Sea bass	Serranidae

Table 3. Continued.

Vernacular name	Taxonomic name
Jack	Carangidae, *Seriola* spp., *Trachinotus paitensis*
Grunt	Haemulidae
Drum	Sciaenidae, *Cynoscion* spp., *Menticirrhus* spp., *Stellifer* spp.
Sea chub	Kyphosidae, *Kyphosus* spp.
Spadefish	*Chaetodipterus zonatus*
Flounder	Pleuronectiformes, Bothidae, *Paralichthys* spp.

Note: Taxonomy reflects attributions made during the original zooarchaeological study except when the currently valid spelling or epithet is clear. Ecological groups are based on information in Chirichigno (1974, 1982), Fowler (1945), Froese and Pauly (2004), Hildebrand (1946), and Schweigger (1964). See Appendix 1 and Reitz et al. (2015, 2017) for further discussion of the taxonomy used and the ecological classifications.

for conditions prevalent in the cool Peru-Chilean province or the warm Panamanian province, or the ability to inhabit either or both provinces.

Biogeographical inferences are based on the premise that relationships exist among the identified organisms, their environmental preferences, environmental conditions at the site, and human behavior. These inferences rely on contemporary observations to infer historical relationships not only among plants, animals, and environments, but also among cultures. This allows archaeologists to evaluate evidence for both environmental and cultural change or stasis. Biogeographic inferences assume that behaviors of organisms observed today, such as feeding, reproduction, and habitat preferences, have not changed considerably within the last few decades or millennia. Furthermore, these inferences predict that changes in one of these variables should be associated with changes in others. These premises enable us to establish a standard against which to evaluate vertebrate evidence for environmental change and continuity in terms of the relative abundance of warm-water and cool-water vertebrates in zooarchaeological assemblages when geochemical or other environmental data are unavailable.

This approach is not without its problems, one of which is that people are not typical predators and foragers. Explanations of cultural change and continuity in an environmental context must take fundamental aspects of human decision-making into account. The choices made by people are conditioned by a wide range of cultural perceptions about what to use, when to use it, how to use it, and other criteria beyond simple availability or energetics (Reitz, 2002). This is sometimes referred to as “cultural imprinting” (Rollins et al., 1990:471) or the “cultural filter” and is a fundamental aspect of all zooarchaeological interpretations (Reitz and Wing, 2008:5–7; Reitz and Shackley, 2012:5).

Interpretations based on biogeography cannot be accepted uncritically as evidence of former environments and cultures because some relationships have changed over the centuries, particularly in places subject to human modifications of long duration (e.g., Carrott and Kenward, 2001). The premise that organisms have not changed their habitats and niches over time is unlikely to be true because many phenomena (e.g., competition, predation, community transformations, climate change) alter such associations, with or without human intervention (e.g., O’Connor and Evans, 2005; Benítez-López, 2018; Gaynor et al., 2018). Organisms previously common in a region may now be rare and those once rare or absent from the area may now be abundant. This is particularly the case for small organisms because many are highly sensitive to subtle environmental stresses and opportunities (e.g., Kenward, 1975, 2006; Webb et al., 1998; Plunkett et al., 2009). Thus, the suite of organisms and/or their relative abundance in a catchment area may change considerably over time. Furthermore, a species may display one suite of characteristics in the middle part of its range and a different suite at the edge of its range (O'Connor and Evans, 2005:24). Environmental changes, such as those occurring during and after the Pleistocene/Holocene transition influence the distribution and abundance of plants and animals found in the archaeological record. These factors complicate efforts to interpret biogeographical inferences from animals represented in the archaeological record.

Perhaps more problematic for assigning animals to ecological groups is that many of the animals prominent in zooarchaeological assemblages are notable for their flexibility and the wide range of habitats and niches they occupy in response to both anthropogenic and non-anthropogenic stimuli. Animals tolerant of a wide range of environmental conditions commonly are fundamental to human economies and dominate zooarchaeological assemblages (e.g., Reitz, 2001, 2014; Reitz et al., 2015). Many of these are eurytopic, tolerant of a broad range of environmental conditions, though some may be less tolerant of environmental conditions and display other differences in growth, size, shape, and behavior at the edges of their preferred range than they do in optimal locations (O'Connor and Evans, 2005:24). Animals dominating zooarchaeological assemblages are likely to be catholic ones with broad feeding, reproductive, and habitat characteristics making them accessible over a large catchment area and used by human communities that might otherwise share few other attributes. Often these same animals are relatively reliable in terms of accessibility, predictability, availability, and vulnerability to specific capture methods, making them even more attractive to fishing communities. Stenotopic species, those with rigid or limited habits and habitats and otherwise narrow environmental tolerances, often are rare or absent in zooarchaeological assemblages, particularly if these species are available irregularly.

For these reasons, few animals consistently found in coastal zooarchaeological assemblages are confined to a single habitat or niche. Many occupy several different habitats or migrate from one habitat type to another during their life cycles. For example, mullets (*Mugil* spp.) move in and out of estuaries as part of their life cycles and might be found in both cooler offshore waters as well as warmer inshore locations depending on age and reproductive status. Mullets even are present in assemblages from the semiarid northern coast of Chile (Béarez et al., 2015). Other fishes common in warm waters, such as bonefishes (*Albula vulpes*) and sea catfishes (Ariidae), also are found as far south as Chile, where the coastal waters are cool but bays offer warmer, though more variable, conditions. Bonefishes, sea catfishes, and mullets, however, are far more common in warm, shallow bays; and much more common in zooarchaeological assemblages associated with those conditions.

A more practical limitation to assigning organisms to ecological groups is that many zooarchaeological attributions are too broad to be assigned to a specific group. Most vertebrate attributions for Peruvian archaeological assemblages are to the level of genus, at best, though most organisms display habitat and niche preferences only at lower taxonomic levels. Ecological classifications could be refined if attributions were at lower taxonomic levels. In addition, the limited life history data available for many animals in Peruvian assemblages precludes strict, inflexible habitat assignments, even if that were appropriate.

Despite problems associated with biogeographical classifications of animals, ecological groups of vertebrates closely track the location of archaeological sites within the Peru-Chilean or Panamanian provinces (Table 4). This suggests that a cautious interpretation of these associations can offer insights into former environmental conditions along the Peruvian coast.

The marine ecological groups used here rely heavily on Chirichigno's (1982:xvi) catalogue of marine species of economic potential for the central and southwestern Pacific coast. This catalogue summarizes information about geographical distribution, habitats or zones of major concentration, average size taken by commercial fishing methods, methods of capture, and economic importance for

Table 4. Percentage of Minimum Number of Individuals (MNI) in each ecological group, organized chronologically within each province.

Province and site	% Terrestrial	% Warm-water	% Cool-water	% Mixed-water	MNI
Southern Peru-Chilean Province (17°–12° S)					
Quebrada Jaguay, Sector II	15.8	0.4	83.0	0.8	253
Ring Site	1.4	2.5	68.1	28.0	436
Paloma					
Probability samples	2.3	1.5	83.3	12.9	132
Grab samples	3.6	5.1	79.8	11.6	277
Northern Peru-Chilean Province (10°–8° S)					
Paiján	83.8	14.3	0.5	1.3	761
Almejas					
6.35 mm fraction	7.0	40.3	35.1	17.5	114
Column fraction	0.8	12.2	84.0	3.1	131
Ostra Base Camp	-	53.5	30.0	16.7	144
Alto Salaverry	-	6.3	85.9	7.8	64
Panamanian Province (4°30′–2° S)					
Las Vegas (OGSE80)	57.2	31.7	2.1	9.0	145
Sitio Siches, Amotape Phase	11.8	29.4	5.9	52.9	34
Sitio Siches, Siches Phase	0.3	50.2	7.0	42.4	1225
Sitio Siches, Honda Phase	0.4	41.9	8.9	48.8	508
Real Alto	5.1	72.9	1.3	20.8	236

Note: Faunal data from Byrd (1976), Chase (1988), Pozorski & Pozorski (1979), Reitz (1988a, 1988b, 1995, 2003); Reitz et al. (2017); Reitz & Sandweiss (2001); Sandweiss et al. (1989), and Wing (1986). See Figure 1 for site locations and Table 1 for dates.

all marine species for which fisheries literature is available, excluding marine mammals.

Chirichigno (1982) divided the central and southern Pacific coast into two fishing areas and several subareas. Area 77 extends from northern Mexico to southern Ecuador (32° 43′ N to 5° 00′ S) and Area 87 consists of Perú and Chile (5° 01′ S to 55° 00′ S). The Panamanian province falls within Area 77 and the Peru-Chilean province falls within Area 87 (Fig. 1). Of specific interest are Chirichigno's Subareas 77C, 87A, and 87B. Subarea 77C is primarily the Ecuadorian coast extending down to Paita, Perú (1° 39′ N to 5° 00′ S). Subarea 87A extends from Paita to Punta Aguja at 6° 00′ S. Subarea 87B includes the rest of the Peruvian coast to 18° 20′ S. Subarea 87C extends from 18° 20′ S to 37° 00′ S, which consists largely of the northern half of the Chilean coast. Sitio Siches is at the southern end of Subarea 77C (Fig. 1; Table 1). Biogeographical characteristics of animals falling within Subareas 77C, 87A, and 87B are summarized in Appendix 1.

This approach has the advantage of permitting us to compare the stratified Sitio Siches assemblage to assemblages from nine other coastal sites using all vertebrate attributions in those assemblages instead of relying on a few specimens from one or two animals from a limited number of contexts. Many paleoenvironmental studies necessarily rely on limited samples due to cost and access to suitable archaeological and reference materials. This is particularly common in applications relying on geochemical studies, which provide essential information about the past but invariably are restricted to a small number of cases. The ecological groups defined here permit us to use much more of each zooarchaeological assemblage.

Multi-proxy studies are important tests of the hypothesis that present environmental and ecological attributes of these animals reflect earlier ones. Nonetheless, these classifications and the interpretations derived from them should be tested using other lines of evidence, particularly geochemical data, whenever possible. We have pursued other research avenues to directly test the environmental conditions prevailing at Sitio Siches and will continue to do so.[3]

SUMMARY OF OTHER ZOOARCHAEOLOGICAL ASSEMBLAGES

Our comparative study of other coastal zooarchaeological assemblages using ecological groups demonstrates that the early- and mid-Holocene coastal environment of Perú was dynamic and that a regional economic pattern based on marine resources flourished from the Late Pleistocene into the mid-Holocene. Zooarchaeological assemblages from sites located in the Peru-Chilean and Panamanian provinces show a strong association between cool- or warm-water vertebrates and either the location of the archaeological site or when it was occupied (Figs. 1–3; Tables 2, 4; Sandweiss et al., 1996, 2007). Cool-water vertebrates dominate some assemblages from the southern Peru-Chilean province. We contrast this affiliation by comparison with assemblages from two Panamanian province sites in which warm-water vertebrates are much more abundant than cool-water ones.

Pervasive biases associated with meta-data analyses are well known (e.g., Reitz and Wing, 2008; Scartascini, 2017; Nims and Butler, 2018). Cross-site summaries such as this rely upon access to data quantified and presented in a similar fashion. Some of the inherent biases in such studies are controlled here by primarily using published data for assemblages studied using the comparative skeletal collection and methods followed in the Environmental Archaeology Laboratory of the Florida Museum of Natural History under the supervision of Elizabeth S. Wing, curator of zooarchaeology, or of Elizabeth J. Reitz, who studied under Wing. This summary focuses on aspects of these other zooarchaeological assemblages that are considered most relevant to establishing a regional context for

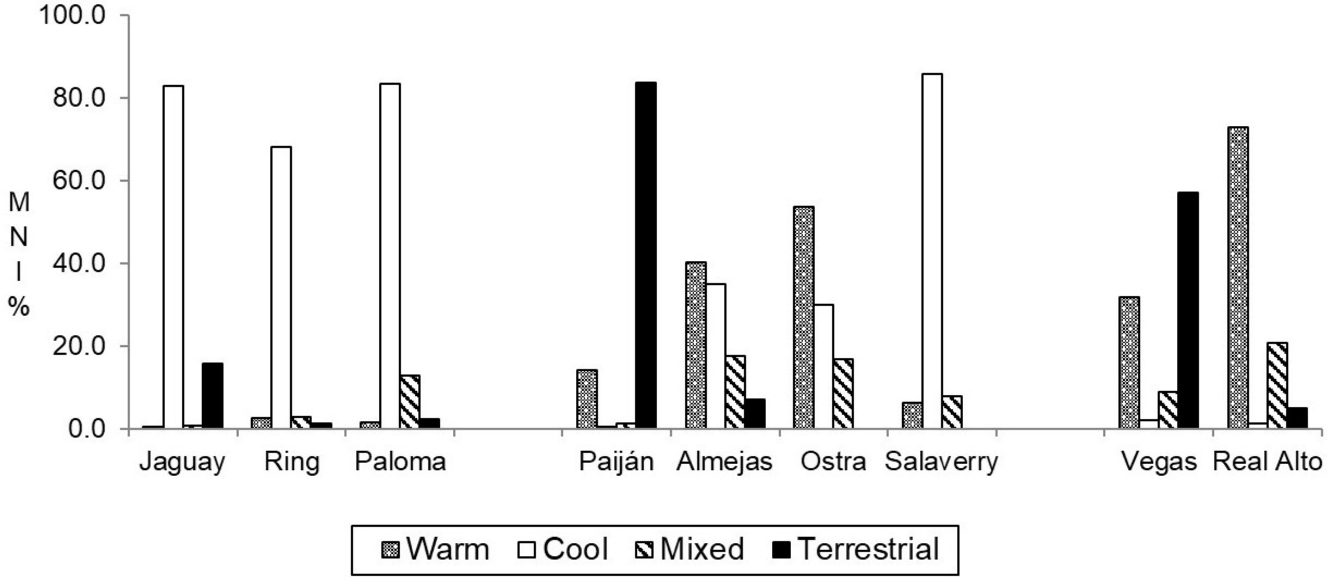

Figure 3. Percentages of vertebrate individuals (MNI) in ecological groups in some coastal Peruvian and Ecuadorian zooarchaeological assemblages. Sites arranged chronologically within the southern Peru-Chilean Province, the northern Peru-Chilean Province, and the Panamanian Province reported in Table 1. See Figure 1 for locations.

Sitio Siches. Readers should consult site-specific publications referenced below for additional information about field methods, analytical procedures, and results for each of these other assemblages.

Distances from the coast reported for each of these sites are estimates informed by modern conditions and geological evidence. This dynamic coastline has experienced and continues to experience tectonic and eustatic changes in sea level, shoreline erosion, and seismic events. Such phenomena impact the meaning of terms such as “coastal” and “inland” (e.g., Erlandson, 2016). The economic orientation of all of the sites summarized here was coastal regardless of the precise distance of each site from the ocean, with the possible exception of sites in the Paiján complex, as described below.

A common attribute of the zooarchaeological assemblages summarized here is that their study included an estimate of the Minimum Number of Individuals (MNI, in Spanish NMI). This is not the only way to quantify zooarchaeological assemblages and is associated with a number of well-known biases (e.g., Reitz and Wing, 2008:205–210). MNI, however, is one of the few forms of quantified data included in most, though not all, species lists available to us at this time. We assign vertebrate MNI estimates made by the original analysts of each assemblage to one of the four ecological groups developed using present-day biogeography (Table 3; Appendix 1; Fowler, 1945; Hildebrand, 1946; Schweigger, 1964; Chirichigno, 1974, 1982; Froese and Pauly, 1998, 2004; Reitz, 2001; Reitz et al., 2015). MNI published in the species list for each assemblage is used, regardless of the taxonomic level for which that estimate was made by the original analyst. This means that in some cases MNI estimates are for taxonomic levels as high as class (e.g., Mammal). More frequently MNI estimates are made for family- or genus-level attributions (e.g., Ariidae or *Mugil* spp.). Rarely are MNI estimates available at the level of species (e.g., *Albula vulpes*). This is the same approach used during the analysis of Sitio Siches.

The taxonomic attributions made during the original study of each vertebrate assemblage are used in this summary whenever there is doubt about the current taxonomic affiliation of the animal. Many of these data are from legacy studies conducted decades ago. The attributions reported by the original analyst reflect the taxonomic attributions of reference skeletons considered valid at the time of the original study. In some cases, subsequent changes in scientific names were relatively simple to implement (e.g., *Sciaena deliciosa* to *Corvina deliciosa*) and the current valid name is used here. In other instances, the name change leaves the original attribution ambiguous, as is the case for foxes (see Appendix 1 for discussion). In such cases, the name reported in the original study is used because to do otherwise would require reanalysis to verify the attribution. The term “fishes” refers to both cartilaginous (Chondrichthyes and Rajiformes) and bony fishes (Actinopterygii) unless otherwise stated.

Other biases are not as readily controlled, particularly those associated with taphonomy, cultural choices manifested in these assemblages, recovery methods, and limited information about plant assemblages at each site. We include this information when we know it but the reader is referred to site-specific references for details of the methods used to excavate these sites and to analyze each faunal assemblage. Sites for which the published data cannot be converted readily into the systematic, quantified format used in this study are not summarized here (e.g., Wing and Reitz, 1982a; Dillehay et al., 2012, 2017).

The comparative summary begins with the southernmost site (Fig. 1; Tables 1, 4). The Ring Site is a stratified shell midden in southern Perú dating to the Early and Middle Preceramic Period (ca. 9800–5800 cal B.P.; Sandweiss et al., 1989; Reitz et al., 2015; Reitz et al., 2016; Reitz et al., 2017). It lies in the Osmore drainage about 7.5 km southeast of Ilo and 10 km south of the Ilo River, a stream with intermittent flow today. The site was less than 5 km from the shoreline when it was first occupied and is less than a kilometer from the present shoreline. The Ring Site is at the southern boundary between Subareas 87B and 87C. Daniel H. Sandweiss and James B. Richardson III conducted excavations at the site over several years, but vertebrate data summarized here are from Unit C-1, which was excavated in 1985 using a 6.35-mm mesh screen.

Fishes dominate the Ring Site vertebrate assemblage (Reitz et al., 2017). Terrestrial mammals (exclusively mice) constitute 0.9% of the Minimum Number of Individuals (MNI, or individuals) and marine mammals contribute 4% of the individuals. Mammals include New World mice (Sigmodontinae), marine otters (*Lontra felina*), and seals or sealions (Pinnipedia). Birds are common in the assemblage (123 individuals; 28% of the MNI). All but one of these is a marine or coastal species. Marine fishes are the most common group of vertebrates (67% of the MNI). The most common of these are drums: corvina (*Cilus gilberti*) and lorna (*Corvina deliciosa*). Warm-water vertebrates constitute 2% of the MNI in the assemblage (Fig. 3; Table 4). The only warm-water species are sea catfishes (Ariidae), groupers (cf. *Epinephelus* spp.), jacks (*Caranx* spp.), and silver perches (*Bairdiella* spp.). In contrast, vertebrates typical of cool waters or the Peru Current constitute 68% of the MNI. The remaining individuals (30% of the MNI) are mixed-water or terrestrial forms and include animals such as seals or sealions, pelicans, and cormorants. These may be found in either ecological area, though they are characteristic of the Peru Current.

Quebrada Jaguay is a Terminal Pleistocene and Early Holocene site located on an alluvial terrace overlooking a seasonal stream in Subarea 87B (McInnis, 1999; Sandweiss et al., 1998; Sandweiss, 2014; Jones et al., 2017; Reitz et al., 2017). The site is approximately 2 km from the modern shoreline; though at the end of the Pleistocene it probably was ca. 6–7 km from the coast. Heather McInnis and Sandweiss conducted excavations here in 1996 and 1999. The materials summarized here were excavated in 1999 from Sector II using a 1.7-mm screen and date around 12,700–11,900 cal B.P. based on bulk samples (Sandweiss, 2009; Jones et al., 2017; AMS dates on short-lived samples suggest a start date of 12,000 cal B.P. [Jones et al., 2017 and recent work by Kurt Rademaker]). Obsidian recovered from the site indicates residents of Jaguay had contact with the Andean highlands some 130–150 km to the west (Sandweiss et al., 1998; Rademaker et al., 2013; Sandweiss and Rademaker, 2013). It is not known if people at Jaguay obtained this obsidian through down-the-line trade or direct contact (Sandweiss and Rademaker, 2013). Bottle gourds (*Lagenaria siceraria*) and fragments of small, knotted cordage suitable for use in netting are present in Early Holocene contexts (Sandweiss et al., 1998; Erickson et al., 2005; Sandweiss, 2009; Piperno, 2011). Some Terminal Pleistocene deposits at Quebrada Jaguay appear to be midden with no direct evidence of a house or hearth; but other Terminal Pleistocene deposits and some Early Holocene deposits are associated with domestic structures and activities (Sandweiss, 2009, 2014).

Fishes dominate the Quebrada Jaguay Sector II assemblage (Reitz et al., 2017). Indeterminate rodents and an indeterminate bird constitute 16% of the MNI. No marine mammals are present. Fishes contribute 84% of the MNI. The most common of these are the two drums: corvina (*Cilus gilberti*) and lorna (*Corvina deliciosa*). These two cool-water drums contribute 82% of the MNI. The only warm-water species are sea catfishes (Ariidae, 0.4% of the individuals; Fig. 3; Table 4). Mixed-water fishes also are rare.

Paloma is an Archaic (Middle Preceramic; 8500–5500 cal B.P.) village site in the Chilca River Valley (Benfer, 1984; Reitz, 1988a, 1988b, 2003). The village lies about 65 km south of Lima, 3.5 km from the present-day shoreline, and 7.5 km north of the Chilca River, an intermittent stream (Benfer, 1984). Probability Samples from the site were recovered by Robert Benfer using a 1.5-mm geological screen (Reitz, 1988a, 2003). Grab Samples were selected randomly by field personnel without the use of a screen (Reitz, 1988b, 2003). Only large specimens with an interesting shape were collected following the Grab Sample protocol; remains of small fishes, such as anchovies, would not be represented in the Grab Samples. Although the Grab Samples are unreliable as indicators of environmental conditions or the economy at Paloma, they are summarized here because they contain vertebrates not present in the Probability Samples.

Mammals are rare in both Grab and Probability Samples (Reitz, 1988a, 2003). In the Probability Samples, mammals and birds contribute 2% of the vertebrate MNI. The remaining vertebrate individuals are fishes. The Probability Samples document heavy use of cool-water fauna typical of the Peru Current, 83% of the MNI (Fig. 3; Table 4). Only 1% are individuals from warm waters. Mixed-water or terrestrial animals constitute 15% of the MNI. In the Grab Samples, terrestrial mammals contribute 2% of the vertebrate MNI (Reitz, 1988b). These include spider monkey (*Ateles* spp.), mice (Sigmodontinae), fox (*Dusicyon* cf. *sechurae*), puma (*Puma concolor*), guanaco (Camelidae), and deer (Cervidae). Marine mammals contribute 4% of the MNI in the Grab Samples; birds 8%; and fishes 85%.

Almejas is a Middle Preceramic (ca. 7900 cal B.P.) shell midden in the Casma River Valley (Pozorski and Pozorski, 1984, 2003; Reitz, 1995). The Casma River today is an intermittent stream. The site is 5.5 km from present shoreline and less than 5 m above sea level. Field work was conducted by Thomas and Shelia Pozorski in 1980. During excavation, faunal materials were recovered as one of two types of samples. Excavated soil was screened primarily through 6.35-mm mesh screen in the field. In addition, the residue from a 25-cm square in each level was screened first through a 6.35-mm mesh and the specimens captured in the 6.35-mm screen were combined with the remains recovered from the rest of the 6.35-mm fraction from the associated level. Then, the material from the 25-cm square that had passed through the 6.35-mm screen was re-screened through 2 mm (#10) and 710 µm (#25) geological soil screens. These fine-screened samples are referred to as column samples by the excavators. Column samples are fine-screened samples from the 25-cm columns from which the 6.35-mm fraction was removed and represent only that portion of the faunal assemblage that passed through the 6.35-mm mesh screen. By and large, evidence for use of larger animals, those with larger skeletal remains such as would be captured in the 6.35-mm mesh, is absent in the column samples. Although samples collected with fine-meshed screens normally would be considered more reliable as indicators of former environments and economies, in the case of Almejas, the 6.35-mm portion is more complete and representative than are the column samples.

Terrestrial mammals constitute 7% of the individuals and marine mammals contribute 0.9% of the individuals in the 6.35-mm Almejas fraction (Reitz, 1995). Terrestrial vertebrates consist of seven mice (Sigmodontinae) and a deer (Cervidae). The most common group of vertebrates are marine fishes, which contribute 90% of the individuals. The most common of these are sea catfishes (Ariidae) and mullets (*Mugil* spp.). Both are typical of warm waters, such as lagoons, though their range can extend further south (Chirichigno, 1982:41, 242). Warm-water individuals constitute 40% of the vertebrates and cool-water vertebrates constitute 35% of the individuals in the 6.35-mm fraction (Fig. 3; Table 4). In the column samples, 12% of the vertebrates are members of the warm-water ecological group and 84% are typical of cool-water regimes or the Peru Current. This is due to the dominance in the column samples of anchovies (Engraulidae), herrings (Clupeidae), and very small mullets. These fishes are typical of shallow inshore waters and often are captured using seine nets or scoops in near-shore grassy locations (see Appendix 1). This may be evidence that such conditions existed near Almejas and that people at Almejas frequently used such methods to capture these fishes.

Ostra Base Camp is located 6.5 km north of the mouth of the Santa River Valley and was excavated by Sandweiss (Sandweiss et al., 1983; Sandweiss et al., 1996; Reitz, 2001; Reitz and Sandweiss, 2001). This Middle Preceramic site dates between 7100 and 6200 cal B.P. and is interpreted as one of a series of collecting stations associated with what was, according to geoarchaeological work at the site, probably a relatively shallow bay. The Santa River is the largest of the permanent streams on the Peruvian coast and extends into the upland as part of the Callejón de Huaylas drainage system. Both 6.35-mm and 1.7-mm mesh screens were used during excavation to recover all excavated material (Reitz and Sandweiss, 2001).

The Ostra assemblage contains no terrestrial animals (Reitz and Sandweiss, 2001). Single individuals identified as seal or sealion (Pinnipedia) and dolphin (Delphinidae) are the only mammals present. Birds contribute 7% of the individuals; cormorants (*Phalacrocorax* spp.) are particularly common. A sea turtle (Cheloniidae) also is present in the assemblage. Marine fishes constitute 91% of the vertebrate individuals. Members of the warm-water ecological group constitute 53% of the vertebrates (Fig. 3; Table 4). Among the warm-water species are bonefishes (*Albula vulpes*), sea catfishes (Ariidae), mullets (*Mugil* spp.), and puffers (*Spheroides annulatus*). These four warm-water fishes alone contribute 40% of the vertebrate individuals in the Ostra Base Camp assemblage. Cool-water individuals contribute 30% of the vertebrates.

Alto Salaverry is a shell midden in the Moche Valley excavated by Shelia and Thomas Pozorski (Pozorski, 1976; Pozorski and Pozorski, 1979). This Late Preceramic site is located ca. 1.5 km inland from a sand beach and 6 km south of the Moche River, an intermittent stream. No radiocarbon dates are available for the Alto Salaverry materials summarized here, but the Late Preceramic attribution places it at between 5000 and 4000 cal B.P. A 6.35-mm mesh screen was used by Shelia Pozorski to recover these materials. Pozorski did the identifications with the assistance of faculty from the University of Trujillo, the Lima Natural History Museum, Melody Shimada, and Wing (Pozorski, 1976:42, 58–59). The only mammals in the assemblage are two sealion (*Otaria flavescens* [formerly *O. byronia*]) individuals. No birds are represented and 97% of the vertebrate individuals are marine fishes. This is a remarkably high percentage considering that fishes are usually better represented when finer gauge screens are used. Members of the warm-water ecological group constitute 6% of the individuals and members of the cool-water group contribute 86% of the individuals (Fig. 3; Table 4). The warm-water animals are mullets and pochocos (*Nicholsina denticulatus* [formerly *Xenoscarus denticulata*]). The cool-water animals are primarily corvinas (*Corvina deliciosa;* 69% of the MNI).

The term “Paiján complex” refers to numerous small sites associated with Early Preceramic people living in the Chicama Valley on the north coast of Perú during the Terminal Pleistocene and Early Holocene between about 12,200 and 9200 cal B.P. (Lumbreras, 1974:28, 30). The sites are between 15 and 36 km from the present-day coastline, though, due to glacially lowered sea levels, the shoreline was as much as 15 km further west when these sites were occupied. Vertebrate remains were identified by Arlene Fradkin, Sylvia Scudder, Erika Simons, and Gary Shapiro under the supervison of Wing (1986). They studied materials from 11 Paiján-complex sites, including Pampa de los Fósiles, Quebrada de Cupisnique, and Ascope excavated under the direction of Claude Chauchat (1976, 1978, 1988, 1992). A fine-gauge screen was used to recover the materials, though the dimensions of the screen are unknown.

The sample size from these sites is highly variable and the data from all of them are merged in this summary. Of the 761 vertebrate individuals identified from this cluster of sites, 7% are terrestrial mammals, 74% are lizards and snakes, 3% are birds, and 16% are fishes (Wing, 1986). The terrestrial mammals are primarily rodents (Sigmodontinae, 5% of the MNI) but also include fox (*Dusicyon* cf. *sechurae*) and viscacha (*Lagidium peruanum*). Less than 1% of the individuals are deer (Cervidae). The lizards are primarily cañan lizards (*Dicrodon* spp.; 70% of the MNI). Members of the warm-water ecological group constitute 14% of the individuals and cool-water individuals constitute 0.5% (Fig. 3; Table 4). Sea catfishes (Ariidae) and mullets (*Mugil* spp.) are the most abundant fishes, though bonefishes (*Albula vulpes*) and tallfin croakers (*Micropogonias* spp.) are common in some Paiján contexts. Small numbers of mojarras (Gerridae, *Eucinostomus* spp.) and porgies (Sparidae) also are present in the assemblage. The members of the cool-water group are anchovies (Engraulidae), herrings (Clupeidae), and cocos (*Paralonchurus* spp.).

Given the distance of Paiján-complex sites from the coast, the high percentage of marine vertebrates is noteworthy, demonstrating that fish were sufficiently important during the Paiján period that people at sites some distance from the coast made use of this important source of animal protein. The recent work by Dillehay and colleagues (2012, 2017) at Huaca Prieta shows that use of marine resources preceded the Paiján period in the Chicama Valley. Today Huaca Prieta is located on the present-day shoreline in the Chicama Valley, but it was many kilometers inland during Paiján times (Dillehay et al., 2012, 2017).

Vertebrate assemblages from two clearly tropical sites highlight differences that might exist between sites associated with cool or warm waters. The Middle Valdivia period faunal remains from Real Alto were excavated by Donald Lathrap and identified by Kathleen M. Byrd at the Florida Museum of Natural History (Byrd, 1976:113–117, 1996). Dolores Piperno and Deborah Pearsall (1998:247) refer to "Middle Valdivia" as Valdivia period III–V and date the occupation to ca. 4400–3800 B.P., following Frederick Schwarz and J. Scott Raymond (1996). The site lies 5 km inland from the present-day coastline in Area 77C of the Panamanian province. Screen size used to recover these materials is not reported by Byrd. Fishes in the Middle Valdivia samples constitute 92% of the vertebrate individuals (Byrd, 1996:309). Terrestrial mammals constitute 5% of the individuals; birds 1% of the MNI; reptiles and amphibians 2%; and fishes 92%. The terrestrial animals at Real Alto are primarily deer (Cervidae, *Mazama* sp., *Odocoileus* sp.; 4% of the MNI). The assemblage is dominated by sea catfishes (Ariidae; 49% of the MNI) and drums (Sciaenidae; 13% of the MNI). Although mullets (*Mugil* spp.) are present in the Real Alto assemblage, bonefishes (*Albula vulpes*) and anchovies (Engraulidae) are absent. Members of the warm-water ecological group contribute 73% of the vertebrate individuals and members of the cool-water group 1% (Fig. 3; Table 4). The mixed-water ecological group contains ducks (Anatidae) and sea turtles (Cheloniidae), in addition to sharks and rays, grunts (Haemulidae), and seatrouts (*Cynoscion* spp.).

Las Vegas (OGSE80) also is located on the Gulf of Guayaquil, about 3.5 km from the present coastline (Stothert, 1988; Piperno and Pearsall, 1998:244–245). Vertebrate remains were excavated by Karen E. Stothert and identified by Byrd (1976:99–100, 1996) and Thomas Chase (1988) under the supervision of Wing at the Florida Museum of Natural History. The screen size used to recover vertebrate remains is not reported by Byrd or Chase. This is one of the few sites for which botanical information is available. Deposits from ca. 9060 B.P. contain phytoliths from bottle gourds (*Lagenaria siceraria*) and lerén (*Calathea allouia*), both of which were introduced from elsewhere (Piperno and Pearsall, 1998:190–198, 244–245; Piperno et al., 2000; Piperno and Stothert, 2003). Beginning in the Terminal Pleistocene, deposits from the site also contain squash/gourd (*Cucurbita* spp.) phytoliths with sizes suggesting a temporal trajectory of intensifying human selective pressure (Piperno et al., 2000). By ca. 7170 B.P., domestic squash/gourds were present at the site.

Las Vegas faunal samples studied by Byrd and by Chase differ in terms of the percentages of vertebrate individuals from terrestrial habitats, but warm-water individuals are more abundant than cool-water and mixed-water individuals in both studies. Terrestrial mammals constitute 46% of the individuals in the combined assemblage; birds 1%; reptiles and amphibians 12%; and fishes 41%. The terrestrial animals are primarily rabbits (*Sylvilagus* cf. *brasiliensis*, 4% of the MNI), mice (26%), foxes (*Dusicyon* cf. *sechurae*, 10%), snakes and cañan lizards (6%), and frogs (5%). Brocket deer (*Mazama* sp.) constitute less than 2% of the individuals. Two fish families dominate the marine component: sea catfishes (Ariidae, 10% of the MNI) and two warm-water drums (Sciaenidae; 11% of the MNI). Although mullets (*Mugil* spp.) are present in the Las Vegas assemblage, bonefishes (*Albula vulpes*) and anchovies (Engraulidae) are absent. Warm-water vertebrates contribute 32% of the MNI and members of the cool-water ecological group contribute 2% of the individuals (Fig. 3; Table 4). The cool-water fishes are three mackerels (Scombridae), which might be considered tropical forms in other locations and are very common in Ecuadorian zooarchaeological assemblages north of the Gulf of Guayaquil (Lippi, 1983; Sánchez, 1993; Reitz and Masucci, 2004:3.3–3.4). These three mackerels are quantified here in the cool-water group because cool-water members of this family tend to be more frequent in coastal assemblages from southern Perú (Reitz et al., 2015).

This summary shows that a distinct and characteristic group of animals is found in Peruvian assemblages and correlates with either time or location despite problems with ecological analogies and the ecological groups used here. To clarify the distinction between warm-water and cool-water vertebrates, Figure 2 and Table 2 summarize the relative abundance of individuals in the warm-water or cool-water ecological groups; excluding mixed-water and terrestrial individuals. South of 12° S latitude, members of the cool-water/Peru Current ecological group comprise at least 96% of the warm- or cool-water individuals. Between 10° S and 8° S latitude, however, warm-water individuals are more abundant than cool-water ones in the Paiján, Almejas (6.35-mm fraction), and Ostra Base Camp assemblages even though these sites are in what is now a cool-water setting. These three assemblages are from deposits older than ca. 5000 ^{14}C B.P. (~5700 cal B.P.). The percentage of cool-water animals in the Alto Salaverry assemblage is more typical of present-day conditions, and this site dates more recently than 5700 cal B.P. In the Panamanian province, marine animals recovered from Las Vegas and Real Alto are almost exclusively members of the warm-water ecological group, though these sites date to opposite sides of the 5000 ^{14}C B.P. climatic transition..

The Paiján complex is noteworthy because it is the earliest assemblage located between 10° and 8° S latitude reported here (Fig. 1; Table 1). Warm-water animals constitute 96% of the marine individuals and cool-water individuals are rare, a relationship made clear when terrestrial and mixed-water animals are excluded from the calculation (Fig. 2; Table 2). In this respect, the Paiján assemblage is more like Panamanian-province assemblages than it is to others from the Peru-Chilean province. The similarity to Las Vegas is particularly interesting as some sites in the Paiján complex probably were contemporaneous with early Las Vegas. The suite of warm-water fishes in the Paiján assemblage (bonefishes [*Albula vulpes*], sea catfishes [Ariidae], and mullets [*Mugil* spp.]), however, is more like that in the Almejas and Ostra Base Camp assemblages than like the suite of fishes from Las Vegas, which is dominated by sea catfishes accompanied by warm-water drums.

The location of some Paiján sites further inland may explain the faunal patterns at sites in this complex. The cost of transporting fish from the coast to these sites might mean that this was done seasonally or using fishing techniques designed to maximize capture of specific fishes, producing a different assemblage of taxa. It also is possible that people reduced the costs of transportation and spoilage by processing fish on the coast instead of transporting inedible portions inland; leaving very little evidence of this activity at inland locations. More importantly to this discussion, conditions clearly existed in the waters near Paiján for fishes from the warm-water ecological group to be taken in large numbers, sufficient to make a substantial contribution to the economy of people living 15–50 km inland.

The Alto Salaverry assemblage suggests a very different strategy prevailed in the northern Peru-Chilean province approximately 4,000 years after the Paiján sites were abandoned. Even though Alto Salaverry is less than 100 km south of Paiján, warm-water vertebrates are minor members of the Alto Salaverry assemblage. The difference in fishes reported from Paiján and from Alto Salaverry suggests both environmental and cultural changes by ca. 5000 B.P. These changes may have begun during the period represented by the Almejas and Ostra assemblages. It is this possibility which is explored further with stratified data from Sitio Siches.

SITIO SICHES

Sitio Siches was selected for archaeological study specifically because Richardson (1973) reported a transition from warmer to cooler water molluscs at sites located south of Sitio Siches and at Sitio Siches (see also Rollins et al., 1986, 1987). This phenomenon also was observed in molluscs from Almejas (Pozorski and Pozorski, 1984, 2003) and Ostra Base Camp (Sandweiss et al., 1983, 1996; Reitz and Sandweiss, 2001). The objective of the Sitio Siches excavation was to test specifically whether the ecological transition observed in the Sitio Siches molluscs was evident in vertebrates from that site.

Site Description

Sitio Siches (PV 7-19) is one of the few stratified preceramic sites on the Peruvian coast bridging the early- and mid-Holocene period for which quantified zooarchaeological data are available (Richardson et al., 1996). The site occupies ca. 20 ha and lies at the present-day southern edge of the Panamanian province about 450 km south of Las Vegas and 600 km north of Paiján (Fig. 1). Radiocarbon dates indicate the site was occupied for much of the early- and mid-Holocene. This occupation is subdivided into three phases: Amotape (9500–9000 ^{14}C B.P./~10,700–10,100 cal B.P.), Siches (7100–6000 ^{14}C B.P./~7900–6800 cal B.P.), and Honda (5150–4550 ^{14}C B.P./~5800–5200 cal B.P.). The Amotape phase is roughly contemporaneous with the Paiján complex to the south and the early Las Vegas site to the north. The Honda phase is contemporary with the Valdivia period in southern Ecuador, represented in this study by Real Alto, and with the Late Preceramic period on the Peruvian coast, represented here by Alto Salaverry.

Sitio Siches is located at the head of a quebrada (or ravine) of the same name overlooking what is today a permanent water seep (Richardson, 1973; Richardson et al., 1996). The seep is ca. 5 km inland from the coast following a direct line, though the distance doubles if one walks down the quebrada to reach the beach. Water in the seep is ground water emerging where the eroding head of the quebrada intersects the water table, well above present-day sea level. At the present time the seep contains water during the austral winter, which is the dry season. The seep has not been visited during today's austral summer, but it likely has more flow during that season. If the area experienced greater precipitation during the mid-Holocene, the seep was a better source of water in the past than it is today. The nearest major permanent freshwater source is the Chira River, ca. 50 km away.

Sea level rose throughout the occupational sequence of Sitio Siches. During the Amotape phase, the shoreline was further from the site than it is today, though the continental shelf is so narrow in this region that the Early Holocene shoreline was not far from the modern beach. As sea level rose during the Siches phase, the distance between the site and the shoreline diminished somewhat. Sea level had reached its modern position by the Honda phase.

Field Methods

Field work at the site was conducted by Richardson, Sandweiss, and Rolando Paredes E. in 1995 (Richardson et al., 1996) and in 2001 by Richardson and Sandweiss. Different portions of the site were excavated during the two field seasons (Fig. 4). The 1995 materials were excavated from two areas of the site designated Area I and Area II. Five 1-x-1 m pits were excavated in 1995, two in Area I (IA and IB), and three in Area II (IIA, IIB, IIC). Honda-phase materials are from Areas IA and IB excavated in 1995. Some Siches-phase materials also are from Areas IIA, IIB, and IIC excavated in 1995, referred to as Pozo II in 1995. In 2001, excavations focused on Area II, with 19 adjacent 1-x-1 m units excavated. The term "feature" (*elemento*) refers to any clearly distinguished stratigraphic unit that interrupted the general horizontal stratigraphy and was limited in extent. Thus, pits and hearths are called features as are very small units embedded in more extensive levels. All Amotape materials are from pit features excavated during 2001 in Area II. Most of the Siches-phase materials are from Area II units excavated in 2001. Natural stratigraphy defined levels within each unit.

Gaps in the stratigraphic record suggest Sitio Siches was abandoned for up to 2,200 years between the Amotape and Siches occupations and again for a shorter period between the Siches and Honda occupations. It is likely that some unknown quantity of the material that accumulated between 9000 and 7100 ^{14}C B.P. (~10,100 and 7900 cal B.P.) was lost due to an erosional event. Amotape remains were found only in midden-filled pit features intruding into sterile deposits; the erosional event(s) removed overlying Amotape sheet midden that might have provided evidence for a more continuous occupation (Sandweiss, 2014:1061). Thus, the apparent Amotape-Siches occupational gap may be due in part to erosion of intervening deposits, probably as the result of flooding during El Niño events. Deposits began to re-accumulate at about 7100 ^{14}C B.P. (~7900 cal B.P.) during the Siches phase. An additional hiatus of about a millennium in the stratigraphic record is interpreted

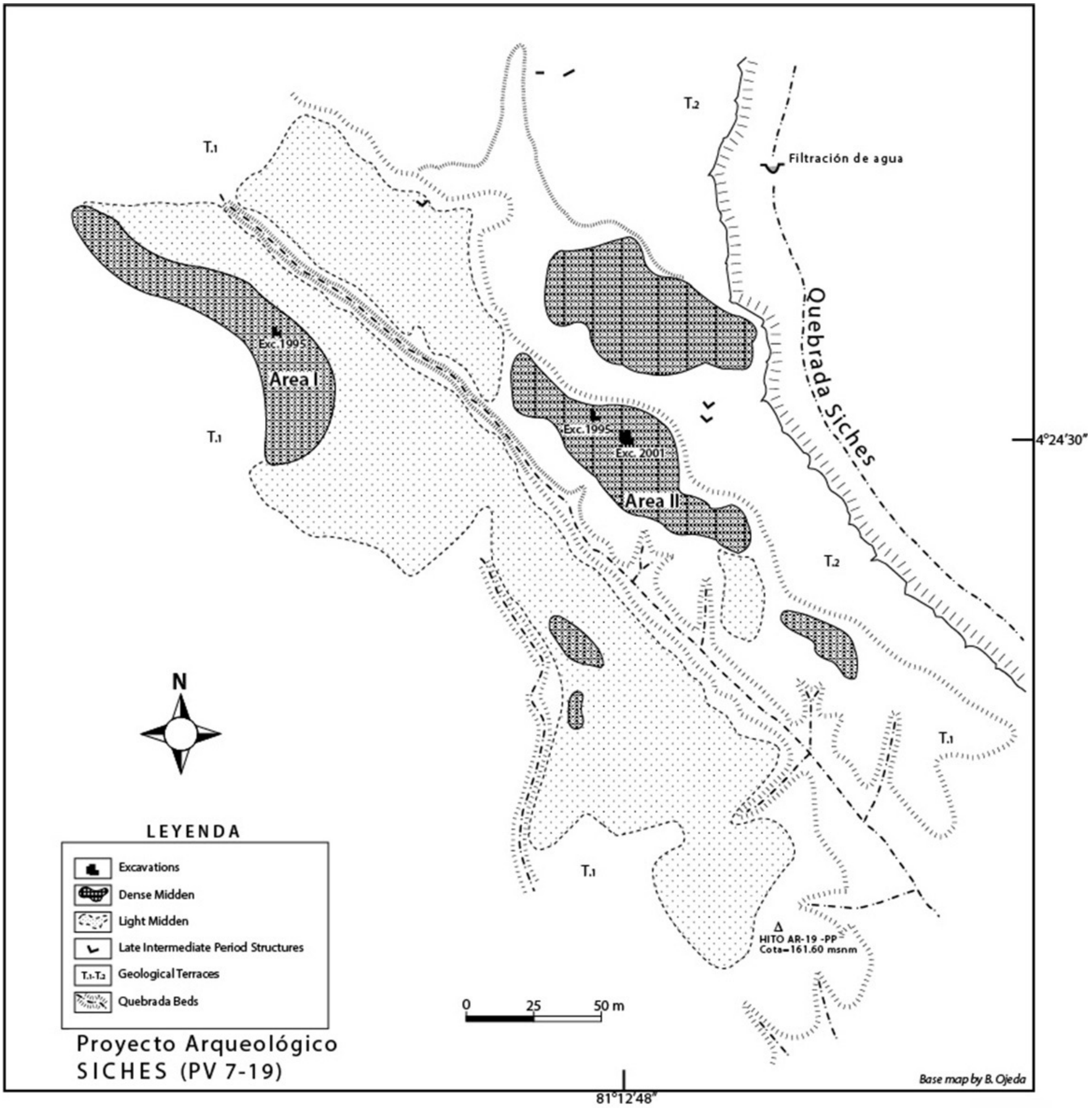

Figure 4. Excavations at Sitio Siches.

as an occupational hiatus between the Siches and Honda occupations. Other smaller gaps also may exist in the occupational sequence.

Occupational gaps likely reflect social or environmental events that made the site unattractive to a community intent on capturing a specific suite of marine fishes. Although it is likely that the location was unoccupied for portions of the sequence, we do not interpret this as evidence that the site was but one stage in a migratory or seasonal round. The geological, architectural, and biological characteristics of the site suggest that breaks in the record were prolonged rather than short-term. When the site was occupied, the occupation was temporally continuous rather than intermittent.

Two sample types were collected in the field: Muestra and General. Muestra samples are from a standard volume (1 bucket, approximately 12 liters) of the stratigraphically most secure material in each context. The 6.35-mm mesh Muestra fraction was sorted in the field and the 1.7-mm fraction was sorted in the laboratory. In 1995, no Muestra samples were taken from Pit IA, thus only the 6.35-mm Muestra fractions from Pit IB and Pit IIA-B-C are included in the vertebrate study reported here. General samples comprise the rest of the material from each pit and level and feature. The 6.35-mm General samples were collected from the screen. The 1.7-mm General fraction was sorted in the field for artifacts and interesting organic materials such as otoliths. The remainder of the 1.7-mm General fraction was discarded in the field without further study. The consequence of this recovery method is that anchovy remains probably are under-represented in the Honda- and Siches-phase vertebrate samples excavated in 1995, which influenced the organization of the subsequent zooarchaeological study (as discussed below).

Structures, Plant Remains, Geochemistry, and Molluscs

Hearths and postholes suggest structures were present in all levels of the site, though they are most common in the early Siches-phase levels. The presence of structures supports our interpretation that Siches was more than an occasional fishing camp visited during a seasonal round. The 1995 excavations recovered broken beads in the process of being manufactured from fossil scallop (*Argopecten* spp.*)* and ark (*Anadara tuberculosa*) shells. These were associated with microlith drills in the Honda deposits. Neither beads nor drills were present in the excavated Amotape or Siches deposits, though the Honda deposits containing beads and drills were in another portion of the site.

The presence of cultivated plants elaborates upon the broad interaction sphere within which the residents of Sitio Siches participated, a sphere that extended into Ecuador, the hypothesized source of cultigens recovered from Sitio Siches. Dolores Piperno identified squash (*Cucurbita* spp.) phytoliths in Amotape deposits and Asunción Cano identified bottle gourd (*Lagenaria siceraria*) pericarp fragments in Siches and Honda deposits (Cano, 1995; Piperno et al., 2000; Piperno, 2005, 2011). In addition, Cano identified seeds of a grass (cadillo, *Cenchrus* spp.), algarrobo (*Prosopis* sp.), and mesquite or huarango (*P. pallida* [formerly *Acacia pallida*]). Although both algarrobo and mesquite are used as firewood, human consumption of both legumes has a long history in South America (Giovannetti et al., 2008).

Oxygen isotope profiles of archaeological sea catfish (*Galeichthys peruvianus*) from Ostra Base Camp and Sitio Siches indicate changes in sea surface temperatures (SST) when these profiles are compared to those from modern catfish otoliths (Andrus et al., 2002, 2003). At Ostra (8° 55′ S latitude), the oxygen isotope profile in the archaeological sea catfish otoliths indicates that summer temperatures were about 3° C warmer than today but winters were like those prevailing today, suggesting a more strongly seasonal climate that may have included seasonal rainfall. The mid-Holocene annual temperature *range* at Siches (4° 25′ S latitude) reconstructed from Siches-phase otoliths was like that experienced today but offset about 3°–4° C warmer. These data also suggest that nearly tropical water conditions prevailed at Sitio Siches by the end of the Siches 3b sub-phase.[4]

Molluscs from Sitio Siches document changes in marine invertebrates over time at the site (Richardson, 1973, 1978; Richardson et al., 1996). Late Pleistocene deposits within ca. 30 km of Sitio Siches contain two mollusc species associated with red mangroves (*Rhizophora mangle*): *Anadara tuberculosa* and *Ostrea colombiensis*. Amotape deposits at Sitio Siches also contain these molluscs (Richardson, 1973, 1978; Richardson et al., 1996). Red mangroves develop in protected bays, estuaries, and areas where continental alluvium transported by run-off accumulates. Both mangroves and estuaries require inputs of fresh water as rainfall and run-off from streams, at least seasonally. This suggests warmer, wetter conditions of the

Late Pleistocene extended into the Amotape phase (Sandweiss, 2003). Other warm-water molluscs in Siches-phase deposits include almejas (*Protothaca ecuatoriana*) and navajas (*Tagelus dombeii*). Although very early Siches-phase deposits (analytical unit 3b) contain these warm-water molluscs, deposits from the subsequent Honda phase do not (Sandweiss, 2003). Honda deposits contain a mixture of warm-water and cool-water molluscs. Mangroves are not present in the area today and local streams are intermittent.

Zooarchaeological Methods

Vertebrate remains from both the 1995 and the 2001 excavations are reported here.[5] The Sitio Siches vertebrate assemblage was recovered in 1995 from five units and in 2001 from 19 units using 6.35-mm and 1.7-mm mesh screens. Fractions from the two mesh sizes were kept separate during analysis. The General samples were distinguished from the Muestra samples during identification but are combined here. All 6.35-mm Muestra samples and the 6.35 + 1.7-mm General samples excavated in 1995 were studied. The 1995 Muestra samples were reported previously (Reitz, 1999) but are merged with the 1995 General samples here because the small quantity of Muestra material (number of identified specimens [NISP] = 369) precludes relevant analysis. Due to time constraints and the very large sample recovered in 2001, only a portion of the 2001 material was studied. Based on the results of analysis of the 1995 materials (Reitz, 1999), all the 2001 sample types (Muestra, General, 6.35 mm, 1.7 mm) are combined for analysis. Surficial levels were omitted from analysis because of possible intrusions from more recent activities.

Five major analytical units structure this analysis, with one of these subdivided into three subcomponents, for a total of seven analytical units. The major analytical units are defined by the area, pit, and temporal period for each sample: Amotape, Siches, Pozo II, Lower Honda, and Upper Honda. Amotape constitutes analytical unit 4 (AU 4), consisting of the oldest deposits. Early Siches-phase materials (AU 3) are divided into two subcomponents designated analytical unit 3b (AU 3b; 7100–6400 ^{14}C B.P./~7900–7300 cal B.P.), and analytical unit 3a (AU 3a; 6300–6100 ^{14}C B.P./~7200–6900 cal B.P.). Later Siches-phase materials form analytical unit 2 (AU 2; ca. 6000 ^{14}C B.P./~6800 cal B.P.). These Siches-phase divisions are defined by stratigraphy and radiocarbon dates. Pozo II likely dates to 6590–6450 ^{14}C B.P. (~7500–7300 cal B.P.). Analytical unit 1 (AU 1) refers to the mixed surface material in Sector II that overlies the Siches deposits; AU 1 lacks stratigraphic integrity and was not analyzed for this study. The Siches-phase materials excavated from Pozo II in 1995 are contemporaneous with analytical unit 3 (early Siches) but are not merged with that level for reasons explained in more detail below. To test the possibility that the lower and upper levels of Area I, Pits A and B might record environmental change during the Honda phase, the Honda levels are separated into two analytical units, Lower Honda (LH) and Upper Honda (UH). The different unit naming conventions in Sectors I and II resulted from the need to accommodate the more complex stratigraphy in Sector II encountered in the 2001 season.

The division of the Honda materials into lower and upper components is based on field observations of a transition from warm- to cool-water invertebrates previously observed at other sites in the region as well as at Sitio Siches. This division is based on this knowledge instead of on radiocarbon dates or obvious changes in stratigraphy. Only warm-water and mixed-water molluscs are present in Lower Honda samples, as well as in the Siches-phase deposits in Pozo II (1995 excavations; Richardson et al., 1996). Cool-water and mixed-water invertebrates are more common in the Upper Honda samples. Radiocarbon evidence is ambiguous about a significant chronological difference between the lower and upper levels, and materials undoubtedly moved among adjacent levels (Richardson et al., 1996:9). Except for two outliers (one older, from the basal level but contradicted by three other dates in the same level, and one younger), the other 10 Honda dates range between 5150 ± 110 ^{14}C B.P. (~5800 cal B.P.) and 4705 ± 90 ^{14}C B.P. (~5400 cal B.P.), placing the Honda deposits at a climatic transition ca. 5000 ^{14}C B.P. (~5700 cal B.P.) that is most tightly dated in the non-archaeological molluscan fauna from the paleoembayment at the Salinas de Chao (8° 40′ S latitude, 27–33 km NNE of the Ostra Base Camp; Perrier et al., 1994; Andrus et al., 2003:Figure 3).

The vertebrate materials in these seven analytical units were examined using standard zooarchaeological methods (Reitz and Wing, 2008). Identifications were made by Reitz using the comparative skeletal collection of the Environmental Archaeology Laboratory, Florida Museum of Natural History, University of Florida. Alana Lynch assisted with the materials excavated in 1995 and Nicole R. Cannarozzi assisted with the 2001 materials. During identification specimens are described by element, portion represented, and symmetry. Evidence for age at death, sex, and modifications is noted when observed. The Number of Identified Specimens (NISP) refers to the number/count of all specimens examined from each context with cross-mended specimens counted as single specimens. The only exceptions to this procedure are unmodified fragments in the Unidentified (UID) Vertebrate category, which are not counted out of concern that the small fragments in this category would crumble further while being counted and were unlikely to be counted accurately. Modified UID Vertebrate specimens are counted so they may be included in tables summarizing modifications. All specimens are weighed to provide additional information about the relative abundance of the animals identified, but neither the weights nor the biomass estimates derived from those weights are included in this study because almost a quarter of the Sitio Siches assemblage consists of otoliths. Assemblages dominated or consisting largely of otoliths, as is the case for Sitio Siches, yield less reliable biomass estimates than do assemblages consisting of a greater mix of other skeletal specimens.

The analysis reported here largely relies on estimates of the Minimum Number of Individuals (MNI or NMI; sensu White [1953]). MNI is used because it is one of the few measures of abundance that is available both for Sitio Siches and several other coastal sites, permitting us to do a regional study. MNI facilitates comparing relative abundance across classes with different anatomical structures and is relevant to the larger goal of assessing ecological transitions from warmer to cooler water vertebrates using ecological groups, taxonomic abundance, richness, diversity, equitability, and trophic levels on a regional scale.

MNI estimates are based on the symmetry, portion, size, and age of skeletal remains (Reitz and Wing, 2008:205–210). MNI is estimated for the lowest taxonomic level consistent with the level of attribution in each analytical unit (compare the list of attributions in Table 5 with those in Table 6). MNI is influenced by the way data from archaeological proveniences are aggregated during analysis. The aggregation of separate samples into one analytical unit allows for a conservative estimate of MNI but the "maximum distinction" method, which estimates MNI for separate samples and then combines those estimates, may be more appropriately applied when analysis discerns discrete sample units that are definitively separated by time and space (Grayson, 1973). The maximum distinction method yields a much larger MNI. MNI for Sitio Siches is estimated for each of the seven analytical units, with no distinction made for recovery method or subdivisions within each analytical unit. MNI estimates for Pozo II are presented in some of the accompanying tables but are not included in the analysis.

Ubiquity is defined as the number of analytical units in which a taxon for which MNI is estimated is present. Taxa present in every analytical unit are highly ubiquitous and those present in only one have a very low ubiquity.

The presence or absence of elements in an archaeological sample provides data on site formation processes, such as the preservation potential, butchering patterns, or transportation and disposal decisions. The skeletal element categories used here are: Otolith, Tooth, Other cranial specimens, Axial, Appendicular, Foot, and Other specimens. The Other cranial category includes only cranial bones. Teeth are quantified separately in the category "Tooth." The Axial category includes either mammal vertebrae and ribs or fish vertebrae. Appendicular includes all bird specimens from the sternum through the phalanges of the manus and from the synsacrum through the phalanges of the pes. For mammals and lizards, the Appendicular category includes only forequarter and hindquarter specimens other than phalanges, which are included in the Foot category. Mammalian Appendicular specimens in the Sitio Siches assemblage consist only of humerii, radii, and tibiae. Mammalian Foot elements are carpals, tarsals, metapodials, and phalanges. Specimens quantified as "Other" are too fragmentary to be assigned to one of these more informative categories.

The relative age of the mammals, thought to be either seals or sealions, is estimated from the degree of epiphyseal fusion for diagnostic elements (Reitz and Wing, 2008:70–73). When mammals are young their elements are not fully formed. Along the area of growth, the shaft, known as the diaphysis, and the ends of the elements, the epiphyses, are not fused. When growth is complete the diaphysis and epiphysis fuse. Although environmental factors influence the actual age when the element reaches adult dimensions and is fully fused (Watson, 1978), the process follows a regular temporal sequence (Silver, 1963; Schmid, 1972). During analysis, marine mammal specimens are recorded in one of three general categories based on when the maturation process generally is completed and complete fusion occurs for that portion of the element. This is more informative for unfused specimens that fuse in the first year or so of life (juveniles) and for fused specimens that are the last to fuse (adults) than for other specimens. An element that fuses before or at ca. 18 months of age and is found fused archaeologically could be from an animal that died immediately after fusion was complete or many years later. The ambiguity inherent in age grouping is controlled by recording each element under the oldest category possible.

Modifications to specimens can indicate weathering, human activity such as butchery, or other site formation processes (Reitz and Wing, 2008:123–143). Except for a single modified specimen from a Lower Honda context, all of the modifications observed in the Sitio Siches assemblage can be attributed to burning, probably intentional. These burned specimens may be the result of exposure to fire during food preparation; but more likely they were burned intentionally or unintentionally to reduce waste or as additional fuel for fires. Although NISP for specimens attributed to UID Vertebrate are not included in the list of taxonomic attributions, modified UID Vertebrate specimens are quantified in the modification table below.

The variety and degree of specialization reflected in the assemblage is measured by the richness, diversity, and equitability of animals in the assemblage. Richness is defined as the number of taxa for which MNI is estimated in each analytical unit. Diversity and equitability permit economic strategies to be assessed in terms of the variety or heterogeneity (diversity) of animals used at the site and the evenness with which taxa were used (equitability). Equitability measures the degree of dependence on specific taxa and the effective variety of species used at the site based on the even, or uneven, use of individual taxa. Biases associated with these indices are discussed elsewhere (Hardesty 1975; Grayson, 1981; Reitz and Wing, 2008:235–246).

Diversity and equitability are estimated using the MNI values for each analytical unit. To measure diversity, the Shannon-Weaver Index is used. The formula is:

$$H' = -\Sigma p_i log_e p_i$$

where p_i is the number of the *ith* species, divided by the sample size (Shannon and Weaver, 1949:14). P_i is the evenness component because the Shannon-Weaver Index measures both how many species were used and how much each was used. Equitability is estimated using the formula:

$$V' = H'/Log_e S$$

where H' is the Diversity Index and $Log_e S$ is the natural log of the number of observed species (Sheldon, 1969).

These indices are interconnected. Diversity increases as both the number of species and the equitability of species increases. A diversity value of 4.99 is very high; a sample with many species identified and in which the number of individuals in the sample slowly declines from most abundant to least abundant will be high in diversity.

Diversity increases when a new taxon is added to the species list, but if another individual of a taxon that is already present in the assemblages is added, diversity decreases. A low diversity can be obtained either by having a few species or by having a low equitability, where one species is considerably more abundant than others. A low equitability value indicates that one species was used more heavily than other species in the sample. A high equitability index, approaching 1.0, indicates an even distribution of individuals among the species in the sample following a normal pattern in which there are a few abundant species, a moderate number of common ones, and several rare ones.

Trophic level is based primarily on a species' dietary composition, habits, and, to a lesser degree, habitat and reflects the health of the community (Reitz, 2004; Quitmyer and Reitz, 2006). Mean trophic level (TL) is estimated by combining modern trophic level assignments derived from the biological literature with estimates of MNI in the Sitio Siches assemblage for these same taxa (Pauly and Christensen, 1995; Pauly et al., 1998; Pauly et al., 2000). The trophic level assignments used are those published in FishBase 1998 (Froese and Pauly, 1998; Pauly et al., 2000; Reitz, 2003, 2004). Trophic level is estimated using the formula:

$$TL_i = \Sigma\,(TL_{ij})\,(MNI_{ij}) \,/\, \Sigma\, MNI_i$$

solving for the mean trophic level for the time period (TL_i). The trophic level (TL_{ij}) of each taxon (j) for the time period (i) is multiplied by the estimated MNI of the taxon (j) for the time period (i). TL_{ij} is divided by the summed MNI for the time period (MNI_i). This formula estimates the mean trophic level for each analytical unit. Sometimes it is necessary to use other taxonomic levels when the identifications in the archaeological data, the modern fishery data, and/or FishBase 1998 are insufficiently precise. In these cases, the trophic level for the closest taxonomic category is used. This same formula is used to estimate the relative emphasis placed on specific trophic levels instead of the mean trophic level by dividing the MNI in each trophic level by the total MNI for the phase. A comprehensive review of the strengths and weakness of this approach is published elsewhere (Reitz, 2004).

Vertebrate data are summarized in several ways to facilitate comparison. One comparison is based on the number of individuals in biological categories such as Mammals, Birds, Reptiles, and Fishes. Another comparison classifies individuals in terms of the ecological groups used in the review of other coastal zooarchaeological assemblages above (e.g., Table 3). In addition, data are summarized in terms of the richness in each analytical unit and the percentage of individuals from each trophic level.

As will be seen, the role of anchovies (Engraulidae) is one of the chief differences between Siches- and Honda-phase analytical units. Anchovy remains are very rare in the samples recovered in 1995 (NISP = 122; MNI = 4) and abundant in the samples recovered in 2001 (NISP = 16,091; MNI = 881; Tables 5–6). This difference may reflect environmental or cultural transitions, or both; but probably can be attributed more directly to the different procedures used for 1.7-mm fractions in 1995 and 2001. All Honda-phase materials and those from Siches-phase Pozo II are from the 1995 excavations. At that time, excavators did not recognize anchovy otoliths and did not extract them from the 1.7-mm General fractions. For this reason, the summary tables upon which the presentation of results is based in this report exclude all anchovies from consideration to facilitate inter-phase comparisons. Anchovies, however, are retained in the accompanying lists of vertebrate attributions for each analytical unit. Pozo II is not quantified in the Siches-phase summaries for this same reason, but those data also are retained in the accompanying lists of vertebrate attributions. Unless otherwise stated, anchovies are not included in the following discussion and Pozo II is not discussed at all.

Anchovies (Engraulidae) and seatrouts (*Cynoscion* spp.) pose additional obstacles to this study. Both taxa include some members specific to warm waters and other members characteristic of cool waters. Classifications of anchovies and seatrouts to an ecological group requires an attribution that includes both a genus and species. None of the Sitio Siches anchovies could be identified beyond family and only a few of the *Cynoscion* could be attributed to a level below genus (e.g., *C.* cf. *analis*). Advances in archaeogenetics, geochemistry, and other methods that do not rely on morphology eventually may clarify the taxonomic and ecological affiliation of these two groups.[3]

Engraulids are found in warm-tropical/estuarine waters, sometimes abundantly. Those found in Ecuadorian archaeological assemblages probably are species commonly present in lagoons and warm waters, such as *Anchoa* spp. Engraulids south of Ecuador are likely cool-water forms, such as *Engraulis ringens*, which are strongly associated with the Peru-Chilean province and abundant in fine-screened zooarchaeological assemblages from sites south of Lima, Perú. No engraulids are reported for either Las Vegas or Real Alto, the two Ecuadorian sites referenced in this study. Thus, engraulids in the Sitio Siches assemblage are attributed only to family (Engraulidae) but classified as cool-water forms.

Seatrouts of the genus *Cynoscion* also are wide-ranging. Some seatrouts inhabit Peruvian waters but the principal fishing zone for most species lies in Ecuador. One member of this genus (weakfish, *C. analis*), for example, is found in both Ecuadorian and Peruvian waters, but the principal fishing zone is Ecuador and northern Perú down to Punta Aguja (Fig. 1; Schweigger, 1964:259; Chirichigno, 1982:198–202). Another member of this genus (*C. stolzmanni*) prefers brackish lagoons and coastal waters; the principal fishing zone also is Ecuador (Froese and Pauly, 2004). In this study, animals attributed only to *Cynoscion* spp. are classified as mixed-water forms.

All of the primary and secondary data used in this study are subject to several common biases reviewed at length elsewhere (e.g., Grayson, 1984; Reitz and Wing, 2008). In general, small samples frequently yield short lists of taxa with undue emphasis on one taxon in relation to others. It is not possible to determine the nature or the extent of the bias, or correct for it, until more materials are studied. These data also reflect the fact that elements of some animals are more readily identified than others and the animals represented by such elements may appear more significant in terms of specimen count than they were in the economy. If animals are identified largely by unpaired elements, such as vertebrae, the estimated MNI for that animal will be low. High specimen count and low MNI for some animals are artifacts of analysis. This source of bias is particularly critical when interpreting assemblages dominated by fishes. In a highly stratified site such as Sitio Siches, various forms of turbation (e.g., bioturbation, flooding) as well as time averaging within and among stratigraphic levels may be two of the most common analytical impediments (Reitz and Shackley, 2012:46), though the full range of taphonomic phenomena likely influenced these materials (Reitz and Shackley, 2012:41–68).

A PREVIEW OF THE SITIO SICHES RESULTS

Federico Scartascini (2017) reported a latitudinal environmental gradient for the desert coast of Patagonia, Argentina, despite the apparent homogeneity of the Patagonian coast. As with the southern Atlantic sites studied by Scartascini (2017), a dominant aspect of Sitio Siches is its location in a transition zone between two biogeographical provinces supporting a high-diversity, multi-species complex of marine organisms.

The Sitio Siches study shows that people living at this early coastal site were able fishers, as were people at other early- and mid-Holocene coastal sites (Fig. 3; Table 4). Ecological groups, taxonomic richness, diversity, equitability, and mean trophic levels for each phase demonstrate the wide range of marine animals used for five millennia at Sitio Siches. These animals have such varied habits and habitat preferences that they required a wide range of fishing methods to acquire (Tables 3, 5–6; Appendix 1). Differences among the phases enhance our ability to see when and where ecological transitions among warm and cool marine conditions occurred (Tables 7–9). After the Amotape phase, half of the vertebrates are characteristic of warm-water conditions, though the dominant animal (Sciaenidae: *Cynoscion* spp.) is a mixed-water, flexible genus able to live in both warm and cool waters. Over time temperatures trended from reliably warm to warmer waters with more sharply seasonal fluctuations in water temperatures; eventually achieving cool conditions similar to those prevailing today at the frontier between the Panamanian and Peru-Chilean provinces. Vertebrates recovered from Sitio Siches suggest when these shifts in the warm-water/cool-water frontier occurred during a span of 5,000 years.

RESULTS, AMOTAPE PHASE (ANALYTICAL UNIT 4)

The earliest Sitio Siches deposits are those in the Amotape analytical unit (AU 4). The Amotape collection contains 335 specimens and the remains of an estimated 50 vertebrate individuals, including anchovies (Tables 5–6). During this phase, the site was further from the shoreline than during the subsequent Siches- and Honda-phase occupations. This may explain why terrestrial individuals constitute 12% of the MNI, excluding anchovies (Engraulidae; Tables 7–8). Despite the small sample size, this analytical unit contains one rodent individual (UID Rodent; Table 6), two cañan lizards (*Dicrodon* sp.), and a non-poisonous snake (Colubridae), in addition to fishes. Fish individuals, however, dominate the collection (88% of the MNI; Table 7). Half of the individuals are members of the mixed-water ecological group (53% of the MNI) though members of the warm-water group comprise 29% of the individuals (Table 8). Members of the drum family (Sciaenidae) contribute 62% of the individuals. Mixed-water drums contribute 81% of the drum individuals and warm-water drums constitute 19% of the drum individuals (Table 9). The most abundant drums are mixed-water seatrouts (*Cynoscion* spp.). The most common warm-water fishes are mullets (*Mugil* spp.). Other warm-water vertebrates include bonefishes (*Albula vulpes*) and sea catfishes (Ariidae). Cool-water individuals are rare (6% of the MNI; Table 8) and cool-water drums are absent (Table 9). Most of the fish specimens are vertebrae (37% of the 295 fish NISP) and otoliths (38%; Table 10). Anchovies (Engraulidae), contribute 40% of the fish vertebrae and 41% of the otoliths. Evidence of burning is found on 17% of the Amotape specimens (excluding UID Vertebrate; Table 11).

Diversity of all vertebrates in the collection (Fig. 5) and of the fish component (Fig. 6) is lower than in the subsequent Siches phase, but higher than in the Honda phase at the end of the sequence. This is the most equitable of the seven analytical units, but richness is very low, perhaps due to the small sample size. Low richness also suggests a fishing strategy focused on seatrouts but which also retained non-targeted fish captured as by-catch. The mean marine trophic level exploited during the Amotape phase is 3.2, reflecting the wide range of trophic levels used in addition to a focus on seatrouts from trophic level 3.4 (Fig. 6; Table 12).

RESULTS, SICHES PHASE (ANALYTICAL UNITS 3 AND 2)

Although anchovy recovery from Siches-phase materials in 2001 was highly successful, unless otherwise specified, anchovies are not included in the analysis to maintain comparability with the Honda-phase materials in which anchovies are undoubtedly under-represented. Likewise, Pozo II, a Siches-phase unit, is not considered here due to the incomplete recovery of anchovies when that unit was excavated. Results for the three Siches-phase collections are summarized in stratigraphic order, beginning with the oldest deposits, those in analytical unit 3b.

Siches Phase, Analytical Unit 3b

The AU 3b collection contains 7,072 specimens and the remains of an estimated 442 vertebrate individuals, including anchovies (Engraulidae; Tables 5–6). Vertebrates include cormorants (*Phalacrocorax* spp.), cañan lizards (*Dicrodon* sp.), and fishes (Table 6). Excluding anchovies, fish individuals dominate the collection (99% of the MNI; Table 7). Half of the individuals are members of the warm-water ecological group (46% of the MNI) and the other half (43%) are members of the mixed-water group (Table 8). Members of the drum family constitute 78% of the individuals in AU 3b and warm-water drums constitute 44% of the drum individuals (Table 9). The most abundant fishes are mixed-water seatrouts (*Cynoscion* spp.), though six other fishes contribute between 5% and 9% of the fish individuals, resulting in the highest overall diversity and the highest fish diversity of the seven analytical units (Table 12). Notable warm-water vertebrates include bonefishes (*Albula vulpes*), mullets (*Mugil* spp.), weakfishes (*Cynoscion* cf. *analis*), Pacific drums (*Larimus* cf. *pacificus*), and tallfin croakers (*Micropogonias* spp.). The most common cool-water vertebrates are cabrillas (*Paralabrax* spp.). Cool-water individuals are rare (10% of the MNI; Table 8). A limited variety of elements are represented in the Siches AU 3b (Table 13). Sixty-seven percent of the fish specimens (fish NISP = 6,996) are vertebrae and 15% are otoliths. Anchovies contribute 85% of the fish vertebrae and 52% of the otoliths. Evidence of burning is found on 3% of the Siches AU 3b specimens (excluding UID Vertebrate; Table 11).

Siches Phase, Analytical Unit 3a

The AU 3a collection contains 13,556 specimens and the remains of an estimated 1,364 vertebrate individuals, including anchovies (Engraulidae; Tables 5–6). Among these individuals are two terrestrial bird individuals (Corvidae, Mimidae) and one cañan lizard (*Dicrodon* sp.; Table 6). Less than 1% of the individuals are terrestrial birds and lizards (Table 7). Excluding anchovies, most of the individuals are fishes (99.6% of the MNI). Half of the fish individuals are members of the warm-water ecological group (50% of the MNI) and slightly fewer of the individuals (43%) are from the mixed-water group (Table 8). Members of the drum family constitute 84% of the individuals in AU 3a and warm-water drums constitute 49% of the drum individuals (Table 9). The most common fishes are warm-water weakfishes (*Cynoscion* cf. *analis*) and Pacific drums (*Larimus* cf. *pacificus*), in addition to mixed-water seatrouts (*Cynoscion* spp.) and star drums (*Stellifer* spp.). Other notable warm-water vertebrates include bonefishes (*Albula vulpes*), sea catfishes (Ariidae), mullets (*Mugil* spp.), and tallfin croakers (*Micropogonias* spp.). The most common cool-water animals are cabrillas (*Paralabrax* spp.). Cool-water individuals are rare (6% of the MNI). A limited variety of elements are represented in AU 3a (Table 14). Sixty percent of the fish specimens (fish NISP = 13,402) are vertebrae and 25% are otoliths. Anchovies contribute 90% of the fish vertebrae and 44% of the otoliths. Evidence of burning is found on 4% of the Siches AU 3a specimens (excluding UID Vertebrate; Table 11).

Siches Phase, Analytical Unit 2

Siches-phase AU 2 contains 997 specimens and the remains of an estimated 284 vertebrate individuals, including anchovies (Engraulidae; Tables 5–6). It contains two UID Bird specimens, for which MNI is not estimated, and otherwise consists entirely of fishes (Table 7). Excluding anchovies, half of the fish individuals are members of the warm-water ecological group (54% of the MNI) and 40% are members of the mixed-water group (Table 8). Drums are the most common vertebrates (82% of the MNI) and half of the drums are members of the warm-water group (51% of the MNI; Table 9). Mixed-water individuals constitute a high percentage of the specimens in this analytical unit primarily because of the prominence of mixed-water seatrouts (*Cynoscion* spp., 33% of the MNI). Weakfishes (*Cynoscion* cf. *analis*), Pacific drums (*Larimus* cf. *pacificus*), tallfin croakers (*Micropogonias* spp.), and Polla drums (*Umbrina* cf. *xanti*) contribute 37% of the individuals (Table 6). Other notable warm-water vertebrates include bonefishes (*Albula vulpes*), sea catfishes (Ariidae), mullets (*Mugil* spp.), grunts (*Orthopristis* spp.), and yellow-eyed croakers (*Odontoscion* spp.). Cool-water individuals are rare (6% of the MNI). Most of the elements represented in AU 2 are from fishes (Table 15). Twelve percent of the fish specimens (fish NISP = 995) are vertebrae and 67% are otoliths. Anchovies (Engraulidae) contribute 50% of the fish vertebrae and 28% of the otoliths. Evidence of burning is found on 11% of the AU 2 specimens (excluding UID Vertebrate; Table 11).

Summary, Siches Phase

The Siches-phase analytical units are similar in most respects (Tables 7–9, 12). All three of the Siches-phase analytical units are dominated by fishes (Tables 6–7) and most of the vertebrates are from warm or mixed waters (Table 8). Seatrouts (*Cynoscion* spp. and *Cynoscion* cf. *analis*) are the dominant vertebrates in all three Siches-phase analytical units, contributing 43% of the Siches-

Table 5. Number of Identified Specimens (NISP) for each analytical unit. See Table 3 for vernacular names.

Attribution	AU 4	AU 3b	AU 3a	AU 2	Pozo II	L. Honda	U. Honda	Total NISP
UID Mammal	14	14	74			1152	485	1739
UID Rodent	1							1
Lycalopex cf. *sechurae*						1		1
Pinnipedia						8	1	9
Otariidae						45	9	54
UID Bird	4	23	43	2		223	96	391
Laridae							2	2
Larosterna inca						10	1	11
Puffinus cf. *griseus*						70	5	75
Sula spp.						6		6
Phalacrocorax spp.		1				2	1	4
Passeriformes			1					1
Corvidae			1					1
Mimidae			1					1
UID Squamata	2	10	8					20
UID Lizard	1	16	8			5		30
Teiidae		1						1
Dicrodon sp.	17	11	18			2		48
Colubridae	1							1
Chondrichthyes	2	5	4			14	3	28
Carcharhinidae	1					126	20	147
Rajiformes		1	5	1				7
Rhinobatos spp.			6	1				7
Dasyatidae			1	2		11	1	15
UID Actinopterygii	114	844	1471	328	16	1257	310	4340
Albula vulpes	1	34	42	7	3	2		89
Engraulidae	123	5598	10077	293	1	116	5	16213
Clupeidae	3	68	189	5		9	24	298
Ariidae	3	18	37	8	2	12	7	87
Mugil spp.	2	14	29	5	3	24	1	78
Serranidae		7	16	3	1	2		29
Epinephelus spp.			3	1				4
Hemanthias peruanus			1	1		3	3	8
Paralabrax spp.	2	21	73	11	9	16	3	135
Gerreidae	2	7	10	1				20
Haemulidae			1			7		8
Anisotremus spp.			1		1	16	10	28
Haemulon spp.		1	1	1				3
Isacia conceptionis			3			2		5
Orthopristis spp.	2	6	17	10	2	1	1	39
Calamus sp.						1		1
Sciaenidae		13	41	10			5	69
Bairdiella cf. *ensifera*		1	3					4
Corvina deliciosa		1	1			1	1	4
Cynoscion spp.	28	159	495	115	87	285	174	1343
Cynoscion cf. *analis*		37	159	54				250

Table 5. Continued.

Attribution	AU 4	AU 3b	AU 3a	AU 2	Pozo II	L. Honda	U. Honda	Total NISP
Cynoscion cf. *stolzmanni*		1	3					4
Larimus spp.			2					2
Larimus cf. *acclivis*		4	17	3				24
Larimus cf. *effulgens*		3	7	2	2		1	15
Larimus cf. *pacificus*	2	38	186	31	11	190	48	506
Menticirrhus spp.					1	1		2
Micropogonias spp.	1	32	81	22	23	5	3	167
Odontoscion spp.	1	13	42	11	1	5	1	74
Ophioscion spp.		3	4					7
Paralonchurus spp.		5	11	3	4	2	5	30
Stellifer spp.	7	37	213	32	19		1	309
Umbrina cf. *xanti*	1	16	92	34	5	64	31	243
Labridae		9	58		1	70	4	142
UID Vertebrate								0
Total NISP	335	7072	13556	997	192	3766	1262	27180

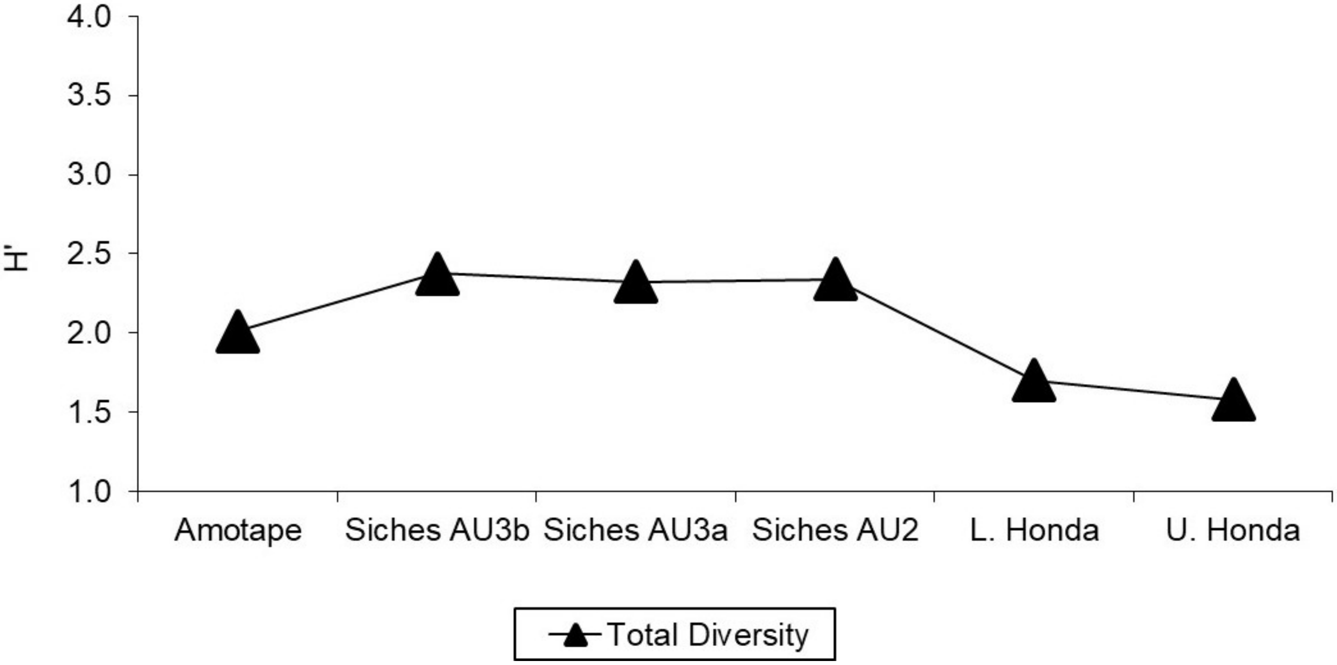

Figure 5. Diversity (H') of all vertebrates in each Sitio Siches collection, excluding Engraulidae and Pozo II. See Table 12 for details.

Table 6. Ecological groups, trophic level, and Minimum Number of Individuals (MNI) for each analytical unit. See Table 3 for vernacular names.

Attribution	Ecological Group	Trophic Level	AU 4	AU 3b	AU 3a	AU 2	Pozo II	L. Honda	U. Honda	Total
UID Rodent	Terrestrial		1							1
Lycalopex cf. *sechurae*	Terrestrial							1		1
Otariidae	Mixed							2	2	4
Larosterna inca	Cool							2	1	3
Puffinus cf. *griseus*	Mixed							6	1	7
Sula spp.	Cool							1		1
Phalacrocorax spp.	Mixed			1				1	1	3
Corvidae	Terrestrial				1					1
Mimidae	Terrestrial				1					1
Dicrodon sp.	Terrestrial		2	1	1			1		5
Colubridae	Terrestrial		1							1
Carcharhinidae	Mixed	4.0	1					1	1	3
Rajiformes	Mixed	3.5		1						1
Rhinobatos spp.	Mixed	3.5			1	1				2
Dasyatidae	Mixed	3.5			1	1		1	1	4
Albula vulpes	Warm	3.0	1	13	21	6	2	2		45
Engraulidae	Cool	2.2	16	205	572	88	1	2	1	885
Clupeidae	Cool	2.6	1	5	5	1		5	1	18
Ariidae	Warm	3.2	1	5	17	5	2	6	4	40
Mugil spp.	Warm	2.0	2	2	13	3	2	4	1	27
Epinephelus spp.	Warm	3.8			3	1				4
Hemanthias peruanus	Warm	3.5			1	1		2	3	7
Paralabrax spp.	Cool	3.5	1	14	35	8	6	10	2	76
Gerreidae	Warm	3.3	1	4	6	1				12
Anisotremus spp.	Cool	3.5			1		1	5	6	13
Haemulon spp.	Warm	3.5		1	1	1				3
Isacia conceptionis	Cool	3.5			2			2		4
Orthopristis spp.	Warm	3.1	1	4	12	6	1	1	1	26
Calamus sp.	Warm	3.4						1		1
Bairdiella cf. *ensifera*	Warm	3.3		1	1					2
Corvina deliciosa	Cool	3.5		1	1			1	1	4
Cynoscion spp.	Mixed	3.4	14	86	257	64	49	133	96	699
Cynoscion cf. *analis*	Warm	3.4		15	86	24				125
Cynoscion cf. *stolzmanni*	Warm	4.0		1	2					3
Larimus cf. *acclivis*	Warm	3.3		3	11	2				16
Larimus cf. *effulgens*	Warm	3.3		2	4	1	2		1	10
Larimus cf. *pacificus*	Warm	3.3	1	22	97	18	8	96	30	272
Menticirrhus spp.	Mixed	3.4					1	1		2
Micropogonias spp.	Warm	3.3	1	17	48	13	13	2	2	96
Odontoscion spp.	Warm	3.3	1	8	25	6	1	3	1	45
Ophioscion spp.	Warm	3.3		2	2					4
Paralonchurus spp.	Cool	3.4		3	6	2	3	1	1	16
Stellifer spp.	Mixed	3.3	3	14	80	13	12		1	123
Umbrina cf. *xanti*	Warm	3.4	1	10	49	18	3	33	20	134
Labridae	Cool	3.6		1	1		1	5	1	9
Total MNI			50	442	1364	284	108	331	180	2759

Table 7. Summary of taxonomic class MNI for each analytical unit. This table does not include Engraulidae or Pozo II (see Tables 5 and 6 for those data).

Class	Mammals		Birds		Reptiles		Fishes		Total MNI
Analytical Unit	MNI	MNI %	MNI	MNI %	MNI	MNI %	MNI	MNI %	
AU 4, Amotape	1	2.9			3	8.8	30	88.2	34
AU 3b, Siches			1	0.4	1	0.4	235	99.2	237
AU 3a, Siches			2	0.3	1	0.1	789	99.6	792
AU 2, Siches							196	100.0	196
Siches Phase Totals			3	0.2	2	0.2	1220	99.6	1225
Lower Honda	3	0.9	10	3.0	1	0.3	315	95.7	329
Upper Honda	2	1.1	3	1.7			174	97.2	179

Table 8. Summary of ecological group MNI for each analytical unit. This table does not include Engraulidae or Pozo II (see Tables 5 and 6 for those data). See Table 3 and Appendix 1 for animals classified in each ecological group.

Ecological Group	Terrestrial		Warm-water		Cool-water		Mixed-water		Total MNI
Analytical Unit	MNI	MNI %	MNI	MNI %	MNI	MNI %	MNI	MNI %	
AU 4, Amotape	4	11.8	10	29.4	2	5.9	18	52.9	34
AU 3b, Siches	1	0.4	110	46.4	24	10.1	102	43.0	237
AU 3a, Siches	3	0.4	399	50.4	51	6.4	339	42.8	792
AU 2, Siches			106	54.1	11	5.6	79	40.3	196
Siches Phase Totals	4	0.3	615	50.2	86	7.0	520	42.4	1225
Lower Honda	2	0.6	150	45.6	32	9.7	145	44.1	329
Upper Honda			63	35.2	13	7.3	103	57.5	179

Table 9. Summary of drum MNI for analytical units. This table does not include Engraulidae or Pozo II (see Tables 5 and 6 for those data). See Table 3 and Appendix 1 for animals classified in each ecological group.

Ecological Group	Warm-water		Cool-water		Mixed-water		Total drum MNI
Analytical Unit	MNI	MNI %	MNI	MNI %	MNI	MNI %	
AU 4, Amotape	4	19.0			17	81.0	21
AU 3b, Siches	81	43.8	4	2.2	100	54.1	185
AU 3a, Siches	325	48.6	7	1.0	337	50.4	669
AU 2, Siches	82	50.9	2	1.2	77	47.8	161
Siches Phase Totals	488	48.1	13	1.3	514	50.6	1015
Lower Honda	134	49.6	2	0.7	134	49.6	270
Upper Honda	54	35.3	2	1.3	97	63.4	153

Table 10. Elements represented (NISP) in analytical unit 4. Axial includes either mammal vertebrae and ribs or fish vertebrae. Appendicular includes all bird specimens from the sternum through the phalanges of the manus and from the synsacrum through the phalanges of the pes. For mammals and lizards, this includes forequarter and hindquarter specimens other than phalanges, which are included in the foot category. NISP includes specimens from both the Muestra and General samples.

Attribution	Otolith	Tooth	Other Cranial	Axial	Appendicular	Foot	Other	Total
UID Mammal							14	14
UID Rodent				1				1
UID Bird					4			4
UID Squamata				1			1	2
UID Lizard					1			1
Dicrodon sp.			4	9	1	3		17
Colubridae				1				1
Chondrichthyes				2				2
Carcharhinidae		1						1
UID Actinopterygii	15	27		63			9	114
Albula vulpes	1							1
Engraulidae	46		33	44				123
Clupeidae	1		1	1				3
Ariidae	2		1					3
Mugil spp.	2							2
Paralabrax spp.	2							2
Gerreidae	2							2
Orthopristis spp.	2							2
Cynoscion spp.	28							28
Larimus cf. *pacificus*	2							2
Micropogonias spp.	1							1
Odontoscion spp.	1							1
Stellifer spp.	7							7
Umbrina cf. *xanti*	1							1
Total NISP	113	28	39	122	6	3	24	335

phase individuals. The mean marine trophic level exploited during the Siches phase is 3.3, reflecting the observation that most of the fish individuals are drums from trophic level 3.4, but that 8–12% of the fish individuals in each analytical unit are from trophic levels below 3.3. Except for herrings (Clupeidae), these low-trophic-level fishes are warm-water bonefishes (*Albula vulpes*), sea catfishes (Ariidae), mullets (*Mugil* spp.), and grunts (*Orthopristis* spp.). Cool-water individuals are rare (7% of the MNI).

Subtle differences exist among the three Siches-phase analytical units (Figs. 5–8). Materials in the earliest of the Siches-phase analytical units (AU 3b) are slightly more diverse than those in the other two analytical units (Table 12). This applies to both the overall vertebrate portion of each collection (Fig. 5) and to the fish portion (Fig. 6). Although the mean trophic level is very similar in all three analytical units (Fig. 6), the percentage of fishes from trophic level 3.4 increases from 48% in the AU 3b collection to 55% in the AU 2 collection (Table 12). The higher emphasis on trophic level 3.4 observed in AU 2 can be attributed to an increase in the percentage of warm-water weakfish (*Cynoscion* cf. *analis*) and Polla drum (*Umbrina* cf. *xanti*) individuals (Tables 6, 9). Terrestrial individuals are present in small numbers only in AU

Table 11. Modifications (NISP) in each analytical unit. No modifications other than burning were observed with the exception of a single worked UID vertebrate specimen in IB9a General, Lower Honda (FLMNH 01900358). NISP includes specimens from both the Muestra and General samples.

Attribution	AU 4	AU 3b	AU 3a	AU 2	L. Honda	U. Honda	Total
UID Mammal	2	7	14		823	417	1263
UID Rodent	1						1
Lycalopex cf. *sechurae*					1		1
Pinnipedia					4	1	5
Otariidae					13	7	20
UID Bird	4	6	10		4	3	27
Puffinus cf. *griseus*						1	1
Mimidae			1				1
UID Squamata	1	4	2				7
UID Lizard	1	6	3				10
Dicrodon sp.	5	2	6				13
Chondrichthyes		1			3	3	7
Carcharhinidae	1				29	7	37
Rajiformes			2				2
Rhinobatos spp.			3	1			4
Dasyatidae				2	3		5
UID Actinopterygii	28	70	149	36	169	120	572
Albula vulpes		4	6				10
Engraulidae	1	17	48	2	13		81
Clupeidae	1	9	5			1	16
Ariidae	2	2	2		1		7
Mugil spp.			6				6
Serranidae		1	3	1	1		6
Paralabrax spp.		3	9	2	1		15
Haemulidae					1		1
Anisotremus spp.					3		3
Orthopristis spp.			1		1		2
Sciaenidae		1	5				6
Bairdiella cf. *ensifera*		1					1
Corvina deliciosa			1				1
Cynoscion spp.	8	40	138	30		5	221
Cynoscion cf. *analis*		9	28	16	9		62
Larimus cf. *acclivis*			3				3
Larimus cf. *pacificus*		9	35	4	13	2	63
Micropogonias spp.		7	29	8	1		45
Odontoscion spp.	1		4				5
Paralonchurus spp.		2	2		1		5
Stellifer spp.		6	28	5			39
Umbrina cf. *xanti*			8	2	3		13
Labridae		1	3		6		10
UID Vertebrate	378	438	1019	23	3	30	1891
Total Modifications	434	646	1573	132	1106	597	4488

Table 12. Summary of richness, diversity (H'), equitability (V'), and trophic levels (TL) for each analytical unit using MNI. Trophic level data from Froese and Pauly (1998, 2004). Data do not include Engraulidae or Pozo II.

Category	AU 4	AU 3b	AU 3a	AU 2	L. Honda	U. Honda
Total MNI	34	237	792	196	329	179
Total Richness	17	26	32	22	28	23
MNI Diversity	2.2612	2.4103	2.3449	2.3384	1.8757	1.7020
MNI Equitability	0.7981	0.7398	0.6766	0.7565	0.5629	0.5428
Fish MNI	30	235	789	196	315	174
Fish Richness	14	24	29	22	21	19
Fish Diversity	2.0136	2.3758	2.3246	2.3384	1.7009	1.5815
Fish Equitability	0.7630	0.7476	0.6904	0.7565	0.5587	0.5371
Mean Fish TL	3.250	3.319	3.326	3.329	3.342	3.373
% fish MNI in each trophic level:						
Trophic Level:	% MNI	% MNI	% MNI	% MNI	% MNI	% MNI
2.0	6.7	0.9	1.6	1.5	1.3	0.6
2.6	3.3	2.1	0.6	0.5	1.6	0.6
3.0	3.3	5.5	2.7	3.1	0.6	
3.1	3.3	1.7	1.5	3.1	0.3	0.6
3.2	3.3	2.1	2.2	2.6	1.9	2.3
3.3	23.3	31.1	34.7	27.6	32.1	20.1
3.4	50.0	48.5	50.4	55.1	53.7	67.2
3.5	3.3	7.2	5.4	6.1	6.7	7.5
3.6-4.0	3.3	0.9	0.8	0.5	1.9	1.1

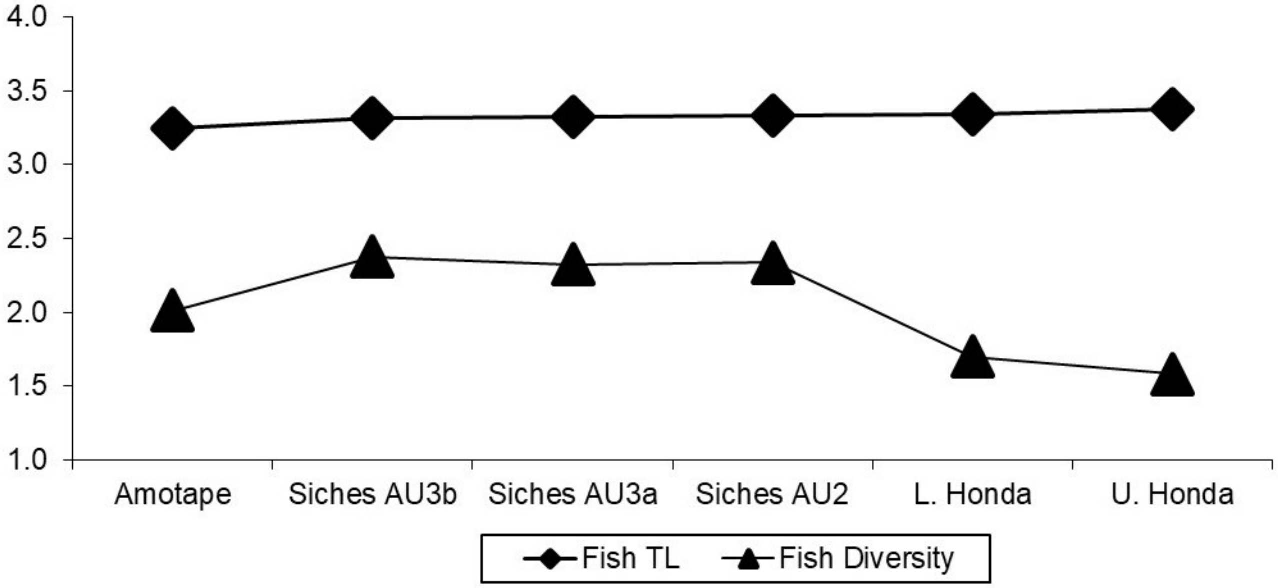

Figure 6. Mean trophic level (TL) and diversity (H') of fishes in each Sitio Siches collection, excluding Engraulidae and Pozo II. See Table 12 for details.

3b and AU 3a (Tables 6, 8). In both cases these are birds and cañan lizards, animals absent in AU 2 (Fig. 7; Tables 6–7).

During the Siches Phase, warm-water vertebrates increased in abundance from 46% to 54% of the individuals, cool-water vertebrates decreased from a high of 10% of the individuals to a low of 6%, diversity declined slightly, equitability increased slightly, and the use of higher trophic levels increased between 7100 ^{14}C B.P. and 6000 ^{14}C B.P. (~7900 and 6800 cal B.P.; Figs. 5–8; Tables 7–9, 12). Individuals other than fishes are slightly more common in the earlier part of the Siches sequence (AU 3a and 3b) than in the latter part (AU 2; Table 7).

RESULTS, HONDA PHASE

Lower Honda Levels, LH

The oldest of the Honda-phase collections, represented by the Lower Honda (LH) analytical unit, contains 3,766 specimens, the remains of an estimated 331 vertebrate individuals, including anchovies (Engraulidae; Tables 5–6). This analytical unit contains the remains of a fox (*Dusicyon* cf. *sechurae*), marine mammals (Pinnipedia, Otariidae), sea birds, and a cañan lizard (*Dicrodon* sp.), in addition to fishes. Most of the individuals are fishes (96% of the MNI, anchovies excluded; Table 7). Most individuals are members of the mixed-water (44% of the MNI) and warm-water ecological groups (46% of the MNI; Table 8). Members of the drum family constitute 82% of the individuals (Table 6). Mixed-water drums constitute 49% of the drum individuals and warm-water drums contribute another 49% of the drum individuals (Table 9). The most abundant fish individuals are seatrouts (*Cynoscion* spp.), Pacific drums (*Larimus* cf. *pacificus*), and Polla drums (*Umbrina* cf. *xanti*). Other notable warm-water vertebrates are bonefishes (*Albula vulpes*), sea catfishes (Ariidae), mullets (*Mugil* spp.), and tallfin croakers (*Micropogonias* spp.). The most common cool-water fishes are herrings (Clupeidae), cabrillas (*Paralabrax* spp.), sargos (*Anisotremus* spp.), and wrasses (Labridae). Cool-water individuals are rare (10% of the MNI; Table 8).

Elements represented in the Lower Honda analytical unit are summarized in Table 16. The fox is represented by a distal fused metapodial in IA7b. Elements from the Foot constitute 70% of the marine mammal (Pinnipedia, Otariidae) specimens, though other portions of the skeleton are represented. The two sealion individuals include one juvenile and one individual which was prob-

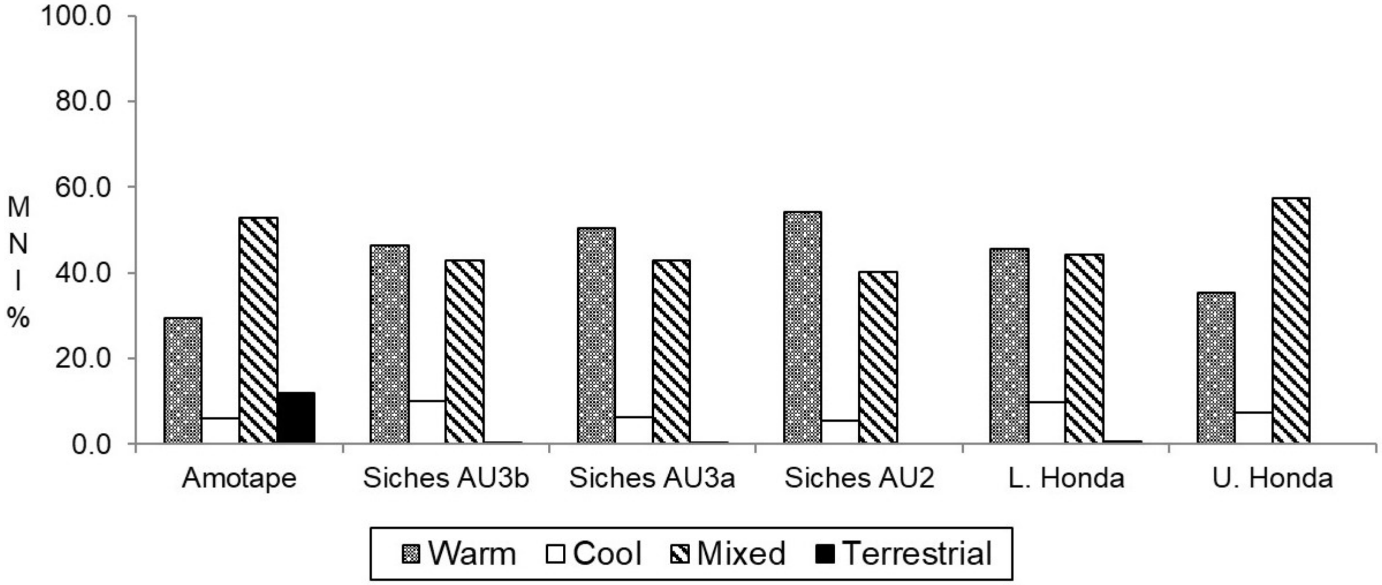

Figure 7. Percentages of vertebrate individuals (MNI) in ecological groups in each Sitio Siches collection, excluding Engraulidae and Pozo II.

Table 13. Elements represented (NISP) in Siches-phase AU 3b. Format as in Table 10.

Attribution	Otolith	Tooth	Other Cranial	Axial	Appendicular	Foot	Other	Total
UID Mammal						2	12	14
UID Bird			1	2	15		5	23
Phalacrocorax spp.					1			1
UID Squamata				6		4		10
UID Lizard			3	7		6		16
Teiidae			1					1
Dicrodon sp.			4	6		1		11
Chondrichthyes				5				5
Rajiformes				1				1
UID Actinopterygii	52	104	81	591			16	844
Albula vulpes	21			13				34
Engraulidae	534		1080	3984				5598
Clupeidae	7		2	59				68
Ariidae	11		2	5				18
Mugil spp.	3			11				14
Serranidae	7							7
Paralabrax spp.	21							21
Gerreidae	7							7
Haemulon spp.	1							1
Orthopristis spp.	6							6
Sciaenidae	13							13
Bairdiella cf. *ensifera*				1				1
Corvina deliciosa	1							1
Cynoscion spp.	159							159
Cynoscion cf. *analis*	37							37
Cynoscion cf. *stolzmanni*	1							1
Larimus cf. *acclivis*	4							4
Larimus cf. *effulgens*	3							3
Larimus cf. *pacificus*	38							38
Micropogonias spp.	32							32
Odontoscion spp.	13							13
Ophioscion spp.	3							3
Paralonchurus spp.	5							5
Stellifer spp.	36			1				37
Umbrina cf. *xanti*	16							16
Labridae			9					9
Total NISP	1031	104	1183	4692	16	13	33	7072

ably an adult (Table 17). A proximal unfused tibia epiphysis and diaphysis (which cross-mend) are from a very young juvenile sealion. Eight of the 53 marine mammal specimens are from Pit IA and 45 are from Pit IB. Half (51%) of the 2,242 fish specimens are vertebrae and 26% are otoliths. Evidence of burning is found on 29% of the Lower Honda specimens (excluding UID vertebrate; Table 11). This collection contains the only modified specimen observed, a small worked, burned UID Vertebrate specimen from IB9a General.

Upper Honda Levels, UH

The Upper Honda (UH) analytical unit represents the youngest, and last, of the analytical units in the Sitio Siches sequence. The collection

Table 14. Elements represented (NISP) in Siches-phase AU 3a. Format as in Table 10.

Attribution	Otolith	Tooth	Other Cranial	Axial	Appendicular	Foot	Other	Total
UID Mammal					1	2	71	74
UID Bird			1		19		23	43
Passeriformes					1			1
Corvidae			1					1
Mimidae					1			1
UID Squamata			1	7				8
UID Lizard			1	7				8
Dicrodon sp.			5	11		2		18
Chondrichthyes		1		3				4
Rajiformes				5				5
Rhinobatos spp.				6				6
Dasyatidae				1				1
UID Actinopterygii	284	530	28	604			25	1471
Albula vulpes	38			4				42
Engraulidae	1467		1334	7276				10077
Clupeidae	8		5	176				189
Ariidae	32		1	4				37
Mugil spp.	27			2				29
Serranidae	16							16
Epinephelus spp.	3							3
Hemanthias peruanus	1							1
Paralabrax spp.	73							73
Gerreidae	10							10
Haemulidae	1							1
Anisotremus spp.	1							1
Haemulon spp.	1							1
Isacia conceptionis	3							3
Orthopristis spp.	17							17
Sciaenidae	40			1				41
Bairdiella cf. *ensifera*	3							3
Corvina deliciosa	1							1
Cynoscion spp.	495							495
Cynoscion cf. *analis*	158			1				159
Cynoscion cf. *stolzmanni*	3							3
Larimus spp.	2							2
Larimus cf. *acclivis*	16			1				17
Larimus cf. *effulgens*	7							7
Larimus cf. *pacificus*	186							186
Micropogonias spp.	81							81
Odontoscion spp.	41			1				42
Ophioscion spp.	4							4
Paralonchurus spp.	11							11
Stellifer spp.	211			2				213
Umbrina cf. *xanti*	91			1				92
Labridae		51	7					58
Total NISP	3332	582	1384	8113	22	4	119	13556

Table 15. Elements represented (NISP) in Siches-phase AU 2. Format as in Table 10.

Attribution	Otolith	Tooth	Other Cranial	Axial	Appendicular	Foot	Other	Total
UID Bird					2			2
Rajiformes				1				1
Rhinobatos spp.				1				1
Dasyatidae				2				2
UID Actinopterygii	118	151	1	50			8	328
Albula vulpes	7							7
Engraulidae	187		46	60				293
Clupeidae				5				5
Ariidae	8							8
Mugil spp.	5							5
Serranidae	3							3
Epinephelus spp.	1							1
Hemanthias peruanus	1							1
Paralabrax spp.	11							11
Gerreidae	1							1
Haemulon spp.	1							1
Orthopristis spp.	10							10
Sciaenidae	10							10
Cynoscion spp.	114			1				115
Cynoscion cf. *analis*	54							54
Larimus cf. *acclivis*	3							3
Larimus cf. *effulgens*	2							2
Larimus cf. *pacificus*	31							31
Micropogonias spp.	22							22
Odontoscion spp.	11							11
Paralonchurus spp.	3							3
Stellifer spp.	32							32
Umbrina cf. *xanti*	34							34
Total NISP	669	151	47	120	2		8	997

contains 1,262 specimens and the remains of an estimated 180 vertebrate individuals, including anchovies (Tables 5–6). This collection contains the remains of marine mammals (Pinnipedia, Otariidae) and several species of sea birds, but no exclusively terrestrial vertebrates. Fishes dominate the collection even with anchovies excluded (97% of the MNI; Table 7). Most of the individuals either are members of the mixed-water ecological group (57% of the MNI) or of the warm-water group (35% of the MNI; Table 8). Members of the drum family constitute 85% of the individuals. Most of the drums are members of the mixed-water (63% of the MNI) or warm-water ecological group (35% of the MNI; Table 9). The most common fishes are seatrouts (*Cynoscion* spp.), Pacific drums (*Larimus* cf. *pacificus*), and Polla drums (*Umbrina* cf. *xanti*). Other notable vertebrates are warm-water sea catfishes (Ariidae) in addition to cool-water cabrillas (*Paralabrax* spp.) and sargos (*Anisotremus* spp.). Cool-water individuals are rare (7% of the MNI).

Elements represented in the Upper Honda analytical unit are summarized in Table 18. The marine mammal specimens (Pinnipedia, Otariidae) are all from Pit IA; nine of the 10 specimens are from the foot. The sealion individuals include at least one juvenile and one individual whose age cannot be determined but which was at least a subadult if not an adult at death (Table 19). Most of the fish specimens are otoliths (49% of the 662

Table 16. Elements represented (NISP) in Lower Honda Analytical Unit. Format as in Table 10.

Attribution	Otolith	Tooth	Other Cranial	Axial	Appendicular	Foot	Other	Total
UID Mammal		2	5	9		1	1135	1152
Lycalopex cf. *sechurae*						1		1
Pinnipedia					2	6		8
Otariidae			11	2	1	31		45
UID Bird				42	6		175	223
Larosterna inca					10			10
Puffinis cf. *griseus*			7	3	60			70
Sula spp.					6			6
Phalacrocorax spp.			1		1			2
UID Lizard				5				5
Dicrodon sp.			2					2
Chondrichthyes				14				14
Carcharhinidae		4		122				126
Dasyatidae				11				11
UID Actinopterygii	35	12	18	814			378	1257
Albula vulpes	2							2
Engraulidae				116				116
Clupeidae	7			2				9
Ariidae	9		2				1	12
Mugil spp.	4		4	16				24
Serranidae				2				2
Hemanthias peruanus	3							3
Paralabrax spp.	14			2				16
Haemulidae	5		2					7
Anisotremus spp.	10		5	1				16
Isacia conceptionis	2							2
Orthopristis spp.				1				1
Calamus sp.			1					1
Corvina deliciosa	1							1
Cynoscion spp.	237		2	46				285
Larimus cf. *pacificus*	190							190
Menticirrhus spp.	1							1
Micropogonias spp.	3		2					5
Odontoscion spp.	5							5
Paralonchurus spp.	1			1				2
Umbrina cf. *xanti*	64							64
Labridae		49	20	1				70
Total NISP	593	67	82	1210	86	39	1689	3766

fish NISP) and vertebrae (41% of the fish NISP). Evidence of burning is found on 45% of the Upper Honda specimens (excluding UID vertebrate), including eight marine mammal specimens (Table 11).

Summary, Honda Phase

Vertebrate remains in the Lower and Upper Honda analytical units are very similar in most respects (Tables 7–9, 12). Both analytical units are dominated by fishes (96–97% of the MNI) and most of the vertebrates are mixed-water or warm-water animals. Fishes in both analytical units are dominated by the same three drums: seatrouts (*Cynoscion* spp.), Pacific drums (*Larimus* cf. *pacificus*), and Polla drums (*Umbrina* cf. *xanti*).

Table 17. Epiphyseal fusion for Pinnipedia and Otariidae specimens in Lower Honda analytical unit.

Category	Unfused	Fused	Total
Early Fusing:			
Humerus, distal	1		1
Scapula, distal			
Radius, proximal		1	1
Acetabulum			
Metapodials, proximal			
1st/2nd phalanx, proximal	1	5	6
Middle Fusing:			
Tibia, distal			
Calcaneus, proximal	1	1	2
Metapodials, distal	1	2	3
Late Fusing:			
Humerus, proximal			
Radius, distal			
Ulna, proximal			
Ulna, distal			
Femur, proximal			
Femur, distal			
Tibia, proximal	1		1
Total observations	5	9	14

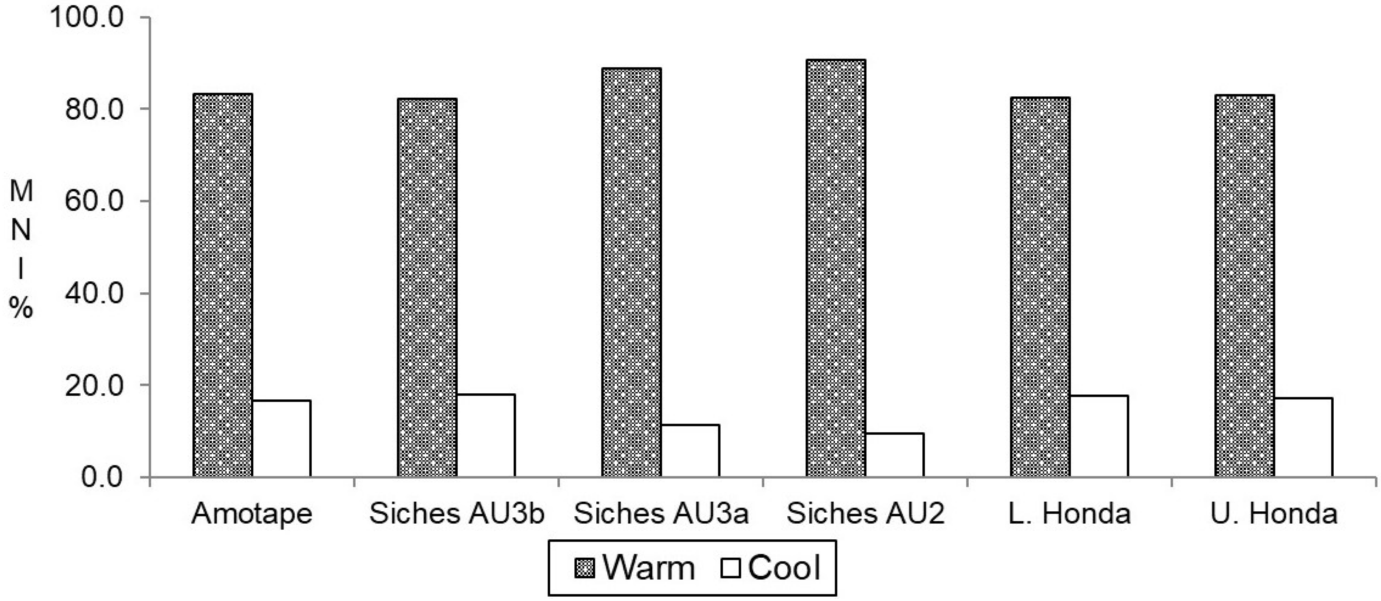

Figure 8. Percentages of vertebrate individuals (MNI) in warm-water and cool-water ecological groups in Sitio Siches collections, excluding Engraulidae and Pozo II.

Table 18. Elements represented (NISP) in Upper Honda analytical unit. Format as in Table 10.

Attribution	Otolith	Tooth	Other Cranial	Axial	Appendicular	Foot	Other	Total
UID Mammal				1			484	485
Pinnipedia						1		1
Otariidae					1	8		9
UID Bird			1	4	1		90	96
Laridae					2			2
Larosterna inca					1			1
Puffinis cf. *griseus*					5			5
Phalacrocorax spp.					1			1
Chondrichthyes				3				3
Carcharhinidae		1		19				20
Dasyatidae				1				1
UID Actinopterygii	38	5	1	214			52	310
Engraulidae				5				5
Clupeidae	2		3	19				24
Ariidae	7							7
Mugil spp.	1							1
Hemanthias peruanus	3							3
Paralabrax spp.	3							3
Anisotremus spp.	10							10
Orthopristis spp.	1							1
Sciaenidae	5							5
Corvina deliciosa	1							1
Cynoscion spp.	169			5				174
Larimus cf. *effulgens*	1							1
Larimus cf. *pacificus*	48							48
Micropogonias spp.	3							3
Odontoscion spp.	1							1
Paralonchurus spp.				5				5
Stellifer spp.	1							1
Umbrina cf. *xanti*	31							31
Labridae			4					4
Total NISP	325	6	9	276	11	9	626	1262

The dominance of mixed-water fishes can be traced to the attribution of *Cynoscion* specimens. Cool-water individuals are rare (9% of the MNI). The mean marine Honda-phase trophic level is 3.3, reflecting the observation that most of the fish individuals are drums and most of these are from trophic levels 3.3 and, especially, 3.4 (Table 12).

Subtle differences exist between the Lower and Upper Honda analytical units (Figs. 5–8; Tables 7–9, 12). The contents of the Lower Honda analytical unit are slightly more diverse and more equitable than the Upper Honda contents. This applies to both the overall vertebrate component (Fig. 5) and to the fish portion of the two analytical units (Fig. 6). Although the mean trophic level is very similar for both analytical units, 54% of the Lower Honda individuals are from trophic level 3.4 compared to 67% of the Upper Honda individuals. The greater emphasis on trophic level 3.4 in the Upper Honda levels is attributable to a marked decline in the percentage of warm-water *Larimus* cf. *pacificus* individuals (from 30% of the fish MNI to 17%) and an increase in the percentage of mixed-water *Cynoscion* spp. individuals (from 42% of the fish MNI to 55%; Table 6). Marine mammals and sea birds are present in both Honda analytical units but terrestrial individuals are present only in the Lower Honda analytical unit (Tables 6–8). The lower diversity and equitability, the slight increase in mean trophic level, and the absence of terrestrial vertebrates in the Upper Honda analytical unit may be due to the difference in sample size; but it also may be part of a broader temporal trend. This possibility is considered in more detail below.

SUMMARY OF SITIO SICHES RESULTS

The Sitio Siches results are summarized as follows:

1. Fishes typical of shallow, warm waters contribute the majority of the taxa and individuals.

2. Rarely were terrestrial animals used at any time, but they are more abundant in the Amotape collection than in the Siches or Honda collections.

3. Terrestrial animals may reflect early, slightly more humid conditions on the coast during the Amotape phase.

4. Large terrestrial game, such as deer, were not used by people living at Sitio Siches at any time.

5. Some marine mammals and marine birds were used, particularly during the Honda occupation.

6. Warm-water fishes constitute 29% of the individuals in the Amotape deposits, 50% of the individual in Siches deposits; and 42% of the Honda individuals.

7. The mean trophic level exploited increases very slightly over time; from 3.2 in the Amotape occupation to 3.3 in the Honda occupation.

8. Seatrouts (*Cynoscion* spp.) from trophic level 3.4 constitute 47% of the Amotape fish individuals and 47% of the Honda fish individuals, after declining to 33% in the Siches-phase collection. Warm-water fishes (*Larimus* cf. *pacificus* and *Umbrina* cf. *xanti*) increase from 7% of the fish individuals in the Amotape phase to 37% of the fish individuals in the Honda-phase collection.

9. The focus on mixed-water seatrouts and the two

Table 19. Epiphyseal fusion for Pinnipedia and Otariidae specimens in Upper Honda analytical unit.

Category	Unfused	Fused	Total
Early Fusing:			
Humerus, distal			
Scapula, distal			
Radius, proximal		1	1
Acetabulum			
Metapodials, proximal			
1st/2nd phalanx, proximal	1	1	2
Middle Fusing:			
Tibia, distal			
Calcaneus, proximal			
Metapodials, distal			
Late Fusing:			
Humerus, proximal			
Radius, distal			
Ulna, proximal			
Ulna, distal			
Femur, proximal			
Femur, distal			
Tibia, proximal			
Total observations	1	2	3

Table 20. Summary of MNI for each phase by class and for Sitio Siches. This table does not include Engraulidae or Pozo II (see Tables 5 and 6 for those data).

	Mammals		Birds		Reptiles		Fishes		Total MNI
Phase	MNI	MNI %	MNI	MNI %	MNI	MNI %	MNI	MNI %	
Amotape	1	2.9			3	8.8	30	88.2	34
Siches			3	0.2	2	0.2	1220	99.6	1225
Honda	5	1.0	13	2.6	1	0.2	489	96.3	508
Sitio Siches total	6	0.3	16	0.9	6	0.3	1739	98.4	1767

warm-water fishes in the Honda phase is associated with low diversity and equitability.

10. These differences likely reflect cultural responses to mid-Holocene environmental changes between 6000 and 5000 ^{14}C B.P. (~6800 and 5700 cal B.P.), with some evidence of this change observed in the late Siches-phase occupation.

11. People living at the site during the Amotape phase fished in warm marine waters.

12. People living at the site during the Siches phase fished in even warmer waters. Variations in fishing strategies during the Siches phase may be responses to sharper annual or seasonal deviations than were experienced during the Amotape or Honda occupations.

13. The Honda collection reflects modern conditions of mixed waters trending to the cooler side at the frontier between the Peru-Chilean and Panamanian provinces.

FISHING ON THE FRONTIER: SITIO SICHES

The following review is based on the premise that the people who lived at Sitio Siches did so year-round for generations and fished for a living, in addition to using terrestrial resources such as plants. Marine invertebrates and marine vegetation were additional attractions accessible from the Sitio Siches location. Fishing was clearly prominent in the local economy (Fig. 9; Table 20). Access to fish and other marine resources was undoubtedly the reason people lived on the coast; the permanent water seep at the head of the Siches quebrada explains the site's specific location. Sitio Siches was not unique in this. All zooarchaeological assemblages reviewed in this report clearly demonstrate that from the very beginning of our record, people skillfully and consistently used marine vertebrates (Table 4). Although quantified invertebrate data are not available for most of the assemblages reviewed here, the abundance of invertebrates at the sites themselves strengthens this assessment (see references in Table 1). Fishing requires a great deal of skill to be successful, measured in terms of the size of the catch, maintaining equipment in good condition, and the survival of the fishing party in an unforgiving sea. People at Sitio Siches were not novices at fishing; they pursued a variety of sophisticated methods to reduce risks and manage their time, labor, and other resources.

It is not uncommon for interpretations of coastal sites to assume explicitly or implicitly that fishing was but one part of seasonal round of hunting, gathering, or farming. We observe that people who fish are highly protective of good fishing grounds and unlikely to leave them, or their fishing gear, unprotected to avoid being usurped by someone else. Nor is it likely that early Americans were unskilled at fishing. If the growing body of evidence for people entering this hemisphere along a Pacific coast route during the terminal Pleistocene (e.g., Dillehay et al., 2008; Braje et al., 2017; Scheib et al., 2018) is accurate (and we agree that it is), then people had thousands of years of coastal

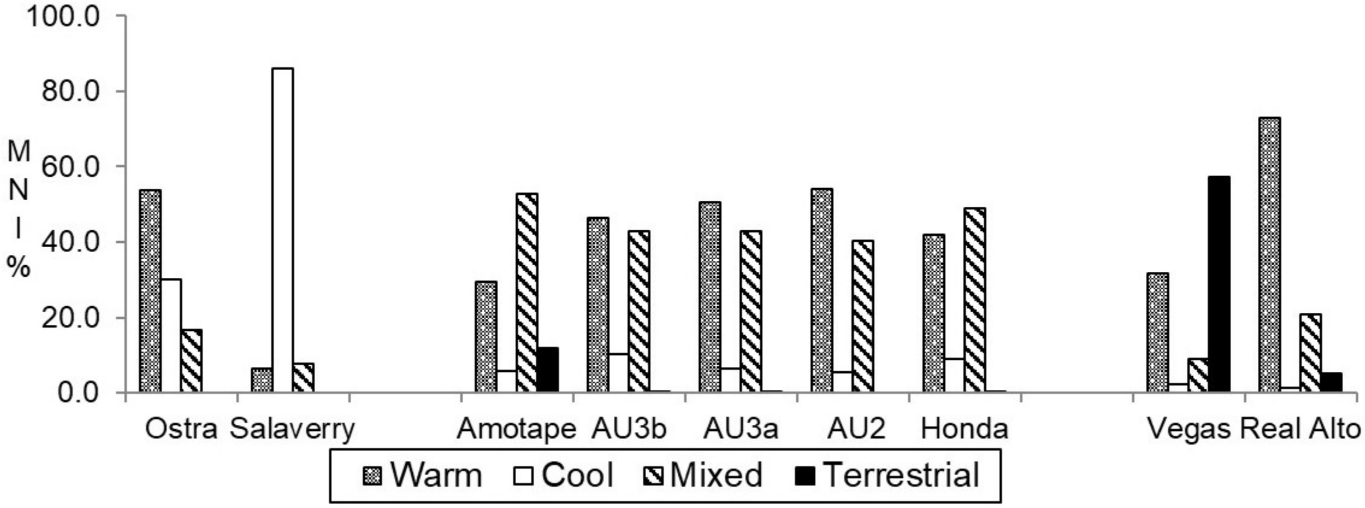

Figure 9. Percentages of vertebrate individuals (MNI) in ecological groups in Sitio Siches compared to these groups in coastal Peruvian and Ecuadorian zooarchaeological assemblages from the northern Peru-Chilean Province and the Panamanian Province. Sites and collections arranged chronologically within each section. Sitio Siches data do not include Engraulidae or Pozo II. See Figure 1 for locations.

experience upon which to build. By the time people reached Perú they possessed a deep tradition of accumulated knowledge, technologies, and social institutions upon which to draw. This was a resource base that the ancestors of people living at Sitio Siches had relied upon for thousands of years.

The focus on marine resources by people living at Sitio Siches is highlighted by the observation that only six of the 11 mammal, bird, and reptile taxa (i.e., richness) in the Sitio Siches assemblage are from terrestrial habitats (Tables 6, 21). The only exclusively terrestrial animals in the assemblage are rodents, desert foxes, song birds, cañan lizards, and non-poisonous snakes. Only cañan lizards are present in deposits from all three phases. In terms of the dominant vertebrate class, 75% of the taxa are fishes (Table 22).

Use of terrestrial resources probably was far more common in the Amotape phase than during the Siches or Honda phases and associated with cañan lizards. One generally would expect a collection as small as that representing the Amotape phase to contain fewer taxa compared to larger collections and it would not be expected to contain novel taxa. Both richness and diversity are often depressed in such small collections. The higher diversity of the Amotape collection compared to the lower diversity of the much larger Honda-phase collections (Figs. 5–6; Table 12) lends some credibility to the conclusion that sample size is unlikely to be the only explanation for the higher use of terrestrial resources during the Amotape phase compared to the later Siches or Honda phases.

Nonetheless, cañan lizards could be intrusive into the Amotape levels given their habit of burrowing into sandy soils. Although it is not possible to eliminate bioturbation as an explanation for the presence of lizards in the Amotape deposits, all 17 of the Amotape cañan specimens are from pit features (FN 18, 40, 89, 91, 136, 143). By contrast, only three specimens in Siches analytical unit 3b (FN 32, 50, 104) and eight specimens in Siches analytical unit 3a (FN 87, 102, 104) are from features. Neither of the Lower Honda specimens is from a feature (I-A-7B; I-B-7). Although the Siches and Honda specimens may represent lizards that burrowed into the archaeological levels either in the past or recently; it seems less likely that the Amotape lizards are intrusive from later occupations. The post-Amotape decline in lizards may indicate that lizards were less attractive as food or medicinal sources after the Amotape phase, but later depictions on Moche jars and their role in post-Columbian dietary and medicinal practices

Table 21. Richness of ecological groups for each phase and for Sitio Siches. Richness is the number of taxa for which MNI is estimated in each category. This table does not include Engraulidae or Pozo II (see Tables 5 and 6 for those data).

Ecological Group	Terrestrial		Warm-water		Cool-water		Mixed-water		Total Richness
Phase	# taxa	%	# taxa	%	# taxa	%	# taxa	%	
Amotape	3	17.6	9	52.9	2	11.8	3	17.6	17
Siches	3	8.8	18	52.9	7	20.6	6	17.6	34
Honda	2	6.7	11	36.7	9	30.0	8	26.7	30
Sitio Siches total	6	13.6	19	43.2	9	20.5	10	22.7	44

Table 22. Richness of classes for each phase and for Sitio Siches. This table does not include Engraulidae or Pozo II (see Tables 5 and 6 for those data).

Phase	Amotape		Siches		Honda		Sitio Siches	
Class	# taxa	%	# taxa	%	# taxa	%	# taxa	%
Mammals	1	5.9			2	6.7	3	6.8
Birds			3	8.8	4	13.3	6	13.6
Reptiles	2	11.8	1	2.9	1	3.3	2	4.5
Fishes	14	82.4	30	88.2	23	76.7	33	75.0
Total richness	17		34		30		44	

suggest that lizards continued to be used elsewhere (Holmberg, 1957).

Other explanations for the lizard decline include changing availability due to decreasing precipitation and/or cultural preference. Lizards were the primary terrestrial prey for the Paiján people contemporary with the Amotape occupation at Sitio Siches and much less common subsequently. Analysis of the avifauna (Campbell, 1982) and insect fauna (Churcher, 1966) from the Pleistocene-age Talara Tar Seeps, about 30 km south of Sitio Siches, indicates that conditions were wetter at that location at the end of the Pleistocene than they are at present. Richardson (1973; Richardson et al., 1996; Sandweiss, 2003) concludes that the Late Pleistocene climate near Sitio Siches was more humid than it is today. If cañan lizards are not intrusive into Amotape deposits, they and the other terrestrial animals in the Amotape collection may be evidence that conditions continued to be wetter than present into the early Holocene, between 9500 and 9000 ^{14}C B.P. (~10,700 and 10,100 cal B.P.). This is consistent with Chauchat's (Chauchat, 1992; Pelegrin and Chauchat, 1993) interpretation of the Paiján environment as less arid than at present, in part because lizards were such common prey for Paiján people. The percentage of mammal and reptile individuals in the Sitio Siches assemblage (i.e., MNI; Table 20) clearly declines after the Amotape occupation, as does the number of taxa in the terrestrial ecological group (i.e., richness; Table 21). This suggests that the Sitio Siches landscape was less favorable for terrestrial animals, including lizards, after 9000 ^{14}C B.P. (~10,100 cal B.P.), particularly during the Honda phase.

If lizards were deliberate prey during the Amotape phase at Sitio Siches and at sites in the Paiján complex, as seems likely, the relative abundance of fishes compared to lizards in the two assemblages may reflect the distance to the sea when the Paiján and Sitio Siches sites were active. Paiján fishing sites are unknown but must have existed given the presence of marine fauna in that assemblage. It seems likely that Paiján-era sites occupied by fishing communities are now submerged under the rising sea. Paiján sites are associated with a wide continental shelf and coastal plain; even today these sites generally are located some distance from the sea. In contrast, the continental shelf and coastal plain is very narrow near Sitio Siches, which remains near the shoreline. Due to this coastal topography, the Amotape-phase materials have survived as a record of a north-coast, Paiján-era fishing economy.

The richness of the Sitio Siches marine assemblage (number of marine taxa = 38; Tables 3, 21–22) might suggest that people caught whatever they could, but further consideration indicates that conclusion is incorrect. Given the wealth of the sea (e.g., Chirichigno, 1982; Appendix 1), the Sitio Siches assemblage reflects a strategy intentionally designed to catch drums, specifically seatrouts, with other marine taxa taken as by-catch. This catch was supplemented by the occasional terrestrial mammal, bird, or reptile. In all three phases, members of the genus *Cynoscion* contributed at least a quarter of the individuals (Table 6). This does not suggest occasional visits by landlubbers or adventurous foragers taking advantage of fishes blown onto the beach by a storm, but a skilled fishing community whose members knew which animals were desirable as well as how, when, and where to acquire them; guided by cultural institutions supporting this risky endeavor. A similar focus on drums characterizes the Late Pleistocene deposits from Quebrada Jaguay as well as those from the Ring Site contemporary with Siches (Sandweiss et al., 1996; Reitz et al., 2017). Both sites are in southern Perú (Fig. 1), suggesting a widespread, targeted interest in this specific coastal resource during the Late Pleistocene, an interest that continued into the Holocene.

Warm-water individuals, members of the ecological group characteristic of the Panamanian province, are abundant in the Sitio Siches assemblage and individuals in the cool-water ecological group typical of the Peru-Chilean province are not, particularly in the Amotape collection (Figs. 9–10; Tables 23–24). The percentage of warm-water individuals increases from the Amotape collection (29% of the individuals) to 50% of the individuals in the Siches collection and declines to 42% of the individuals in the Honda collection (Table 23). Less than 9% of the individuals are members of the

Table 23. Summary of ecological group MNI for each phase and for Sitio Siches.This table does not include Engraulidae or Pozo II (see Tables 5 and 6 for those data).

Ecological Group	Terrestrial		Warm-water		Cool-water		Mixed-water		Total MNI
Phase	MNI	MNI %	MNI	MNI %	MNI	MNI %	MNI	MNI %	
Amotape	4	11.8	10	29.4	2	5.9	18	52.9	34
Siches	4	0.3	615	50.2	86	7.0	520	42.4	1225
Honda	2	0.4	213	41.9	45	8.9	248	48.8	508
Sitio Siches total	10	0.6	838	47.4	133	7.5	786	44.5	1767

cool-water group during any of the three phases. It seems very likely that most of the *Cynoscion* in the Sitio Siches assemblage either were animals typical of warm waters, such as *C. analis*, or were other members of this genus tolerant of variable water conditions that are primarily warm, particularly during the Amotape and Siches phases. The dominance of a genus tolerant of a wide range of environmental conditions suggests waters adjacent to the site were subject to periodic variations in environmental conditions, as does the presence of high percentages of mixed-water individuals.

As part of this trend, warm-water drum individuals increase from 19% of the drum individuals in the Amotape collection to 48% in the Siches collection, and then decline slightly to 44% in the Honda collection (Fig. 11; Table 25). Some of the Siches-phase increase reflects the attribu-

Table 24. Summary of warm-water and cool-water MNI for each phase and for Sitio Siches. This table does not include Engraulidae or Pozo II (see Tables 5 and 6 for those data).

Phase	Amotape		Siches		Honda		Sitio Siches	
Ecological groups	MNI	MNI %	MNI	MNI %	MNI	MNI %	MNI	MNI %
Warm-water	10	83.3	615	87.7	213	82.6	838	86.3
Cool-water	2	16.7	86	12.3	45	17.4	133	13.7
Total MNI	12		701		258		971	

Table 25. Ecological groups of drum (Sciaenidae) MNI in each phase. This table does not include Pozo II. See Tables 5 and 6 for those data.

Phase	Amotape		Siches		Honda	
Ecological Group	MNI	MNI%	MNI	MNI%	MNI	MNI%
Warm-water						
Bairdiella cf. *ensifera*			2	0.2		
Cynoscion cf. *analis*			125	12.3		
Cynoscion cf. *stolzmanni*			3	0.3		
Larimus cf. *acclivis*			16	1.6		
Larimus cf. *effulgens*			7	0.7	1	0.2
Larimus cf. *pacificus*	1	4.8	137	13.5	126	29.8
Micropogonias spp.	1	4.8	78	7.7	4	0.9
Odontoscion spp.	1	4.8	39	3.8	4	0.9
Ophioscion spp.			4	0.4		
Umbrina cf. *xanti*	1	4.8	77	7.6	53	12.5
Cool-water						
Corvina deliciosa			2	0.2	2	0.5
Paralonchurus spp.			11	1.1	2	0.5
Mixed-water						
Cynoscion spp.	14	66.7	407	40.1	229	54.1
Menticirrhus spp.				0.0	1	0.2
Stellifer spp.	3	14.3	107	10.5	1	0.2
Total drum MNI	21		1015		423	

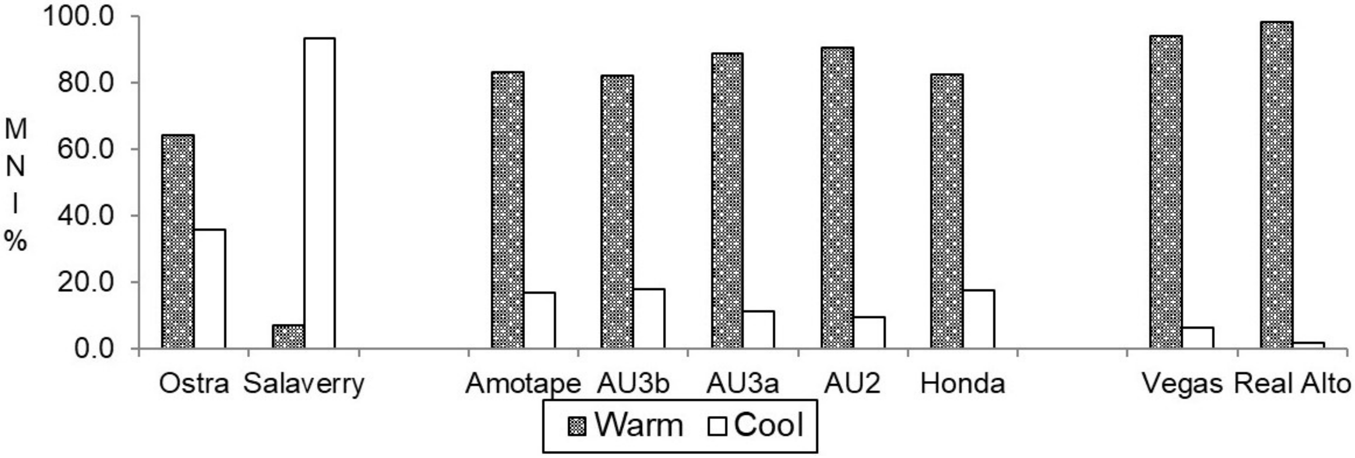

Figure 10. Percentages of vertebrate individuals (MNI) in warm-water and cool-water ecological groups in Sitio Siches compared to these groups in coastal Peruvian and Ecuadorian zooarchaeological assemblages from the northern Peru-Chilean Province and the Panamanian Province. Sites and collections arranged chronologically within each section. Sitio Siches data do not include Engraulidae or Pozo II. See Figure 1 for locations.

tion of many fish specimens to a lower-level taxon (*Cynoscion* cf. *analis*), which is not present in the Amotape collection, constitutes 10% of the Siches-phase vertebrate individuals, and is absent in the Honda collection (Table 6). The warm-water Pacific drums (*Larimus* cf. *pacificus*) and Polla drums (*Umbrina* cf. *xanti*) increase over time. Much of this variability can be attributed to the greater richness of the Siches-phase collection, which contains 14 drum taxa compared to six in the Amotape collection and 10 in the Honda collection (Table 25).

With only a few exceptions, this suggests a progression in the use of warm-water resources from the Amotape phase through the Siches phase and increased use of animals in the mixed-water ecological groups during the Honda phase. This also suggests variable marine conditions best tolerated by animals characterized by flexible niche and habitat preferences. If this interpretation is correct, waters were primarily warm throughout the sequence, but were warmer, or more frequently warmer, during the Siches phase. This condition persisted for most of the Siches phase but was followed by cooler or more unstable conditions in the Honda phase.

Anchovies (Engraulidae) are excluded from this analysis because of differences in the 1995 and 2001 field methods. The difference between the number of anchovies in the Honda-phase collection excavated in 1995 (NISP = 121) and the Amotape/Siches collections (NISP = 16,091) excavated in 2001 almost certainly is because anchovy otoliths were not recognized in 1995 when the Honda deposits were excavated (Tables 16, 18). This precludes studying the role of these small fishes for the full occupational sequence.

The role of anchovies (Engraulidae) in the Amotape/Siches sequence can be considered because the field crew recognized anchovy otoliths and vertebrae in the fine-screen samples during the 2001 field season when these materials were collected. Anchovies constitute 32% of the 2001 Amotape-phase individuals, peak at a high of 46% of the individuals in the earliest Siches-phase deposits (AU 3b) and decline to 31% of the individuals in the last Siches-phase collection (AU 2; Table 26). Given the virtual absence of other cool-water members of the Peru-Chilean ecological group and the abundance of vertebrates more typical of the warm-water Panamanian province, it seems likely that the anchovies in the Sitio Siches assemblage are warm-water species though this cannot be determined from the identifications. If that is true, then the trend for increased use of warm-water habitats described above suggests that water conditions would be described as persistently, but increas-

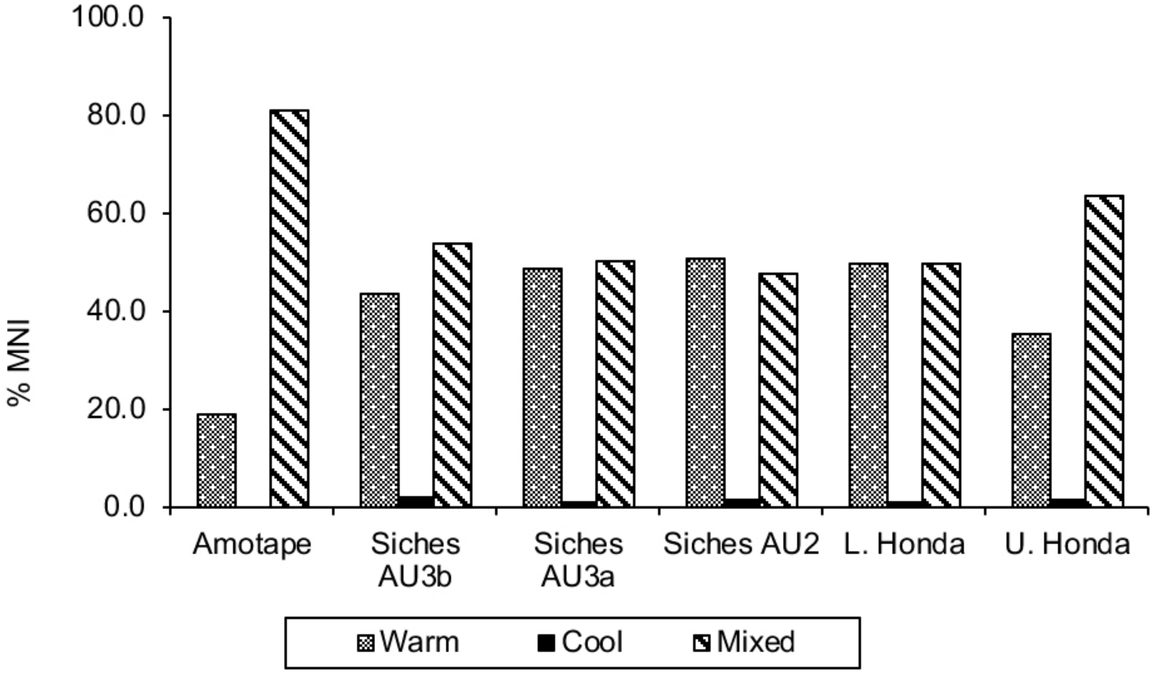

Figure 11. Variation in ecological groups for drums (Sciaenidae) in collections from Sitio Siches.

ingly, warm until the last centuries of the Siches-phase sequence, when they began to become more frequently or persistently cooler.

These proposed changes in water conditions are reflected in the mean trophic levels estimated for each phase and the trophic levels from which most of the fishes were taken (Fig. 12; Table 27). With anchovies (Engraulidae) excluded in order to examine the full stratigraphic sequence, the mean trophic level of the catch increased slightly from the Amotape phase (TL = 3.25) into the Honda phase (TL = 3.53), reflecting an increase in the use of drums from trophic level 3.4. This increase in higher-trophic-level drums persists throughout the occupational sequence from the Amotape phase through the subsequent Siches and Honda analytical units (Table 12). Furthermore, the practice of using fish from several trophic levels during the Amotape phase contrasts with the emphasis on trophic levels 3.3 and 3.4 during the Honda phase. Approximately 20% of the Amotape fish individuals are from trophic levels below 3.3, compared to 10% in the Siches-phase collection and 5% in the Honda-phase collection. Use of fishes from trophic levels above 3.4 was similar in the Amotape and Siches occupations (7% of the MNI); but use of higher-trophic-level fishes increased in the Honda phase (9% of the MNI).

As the use of animals from higher trophic levels came to dominate the fishing effort at Sitio Siches, diversity and equitability declined (Fig. 13; Table 27). The decline in fish diversity is particularly interesting when sample size is considered because often diversity increases as sample size and richness increase. In this case, however, fish diversity in the small Amotape collection is more similar to that in the much larger Siches-phase collection and is much higher than in the larger Honda collection. Low diversity and equitability in a larger collection is further evidence that the Honda fishing effort focused on a single taxon, probably fishes common in a specific habitat and susceptible to a specific fishing technique (Tables 12, 27). In contrast, the strategy during the Amotape phase was more general, using few fish taxa but more evenly. The shift from this generalist strategy to a focused one can be seen in the Siches-phase collection and is pronounced in the Honda collection. This applies both to fishing effort as well as to the use of other vertebrates.

Table 26. Summary of anchovy (Engraulidae) and drum (Sciaenidae) MNI for ecological groups in Amotape- and Siches-phase analytical units. This table does not include data for the Honda phase or Pozo II (see Tables 5 and 6 for those data).

Phase	Amotape		Siches AU 3b		Siches AU 3a		Siches AU 2	
Dates, B.P.	9500-9000		7100-6400		6300-6100		ca. 6000	
Ecological Group	MNI	MNI %	MNI	MNI %	MNI	MNI %	MNI	MNI %
Rodents, birds, reptiles	4	8.0	2	0.5	3	0.2		
Engraulidae	16	32.0	205	46.4	572	41.9	88	31.0
Warm-water drums	4	8.0	81	18.3	325	23.8	82	28.9
Cool-water drums		0.0	4	0.9	7	0.5	2	0.7
Mixed-water drums	17	34.0	100	22.6	337	24.7	77	27.1
Other fishes	9	18.0	50	11.3	120	8.8	35	12.3
Total MNI	50		442		1364		284	

Table 27. Summary of richness, diversity (H'), equitability (V'), and trophic levels (TL) for each phase using MNI. Trophic level data from Froese and Pauly (1998, 2004). Data do not include Engraulidae or Pozo II.

Category	Amotape	Siches	Honda
MNI Total	34	1225	508
Total Richness	17	34	30
MNI Diversity	2.2612	2.3815	1.8494
MNI Equitability	0.7981	0.6753	0.5438
Fish MNI	30	1220	489
Fish Richness	14	30	23
Fish Diversity	2.0136	2.3592	1.6892
Fish Equitability	0.7630	0.6936	0.5387
Mean Fish TL	3.250	3.325	3.353
% fish MNI in each trophic level:			
Trophic Level:	% MNI	% MNI	% MNI
2.0	6.7	1.5	1.0
2.6	3.3	0.9	1.2
3.0	3.3	3.3	0.4
3.1	3.3	1.8	0.4
3.2	3.3	2.2	2.0
3.3	23.3	32.9	27.8
3.4	50.0	50.8	58.5
3.5	3.3	5.9	7.0
3.6-4.0	3.3	0.7	1.6

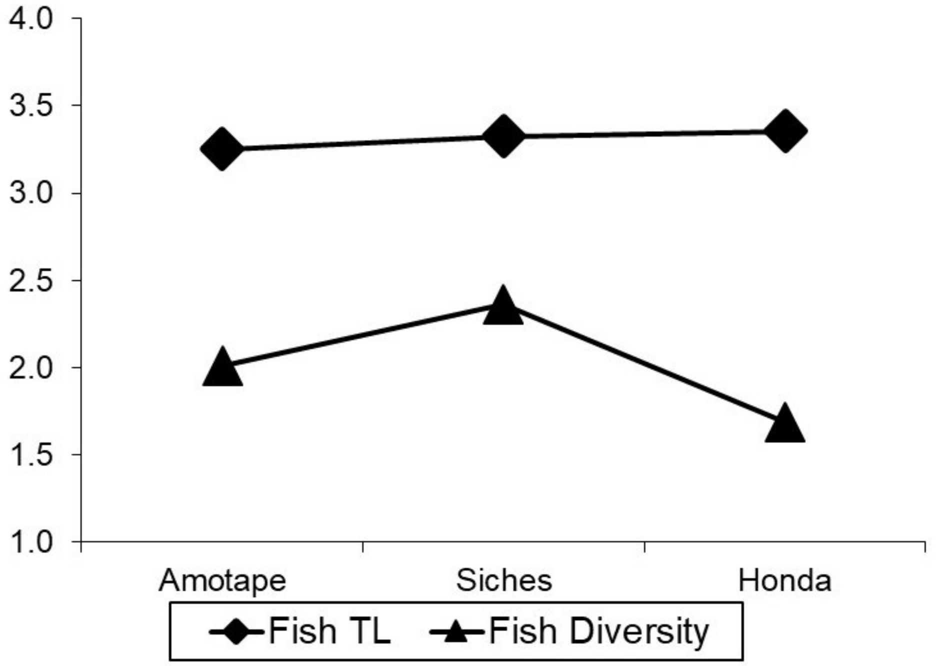

Figure 12. Fish mean trophic level (TL) and diversity (H') for the three phases at Sitio Siches, excluding Engraulidae and Pozo II. See Table 27 for details.

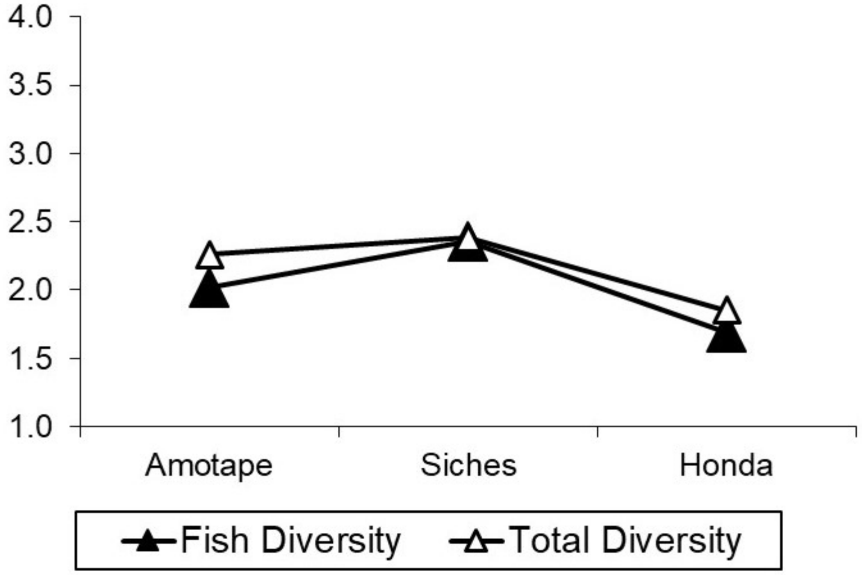

Figure 13. Fish and total diversity (H') for the three phases at Sitio Siches, excluding Engraulidae and Pozo II. See Table 27 for details.

The lower diversity and equitability of the Honda collection, combined with an emphasis on high-trophic-level fishes, may reflect a change in marine conditions, particularly in light of contemporaneous changes in the marine ecological groups and trophic levels exploited. Although molluscs are not examined as part of the formal zooarchaeological study, it is important to note that only warm-water and mixed-water molluscs were encountered in the Lower Honda deposits and in the Siches-phase deposits of Pozo II (Richardson, 1973; Richardson et al., 1996; Sandweiss, 2003). Cooler-water molluscs were more common in the Upper Honda levels. We see a similar decline in the warm-water vertebrates present in the Lower and Upper Honda collections, though cool-water vertebrates also decline. This decline occurs in the context of an increase in mixed-water vertebrates (Fig. 7; Table 8). Populations of sessile molluscs respond to unfavorable conditions by not reproducing and larvae will not settle in unfavorable areas. As recruitment becomes limited or even unsuccessful, local mollusc populations may decline. The fishes used at Sitio Siches, however, are widespread, eurytopic animals, ones that tolerate a broad range of environmental conditions. They are unlikely to be as sensitive to changing water conditions as sessile organisms might be and the responses of fishes to gradual or modest changes in water conditions may be slower and less obvious. Thus, the response of molluscs to cooling waters might be more immediate than would be the response of mobile fishes; but the increase in mixed-water vertebrates could be another aspect of such a phenomenon.

The preference of the dominant drums (*Cynoscion* cf. *analis*; *Larimus* cf. *pacificus*; and *Umbrina* cf. *xanti*) for relatively shallow waters of the warm-water Panamanian province and the very northern portion of the Peru-Chilean province suggests that a similar habitat existed when Sitio Siches was occupied and that conditions were very favorable for these three drums between roughly 7100 and 6000 ^{14}C B.P. (~7900 and 6800 cal B.P.). As acknowledged earlier, the classification of animals into ecological groups using modern biogeography must be viewed with caution because all of these animals can be found in other locations today and also may have changed their habitat preferences and niches over the intervening millennia, at least slightly. This is particularly the case for members of the genus *Cynoscion*. *Cynoscion* spp. are present in Peruvian zooarchaeological assemblages as far south as Quebrada de los Burros (Fig. 1; Béarez, 2000, 2012; Lavallée et al., 2011); but the species *C. analis* seldom is reported in southern assemblages. When it is present, it is a minor component (e.g., Lo Demas [Sandweiss, 1992:115–116], Quebrada de los Burros [Béarez, 2000, 2012]). *Larimus* cf. *pacificus* and *Umbrina* cf. *xanti* are stronger markers for warm-water conditions than is *Cynoscion* cf. *analis*. The steady increase of these two, small, clearly warm-water drums and the decline in terrestrial vertebrates suggest warmer coastal waters and slightly more humid conditions prevailed during the Amotape occupation; warmer, perhaps drier, conditions during the Siches occupation, and cooler, perhaps even drier, conditions prevailed during the Honda occupation. Throughout the occupation of Sitio Siches, however, conditions were more similar to those in the southern Panamanian province (to which the site currently belongs) than those in the Peru-Chilean province.

Fisheries research shows that temperature changes of only a few degrees can fundamentally alter a marine ecosystem (Chavez et al., 1999, 2003; Attrill and Power, 2002; Greene, 2002; Sandweiss et al., 2004). Changes in sea surface temperature (SST) such as those suggested by the Siches otolith geochemistry (Andrus et al., 2002) might alter the productivity of coastal waters, the reproductive and growth habits of traditional prey vertebrates, the distribution of these animals, and the trophic structure of near-shore waters. The decline in diversity evident in the Honda-phase collections and the increased use of a higher-trophic-level drum from the mixed-water ecological group suggests an altered marine ecosystem reflecting temperature changes.

It also seems likely that a wider annual variation in water temperatures would increase local diversity as a greater seasonal replacement in vertebrate composition might occur. This seems to be the case at the mid-Holocene Ostra Base Camp (Reitz and Sandweiss, 2001), where otolith geochemistry indicates enhanced seasonality (Andrus et al., 2002).

Thus far, the discussion has focused on environmental changes and presumed cultural responses. The possibility that the fishing strategy itself changed over time should not be discounted, however. The trends observed suggest a change in technology, particularly between the Amotape and Siches phases. If, as seems possible, the engraulids in the Siches- and Amotape-phase collections are warm-water, Panamanian province anchovies rather than members of the cool-water Peru-Chilean province ecological group, they probably were caught in shallow, near-shore waters with nets, scoops, and similar devices. Other smaller warm-water fishes (e.g., sea catfishes [Ariidae], mullets [*Mugil* spp.], and small drums [Sciaenidae]) could be taken with these same hand-held devices or could be captured in shallow waters with mass-capture techniques such as trotlines, seine nets of various designs, weirs, and traps. Larger/older drum individuals were more likely taken in deeper waters with more substantial gear such as weirs in tidal areas, setlines with gorges or hooks in deeper waters, or leisters in shallow waters. The higher fish diversity in the Siches-phase collections may reflect a fishing technology that included tools and strategies designed to capture both large seatrouts and small anchovies. The richness of the by-catch is a strong argument for mass-capture devices. Much of the evidence for these devices would be invisible archaeologically to the extent they were lost or destroyed during use at the coast or manufactured from fugitive organic materials. This interpretation does not preclude the likelihood that technological changes took place within a changing marine environment.

SITIO SICHES IN THE BROADER CONTEXT

The goal of the Sitio Siches vertebrate analysis is to discover whether ecological shifts observed in molluscs from sites on the northern Peruvian coast are evident in vertebrates from Sitio Siches and, if so, whether Sitio Siches contributes to understanding the location and timing of ecological shifts along the Peruvian coast. We approached this goal by defining ecological groups of animals characteristic of distinct ecological zones and observing changes in the relative abundance of these groups in preceramic Peruvian vertebrate assemblages. We conclude that preceramic Peruvian assemblages reflect location, time period, and ecological shifts. South of 12° S latitude, animals characterized as members of the cool-water/Peru Current ecological group comprise over 96% of the warm- or cool-water individuals (Fig. 2; Table 2). Assemblages from sites between 10° S and 8° S latitude (Paiján, Almejas, and Ostra Base Camp) deposited prior to ca. 5000 ^{14}C B.P. (~5700 cal B.P.) contain fewer cool-water animals than do more recent assemblages in the same area (e.g., Alto Salaverry, Los Morteros). In the Panamanian province, marine animals recovered from Real Alto and Las Vegas are primarily warm-water taxa. Sitio Siches lies within a transition zone between these two provinces and the animals used at the site reflect this frontier setting.

A common feature shared by the early- and mid-Holocene archaeological assemblages from the northern Peru-Chilean province and the southern Panamanian province is the prominence of animals from the warm-water ecological group in assemblages from sites above 10° S latitude in the early part of the sequence (Figs. 9–10; Tables 2, 4). The identity of the taxa dominant in assemblages from these sites, however, suggests environmental conditions between 10°–8° S latitude and 4°30′–2° S latitude were distinct.

The occupation at Ostra Base Camp occurred shortly before the regional transition to cooler waters ca. 5000 ^{14}C B.P. (~5700 cal B.P.). Otolith geochemistry for the site suggests a higher seasonal SST amplitude prevailed during the mid-Holocene occupation compared to conditions prevailing today (Andrus et al., 2002). Bonefishes (*Albula vulpes*), sea catfishes (Ariidae), and mullets (*Mugil* spp.) contribute 35% of vertebrate individuals in the Ostra assemblage. No Pacific drums (*Larimus* cf. *pacificus*) or Polla drums (*Umbrina* cf. *xanti*) are present and seatrouts (*Cynoscion* spp.) are minor components. Another third of the vertebrate individuals prefer cool waters (30%; Fig. 9; Table 4). Although it is likely that warm-water habitats, such as a shallow bay, were present near Ostra when it was occupied, it is unlikely that marine waters outside the bay were as persistently warm or as stable as those prevailing at Sitio Siches.

The youngest Siches-phase collection (AU

2) is roughly contemporaneous with the Ostra assemblage and contains the highest percentage of warm-water individuals in the Sitio Siches assemblage (Fig. 9; Table 8). This percentage (54%) is remarkably similar to the percentage of warm-water individuals in the Ostra assemblage (53%). Most of the AU 2 warm-water fishes, however, are drums, particularly seatrouts (*Cynoscion* spp.), Pacific drums (*Larimus* cf. *pacificus*), Polla drums (*Umbrina* cf. *xanti*), and tallfin croakers (*Micropogonias* spp.*)*. The bonefishes (*Albula vulpes*), sea catfishes (Ariidae), and mullets (*Mugil* spp.) that dominate the Ostra assemblage contribute only 7% of the individuals in the AU 2 collection. Further, the percentage of mixed-water individuals (40%) in AU 2 is higher than that of cool-water individuals (6% of the MNI), indicative of a frontier zone between the northern Peru-Chilean Province and the Panamanian Province.

Both the Ostra assemblage and Siches-phase AU 2 collection stand in stark contrast to assemblages from Las Vegas and Real Alto (a contemporary and a later site further north) and Alto Salaverry (a later site located further south). They also are distinct from Los Morteros (Mauricio Llonto, 2015). Los Morteros was not reviewed earlier because it was studied under different protocols; but it is relevant here. The site is associated with the Pampa de las Salinas complex in the lower Chao Valley, ca. 5 km from the modern coastline and ca. 28 km north-northeast of Ostra (Fig.1; Sandweiss et al., 1983). Most of the faunal remains were in deposits that two radiocarbon dates suggest formed between 5570–5041 cal B.P. and 5469–5050 cal B.P. (Mauricio Llonto, 2015:411–416). These date about 700 years after Ostra (ca. 7100–6200 cal B.P.), and shortly after the climatic transition at about 5700 cal B.P. (see also Andrus et al., 2003:Figure 3 for dates on warm-, cool-, and mixed-water molluscs from non-archaeological deposits at the Salinas de Chao). The Morteros fish assemblage is dominated by cool-water forms (Mauricio Llonto, 2015:274).

In many respects, the Sitio Siches assemblage is more similar to the early Holocene Las Vegas or Middle Valdivia Real Alto assemblages in the Panamanian province. Even so, differences in the types of warm-water vertebrates exist. In the Ecuadorian assemblages, sea catfishes (Ariidae) and drums (Sciaenidae) are equally common (Las Vegas; 10% and 11% of the Las Vegas MNI respectively) or sea catfishes are much more common than drums (Real Alto; 49% and 13% of the Real Alto MNI respectively). Bonefishes (*Albula vulpes*) and anchovies (Engraulidae) are not present in either assemblage and mullets (*Mugil* spp.) are rare. Many of the warm-water fishes present in both assemblages are absent or rare in assemblages from further south (e.g., snooks [*Centropomus* spp.], snappers [Lutjanidae], yellow-eyed croakers [*Odontoscion* spp.]). No *Umbrina* are present in either Panamanian-province assemblage; *Cynoscion* and *Larimus* are minor members.

A feature shared by all of the coastal vertebrate assemblages, regardless of the province in which they are classified here, is the decline in terrestrial animals between early assemblages (Quebrada Jaguay, Paiján, Las Vegas) and later ones (Fig. 3; Table 4). Terrestrial animals in the Paiján complex are primarily lizards (70% of the individuals) whereas the terrestrial animals in Las Vegas are rodents and foxes (36% of the individuals). Deer are present in both the Paiján and Las Vegas assemblages but contribute less than 2% of the individuals. The Paiján complex lies much further from the shoreline than do either Las Vegas or Sitio Siches, so the dominance of terrestrial forms in Paiján samples is not surprising. Probably more interesting is the prominence of lizards in the Paiján complex and the virtual absence of terrestrial animals in the other assemblages reviewed here. This same decline in members of the terrestrial ecological group also is found in the stratified Sitio Siches deposits.

After 5000 ^{14}C B.P. (~5700 cal B.P.), marine resource use in the northern Peru-Chilean province emphasized members of the cool-water ecological group (e.g., Alto Salaverry); but members of the warm-water group continued to dominate assemblages in the Panamanian province. Although the decline in warm-water individuals between 6000 and 5000 ^{14}C B.P. (~6800 and 5700 cal B.P.) is less dramatic at Sitio Siches than it is after 5000

^{14}C B.P. among assemblages from sites located between 10° S and 8° S latitude, the percentage of warm-water individuals is nonetheless lower in the Honda-phase collection than in the preceding Siches-phase collection (Table 23). This suggests warmer waters or more sharply seasonal fluctuations in water temperatures prevailed during the Siches phase than during the Honda phase when water conditions were similar to their current status. The Honda conditions are likely typical of sites at the southern end of the Panamanian province after 5000 ^{14}C B.P. (~5700 cal B.P.). Warm-water individuals are even more abundant in the Real Alto assemblage than in the Honda-phase collection when mixed-water animals are removed from consideration (Table 2). The abundance of mixed-water animals, however, may be more informative than appears at first glance. Members of this group are ones that are most likely to be cosmopolitan and tolerant of a wide range of water conditions. Some, such as marine mammals and birds, also are highly mobile and able to take advantage of short-term as well as long-term changes in the marine environment. The use of eurytopic animals tolerant of a broad range of environmental conditions at Sitio Siches and Real Alto probably reflects on-going changes in the coastal environment.

Several other explanations offer themselves for this pattern. One of these is recovery technique. It is highly probable that the low numbers of anchovies and herrings in some assemblages, such as in the Almejas 6.35-mm fraction and the 1995 samples from Sitio Siches, are due to field methods. Much of this pattern, however, reflects changes in the types of larger fishes represented (bonefishes [*Albula vulpes*], sea catfishes [Ariidae], drums [Sciaenidae], and mullets [*Mugil* spp.]), which are unlikely to be as biased by a 6.35-mm screen as anchovies would be. Nonetheless, tests of the hypothesis proposed here should be constructed using large data sets rigorously and consistently collected with fine-screen recovery methods.

Among the potential cultural explanations is the possibility that people along this stretch of the southeastern Pacific coast chose to increase their use of animals in the mixed-water ecological group, targeting seatrouts. Changes in residential patterns, such as a shift from year-round to occasional use of the site, might yield a similar increase in the use of mixed-water fishes, but structures and geochemical data suggest these sites were used more permanently than if they were simply seasonal fish camps. It seems particularly likely that technological changes occurred at Sitio Siches over time, particularly in net and other fishing technologies, as well as in labor management. By themselves, these changes may or may not indicate changes in water conditions. If a change in technology occurred, as well as companion changes in social organization and the division of labor, this would explain the shift from members of the warm-water ecological group to those in the mixed-water group. Available geochemical data from Siches otoliths do indicate that marine waters during the Siches phase were 3° C warmer than present, so at least some of the changes are probably the result of climatic change. Additional environmental data are needed to test this.

The broad similarities among assemblages at similar latitudes, however, suggest the patterns observed in the Sitio Siches assemblage are not exclusively due to cultural dynamics, but reflect larger environmental patterns influencing the economies of all human communities in the region. By the end of the sequence domestic plants were part of the economies of coastal communities in northern Perú. Some communities may have specialized in fishing in order to trade coastal commodities with inland communities in exchange for cultivated plant products (e.g., Pozorski and Pozorski, 1979), perhaps trading with communities in what is now Ecuador (e.g., Piperno and Pearsall, 1998; Piperno et al., 2000; Piperno, 2005, 2011).

An equally valid possibility is that warm-water animals increasingly became rare in the Peru-Chilean province after ca. 5000 ^{14}C B.P. (~5700 cal B.P.), or more difficult to capture, so that exploiting them was not energetically worthwhile. It is clear that conditions once existed in northern Perú for a typical estuarine complex of animals to be reliably taken in large numbers, a condition that did not prevail by the time Alto Salaverry was occupied.

Although this could indicate over-exploitation of the resource base impacting not just a single animal but an ecologically similar suite of indicator animals over a wide area, it seems more likely that coastal waters in northern Perú gradually cooled and those of the Panamanian province became persistently warm as the Peru Current assumed its present course as part of an overall mid-Holocene climatic trend. This change was less pronounced in the Panamanian province and in zooarchaeological assemblages from that region; but it is evident at the frontier between the two biogeographical provinces. Alto Salaverry and the Honda-phase occupation of Sitio Siches approximate modern water conditions at those two locations, with cool-water animals dominant to the south and slightly later at Alto Salaverry and warm-water animals dominant to the north and slightly earlier at Sitio Siches.

This change in coastal conditions appears to be consistent with similar changes documented for other areas around the globe (Sandweiss et al., 1999). It also is consistent with the evidence from debris flows recovered from an alpine lake 75 km east of the Pacific Ocean in southwestern Ecuador (Rodbell et al., 1999), as well as the sites of Las Vegas and Sitio Siches. These suggest that El Niño cycles involving aperiodic oscillations in water temperature became more frequent over the last 5,700 years, replacing earlier conditions where waters were more consistently warm (Rodbell et al., 1999; Sandweiss et al., 1996, 2007). This transition from a regime of persistent warm waters to one of cooler waters with increasingly frequent warmer oscillations may have begun around 11,400 cal B.P. and intensified after 7900–5700 cal B.P. The archaeological data reviewed here support this possibility. The warmer-water fauna of the early Holocene was replaced by animals preferring cooler waters at about this same time, around 5700 cal B.P.; variations among the Siches-phase collections may reflect transitional oscillations in water temperature during that phase leading up to the transition. Some of these may reflect coastal El Niños in addition to basin-scale events (e.g., Hu et al., 2018).

On a broader scale, Sitio Siches demonstrates the benefits of comparing diachronic trends within a single site and synchronic trends across multiple regions and coastal biomes (e.g., Moss, 2012). It can no longer be considered appropriate to extrapolate from a single coastal site to all coastal sites, even when those sites are roughly contemporaneous. Although shell, lithic, and bone tools are recovered from these sites, our ability to demonstrate cultural affiliation within Sitio Siches or among local and regional groups is limited because ceramic evidence for cultural affiliations is absent. Nonetheless, lithic evidence from Quebrada Jaguay documents either down-the-line or direct trade occurred between coastal communities and inland locations (Sandweiss et al., 1998; Rademaker et al., 2013; Sandweiss and Rademaker, 2013). In the case of the Paiján complex, this trade, either direct or indirect through intermediaries, included fish products. Lithic evidence from Ostra Base Camp indicates a relationship existed between that community and coastal Ecuador (Sandweiss, 1996), 700 km to the north. The artifacts are part of a northwestern Andean pebble-figurine tradition associated with the tropical coast. Botanical evidence from Sitio Siches also supports interaction with coastal Ecuador (Cano, 1995; Piperno and Pearsall, 1998; Piperno et al., 2000; Piperno, 2005, 2011). Thus, coastal communities did not exist in isolation, even early ones; though we argue against presuming all coastal sites were seasonal camps. It does, however, demonstrate the importance of studying interactions among coastal and non-coastal communities on regional and interregional scales (e.g., Erlandson, 2016).

CONCLUSIONS

Sitio Siches data contribute to our knowledge of coastal life during the early- and mid-Holocene by documenting changes in resource use at the same time coastal environments responded to larger global climate phenomena. First, Sitio Siches contributes to regional data showing that early- and mid-Holocene coastal peoples were able fishers. Ecological groups, taxonomic richness, diversity, equitability, and mean trophic levels demonstrate that a wide range of marine animals were taken from diverse habitats using several different technologies and these dominate the Sitio Siches assemblage. The strategies used to access this resource base were neither simple nor experimental. They clearly targeted specific fish but also used some of the by-catch. Second, these data enhance our ability to see when and where ecological transitions among warm and cool marine conditions occurred. After the Amotape phase, half of the vertebrates are characteristic of warm-water conditions, though the dominant fish is sufficiently flexible to be found in both warm and cool waters. Over time water temperatures trended from reliably warm to warmer waters with more sharply seasonal fluctuations in water temperatures; eventually reaching cool conditions similar to those prevailing today at the frontier between these two provinces. This description is consistent with a transitional boundary between the Panamanian and Peru-Chilean provinces, an area in which the warm/cold water frontier shifted several times over a 5,000-year period, setting the stage for later cultural developments in this region.

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FOOTNOTES

1. We include calibrated median probability dates using Calib 7.1 (Reimer et al., 2013) and the SHCal databases (Hogg et al., 2013). Age ranges for sites used in this report are based on the uncalibrated means of earliest and latest radiocarbon dates for each site, excluding outliers rejected by the excavators, or on excavator's estimates when no ^{14}C dates are available. The sources cited in Table 1 provide lists of dates and standard deviations. Throughout the text we refer to fish and fishing. Only vertebrate data are presented here because comparable invertebrate data are not available for all of the assemblages upon which this study is based. Despite this, our concept of "fishing" includes crustaceans, molluscs, and echinoderms in addition to sharks, rays, and bony fishes. We consider fishing for invertebrates to be among the important activities at Sitio Siches and other coastal sites, though in need of further study.

2. Gaps from 12°–10° and 8°–4° are due to lack of quantified zooarchaeological data meeting the critieria required to be included in this study, not because we choose to exclude quantified data at variance with our analysis.

3. Climatic interpretations based on zooarchaeological attributions and modern habitat preferences are subject to a wide range of biases that lend caution to our interpretations. To correct for this, we have submitted samples of Engraulidae otoliths and vertebrae and *Cynoscion* otoliths to Dr. Mike Buckley (University of Manchester, UK) for Matrix Assisted Laser Desorption Ionization Time of Flight Mass Spectrometry (ZooMS) to obtain an additional proxy assessment of the climate signal by using proteins to distinguish between warm-water and cool-water members of these two groups. These two taxa were selected because they include species with divergent preferences for warmer or cooler waters. Distinguishing between species of these two fishes could substantially influence future studies. Oxygen isotopes from the final pre-mortem increment of *Cynoscion* otoliths also are being assessed. This multi-proxy study is on-going and results are not yet available.

4. Direct exposure to heat alters the biochemistry of otoliths (Andrus and Crowe, 2002), but none of the Ostra Base Camp or Sitio Siches otoliths subjected to biochemical analysis showed signs of being heat-altered (Andrus et al., 2002, 2003).

5. Sitio Siches data reported here replace those in all previous publications.

LITERATURE CITED

Andrus, C. F. T., and D. E. Crowe. 2002. Alteration of otolith aragonite: effects of prehistoric cooking methods on otolith chemistry. Journal of Archaeological Science 29:291–299.

Andrus, C. F. T., D. E. Crowe, D. H. Sandweiss, E. J. Reitz, and C. S. Romanek. 2002. Otolith $\delta^{18}O$ record of mid-Holocene sea surface temperatures in Peru. Science 295:1508–1511.

Andrus, C. F. T., D. E. Crowe, D. H. Sandweiss, E. J. Reitz, and C. S. Romanek. 2003. Response to comments on “Otolith $\delta^{18}O$ record of mid-Holocene sea surface temperatures in Peru”. Science 299:203b.

Attrill, M. J., and M. Power. 2002. Climate influence on a marine fish assemblage. Nature 417:275–278.

Béarez, P. 2000. Archaic fishing at Quebrada De Los Burros, southern coast of Peru. Reconstruction of fish size using otoliths. Archaeofauna 9:29–34.

Béarez, P. 2012. Los peces y la pesca. Pp. 99–123 *in* D. Lavallée and M. Julien, eds. Prehistoria de la Costa Extremo-Sur del Perú. Los Pescadores Arcaicos de la Quebrada de los Burros (10000–7000 A.P.). IFEA-PUCP, Lima, Peru.

Béarez, P., D. Jackson, and N. Mollare. 2015. Early Archaic fishing (12,600–9,200 cal yr BP) in the semiarid north coast of Chile. The Journal of Island and Coastal Archaeology 10:133–148.

Benfer, R. A. 1984. The challenges and rewards of sedentism: the preceramic village of Paloma, Peru. Pp. 531–558 *in* M. N. Cohen and G. J. Armelagos, eds. Paleopathology and the Origin of Agriculture. Academic Press, New York.

Benítez-López, A. 2018. Animals feel safer from humans in the dark. Science 360:1185–1186.

Braje, T. J., T, D. Dillehay, J. M. Erlandson, R. G. Klein, and T. C. Rick. 2017. Finding the first Americans. Science 358:592–594.

Briggs, J. 1974. Marine Zoogeography. McGraw-Hill, New York, 475 p.

Byrd, K. M. 1976. Changing animal utilization patterns and their implications: southwest Ecuador (6500 B. C.–A. D. 1400). Ph.D. dissertation. University of Florida, Gainesville, 165 p.

Byrd, K. M. 1996. Subsistence strategies in coastal Ecuador. Pp. 87–101 *in* E. J. Reitz, L. A. Newsom, and S. J. Scudder, eds. Case Studies in Environmental Archaeology. Plenum Press, New York.

Campbell, K. E. 1982. Late Pleistocene events along the coastal plain of northwestern Peru. Pp. 423–440 *in* G. Prance, ed. Biological Diversification in the Tropics. Columbia University Press, New York.

Cano Echevarria, A. A. 1995. Proyecto arqueologico “Siches:” Estudio de los restos vegetales. Ms. on file, Anthropology Department and Climate Change Institute, University of Maine, Orono, 3 p.

Carré, M., J. P. Sachs, S. Purca, A. J. Schauer, P. Braconnot, R. Angeles Falcón, M. Julien, and D. Lavallée. 2014. Holocene history of ENSO variance and asymmetry in the eastern tropical Pacific. Science 345:1045–1048.

Carrillo de Espinoza, N. 1970. Contribución al conocimiento de los reptiles del Peru. Publicaciones del Museo de Historia Natural “Javier Prado”, Serie A: Zoología 22, Lima, Peru, 64 p.

Carrott, J., and H. Kenward. 2001. Species associations among insect remains from urban archaeological deposits and their significance in reconstructing past human environments. Journal of Archaeological Science 28:887–905.

Chase, T. 1988. Restos fáunicos. Pp. 171–178 *in* K. E. Stothert, ed. La Prehistoria Temprana de la Península de Santa Elena, Ecuador: Cultura Las Vegas. Miscelánea Antropológica Ecuatoriana Serie Monográfica 10. Museos del Banco Central del Ecuador, Guayaquil.

Chauchat, C. 1976. The Paiján Complex, Pampa de Cupisnique, Peru. Ñawpa Pacha 13:85–96.

Chauchat, C. 1978. Additional observations on the Paiján Complex. Ñawpa Pacha 16:51–65.

Chauchat, C. 1988. Early hunter-gatherers on the Peruvian coast. Pp. 41–66 *in* R. Keatinge, ed.

Peruvian Prehistory. University of Cambridge Press, Cambridge.

Chauchat, C. 1992. Préhistoire de la Côte Nord du Pérou Le Paijanien de Cupisnique. Cahiers du Quaternaire 18, CNRS-Éditions, Paris, 391 p.

Chavez, F. P., J. Ryan, S. E. Lluch-Cota, and C. M. Ñiquen. 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. Science 299:217–221.

Chavez, F. P., P. G. Strutton, G. E. Friederich, R. A. Feely, G. C. Feldman, D. G. Foley, and M. J. McPhaden. 1999. Biological and chemical response of the equatorial Pacific Ocean to the 1997-1998 El Niño. Science 286:2126–2131.

Chirichigno F., N. 1974. Clave para identificar los peces marinos del Perú. Instituto del Mar del Perú Informe No. 44, Callao, Perú, 387 p.

Chirichigno F., N. 1982. Catálogo de especies marinas de interés económico actual o potencial para America Latina: Parte II, Pacífico Centro y Suroriental. FAO, Rome, Italy, 588 p.

Churcher, C. S. 1966. The insect fauna from the Talara Tar-Seeps, Peru. Canadian Journal of Zoology 44:985–993.

Cooke, R. 1992. Prehistoric nearshore and littoral fishing in the eastern tropical Pacific: an ichthyological evaluation. Journal of World Prehistory 6:1–49.

DEIS. 1978. Draft Environmental Impact Statement for Preferred Alternative Location for a Fleet Ballistic Missile (FBM) Submarine Support Base: Appendix 2. Department of the Navy, Washington, D.C., 613 p.

Dillehay T. D., C. Ramírez, M. Pino, M. B. Collins, J. Rossen, and J. D. Pino-Navarro. 2008. Monte Verde: Seaweed, food, medicine, and the peopling of South America. Science 320:784–786.

Dillehay, T. D., D. Bonavia, S. L. Goodbred, Jr., M. Pino, V. Vásquez, and T.R. Tham. 2012. A late Pleistocene human presence at Huaca Prieta, Peru, and early Pacific coastal adaptations. Quaternary Research 77:418–423.

Dillehay, T. D., S. Goodbred, M. Pino, V. F. Vásquez Sánchez, T. Rosales Tham, J. Adovasio, M. B. Collins, P. J. Netherly, C. A. Hastorf, K. L. Chiou, D. Piperno, I. Rey, and N. Velc. 2017. Simple technologies and diverse food strategies of the Late Pleistocene and Early Holocene at Huaca Prieta, coastal Peru. Science Advances 3:e1602778. DOI: 10.1126/sciadv.1602778.

Eigenmann, C. H. 1921. The nature and organization of the fishes of the Pacific slope of Ecuador, Peru, and Chile. Proceedings of the American Philosophical Society 60:503–523.

Ekman, S. 1953. Zoogeography of the Sea. Sidgwick and Jackson, London, 417 p.

Eisenberg, J. F., and K. H. Redford. 1999. Mammals of the Neotropics: The Central Neotropics, vol. 3, Ecuador, Peru, Bolivia, Brazil. University of Chicago Press, Chicago, 644 p.

Erickson, D. L., B. D. Smith, A. C. Clark, D. H. Sandweiss, and N. Tuross. 2005. An Asian origin for a 10,000-year-old domesticated plant in the Americas. Proceedings of the National Academy of Sciences 102:18,315–18,320.

Erlandson, J. M. 2016. Coastal versus interior: some thoughts on the archaeology of California's Channel Islands. The Journal of Island and Coastal Archaeology 11:443–446.

Eschmeyer, W. N., E. S. Herald, H. Hammann, and K. P. Smith. 1984. A Field Guide to Pacific Coast Fishes of North America. Houghton Mifflin, Boston, 336 p.

Fontugne, M., P. Usselmann, D. Lavallée, M. Julien, and C. Hatté. 1999. El Niño variability in the coastal desert of southern Peru during the mid-Holocene. Quaternary Research 52:171–179.

Fowler, H. W. 1945. Los peces del Perú: Catálogo sistemático de los peces que habitan en aguas peruanas. Publicaciones del Museo de Historia Natural "Javier Prado", Universidad Nacional Mayor de San Marcos, Lima, Perú, 298 p.

Froese, R., and D. Pauly, editors. 1998. FishBase 98: Concepts, Design and Data Sources. The International Center for Living Resources Management, Kakati City, Philippines, 293 p.

Froese, R., and D. Pauly, editors. 2004. FishBase. World Wide Web electronic publication. <www.fishbase.org>, version (05/2004).

Gaynor, K. M., C. E. Hojnowski, N. H. Carter, and J. S. Brashares. 2018. The influence of human disturbance on wildlife nocturnality. Science 360:1232–1235.

Giovannetti, M. A., V. S. Lerna, C. G. Bartoli, and A. Capparelli. 2008. Starch grain characterization of *Prosopis chilensis* (Mol.) Stuntz and *P. flexuosa* DC, and the analysis of their archaeological remains in Andean South America. Journal of Archaeological Science 35:2973–2985.

Grayson, D. K. 1973. On the methodology of faunal analysis. American Antiquity 38:432–439.

Grayson, D. K. 1981. A critical view of the use of archaeological vertebrates in paleoenvironmental reconstruction. Journal of Ethnobiology 1:28–38.

Grayson, D. K. 1984. Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas. Academic Press, Orlando, 202 p.

Grimwood, I. R. 1969. Notes on the distribution and status of some Peruvian mammals. American Committee for International Wildlife Protection Special Publication No. 21, 86 p.

Greene, K. 2002. Coastal cool down. Science 295:1823.

Guillén G., O. 1980. The Peru Current system. 1: physical aspects. Pp. 185–216 *in* Proceedings of the Workshop on the Phenomenon Known as ‘El Niño’. UNESCO, Paris.

Hardesty, D. L. 1975. The niche concept: suggestions for its use in human ecology. Human Ecology 3:71–85.

Handler, P. 1984. Possible association of stratospheric aerosols and El Niño type events. Geophysical Research Letters 11:1121–1124.

Hildebrand, S. F. 1946. A Descriptive Catalog of the Shore Fishes of Peru. U.S. National Museum Bulletin 189, 530 p.

Hoese, H. D., and R. H. Moore. 1977. Fishes of the Gulf of Mexico: Texas, Louisiana, and Adjacent Waters. Texas A & M University Press, College Station, 327 p.

Hogg, A. G., Q. Hua, P. G. Blackwell, C. E. Buck, T. P. Guilderson, T. J. Heaton, M. Niu, J. G. Palmer, P. J. Reimer, R. W. Reimer, C. S. M. Turney, and S. R. H. Zimmerman. 2013. SHCal13 Southern Hemisphere Calibration, 0–50,000 Years cal BP. Radiocarbon 55:1889–1903.

Hu, Z.-A., B. Huang, J. Zhu, A. Kumar, and M. J. McPhaden. 2018. On the variety of coastal El Niño events. Climate Dynamics Vol.: 0112 33456789. https://doi.org/10.1007/s00382-018-4290-4.

Holmberg, A. R. 1957. Lizard hunts on the north coast of Peru. Fieldiana: Anthropology 36:203–220.

Jones, K. B., G. W. L. Hodgins, and D. H. Sandweiss. 2017. Radiocarbon chronometry of site QJ-280, Quebrada Jaguay, a Terminal Pleistocene to Early Holocene fishing site in southern Peru. The Journal of Island and Coastal Archaeology. DOI: 10.1080/15564894.2017.1338316.

Kenward, H. K. 1975. Pitfalls in the environmental interpretation of insect death assemblages. Journal of Archaeological Science 2:85–94.

Kenward, H. K. 2006. The visibility of past trees and woodlands: testing the value of insect remains. Journal of Archaeological Science 33:1368–1380.

Kenward, H. K., and A. Hall. 1997. Enhancing bioarchaeological interpretation using indicator groups: stable manure as a paradigm. Journal of Archaeological Science 24:663–673.

Koepcke, M. 1970. The Birds of the Department of Lima, Peru. Livingston Publishing, Wynnewood, PA, 144 p.

Lavallée, D., M. Julien, P. Béarez, A. Bolaños, M. Carré, A. Chevalier, T. Delabarde, M. Fontugne, C. Rodríguez-Loredo, L. Klaric, P. Usselmann, and M. Vanhaeren. 2011. Quebrada de los Burros. Los primeros pescadores del litoral Pacífico en el extremo sur peruano. Chungara, Revista de Antropología Chilena 43:333–351.

Lippi, R. D. 1983. La Ponga and the Machalilla phase of coastal Ecuador. Ph.D. dissertation. University of Wisconsin, Madison, 534 p.

Lumbreras, L. G. 1974. The Peoples and Cultures of Ancient Peru, translated by B. J. Meggars.

Smithsonian Institution Press, Washington, D.C., 248 p.

McInnis, H. E. 1999. Subsistence and maritime adaptations at Quebrada Jaguay, Camaná, Peru: a faunal analysis. M.A. thesis. University of Maine, Orono, 146 p.

Mauricio Llonto, A. C. 2015. Los Morteros: early monumentality and environmental change in the lower Chao Valley, northern Peruvian coast. Ph.D. dissertation. University of Maine, Orono, 559 p.

Mann F., G. 1950. Peces de Chile: Clave de Determinación. Ministerio de Agricultura, Santiago de Chile, Chile, 48 p.

Moss, M. 2012. Understanding variability in Northwest coast faunal assemblages: beyond economic intensification and cultural complexity. The Journal of Island and Coastal Archaeology 7:1–22.

Myers, R. A., and B. Worm. 2003. Rapid worldwide depletion of predatory fish communities. Nature 423:280–283.

Nims, R., and V. L. Butler. 2018. Increasing the robustness of meta-analysis through life history and middle-range models: an example from the Northeast Pacific. Journal of Archaeological Method and Theory. DOI: 10.1007/s10816–018-9383-1.

Nowak, R. M., and J. L. Paradiso. 1983. Walker's Mammals of the World. The Johns Hopkins University Press, Baltimore, 1362 p.

O'Connor, T., and J. Evans. 2005. Environmental Archaeology: Principles and Methods, Second Edition. Sutton Publishing, Stroud, England, 280 p.

Pauly, D., and V. Christensen. 1995. Primary production required to sustain global fisheries. Nature 374:255–257.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese, and F. Torres, Jr. 1998. Fishing down marine food webs. Science 279:860–863.

Pauly, D., V. Christensen, R. Froese, and M. L. Palomares. 2000. Fishing down aquatic food webs. American Scientist 88(1):46–51.

Pelegrin, J., and C. Chauchat. 1993. Tecnología y función de las puntas de Paiján: el aporte de la experimentación. Latin American Antiquity 4:367–382.

Perrier, C., C. Hillaire-Marcel, and L. Ortlieb. 1994. Paléógéographie littorale et enregistrement isotopique (^{13}C, ^{18}O) d'événements de type El Niño par les mollusques Holocènes et récents du nordouest Péruvien. Géographie Physique et Quaternaire 48:23–38.

Piperno, D. R. 2005. Untitled report on *Cucurbita* spp. from Sitio Siches. Ms. on file, Anthropology Department and Climate Change Institute, University of Maine, Orono, 6 p.

Piperno, D. R. 2011. The origins of plant cultivation and domestication in the New World tropics. Current Anthropology 52, Supplement 4:S453–S470.

Piperno, D. R., T. C. Andres, and K. E. Stothert. 2000. Phytoliths in *Cucurbita* and other Neotropical Cucurbitaceae and their occurrence in early archaeological sites from the lowland American tropics. Journal of Archaeological Science 27:193–208.

Piperno, D. R., and D. M. Pearsall. 1998. The Origins of Agriculture in the Lowland Neotropics. Academic Press, San Diego, 400 p.

Piperno, D. R., and K. E. Stothert. 2003. Phytolith evidence for early Holocene *Cucurbita* domestication in southwest Ecuador. Science 299:1054–1057.

Plunkett, G., N. J. Whitehouse, V. A. Hall, D. J. Charman, M, Blaauw, E. Kelly, and I. Mulhall. 2009. A multi-proxy palaeoenvironmental investigation of the findspot of an Iron Age bog body from Oldcroghan, Co. Offaly, Ireland. Journal of Archaeological Science 36:265–277.

Pozorski, S. G. 1976. Prehistoric subsistence patterns and site economics in the Moche Valley, Peru. Ph.D. dissertation. University of Texas, Austin, 492 p.

Pozorski, S., and T. Pozorski. 1979. Alto Salaverry: a Peruvian coastal preceramic site. Annals of Carnegie Museum 48:337–375.

Pozorski, S., and T. Pozorski. 2003. Paleoenvironment at Almejas: early exploitation of estuarine fauna on the north coast of Peru.

Pp. 52–70 *in* J. Haas and M. O. Dillon, eds., El Niño in Peru: Biology and Culture over 10,000 years: Papers from the VIII Annual A. Watson Armour III Spring Symposium, May 28-29, 1999, Chicago. Fieldiana, Botany, new series 43. Field Museum of Natural History, Chicago.

Pozorski, T., and S. Pozorski. 1984. Almejas: early exploitation of warm-water shellfish on the north central coast of Peru. Final report submitted to the National Science Foundation, grant BNS 82-03452. University of Texas, Pan-American, Edinburg, Texas.

Quitmyer, I. R., and E. J. Reitz. 2006. Marine trophic levels targeted between AD 300 and 1500 on the Georgia coast, USA. Journal of Archaeological Science 33:806–822.

Rademaker, K., G. R. M. Bromley, and D. H. Sandweiss. 2013. Peru archaeological radiocarbon database, 13,000–7000 ^{14}C B.P. Quaternary International 301:34–45.

Randall, J. 1968. Caribbean Reef Fishes. THF Publications, Jersey City, 318 p.

Reimer, P. J. E. Bard, A. Bayliss, J. W. Beck, P. G Blackwell, C. Bronk Ramsey, C. E Buck, H. Cheng, R. L. Edwards, M. Friedrich, P. M Grootes, T. P Guilderson, H. Haflidason, I. Hajdas, C. Hatté, T. J. Heaton, D. L. Hoffmann, A. G. Hogg, K. A. Hughen, K. F. Kaiser, B. Kromer, S. W Manning, M. Niu, R. W Reimer, D. A. Richards, E. M. Scott, J. R. Southon, R. A. Staff, C. S. M. Turney, and J. van der Plicht. 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55:1869–1887.

Reitz, E. J. 1988a. Faunal remains from Paloma, an Archaic site in Peru. American Anthropologist 90:310–322.

Reitz, E. J. 1988b. Preceramic animal use on the central coast. Pp. 31–55 *in* E. S. Wing and J. C. Wheeler, eds. Economic Prehistory of the Central Andes. BAR International Series 427, Oxford.

Reitz, E. J. 1995. Environmental change at Almejas, Peru. Ms. on file, Zooarchaeology Laboratory, Georgia Museum of Natural History, University of Georgia, Athens.

Reitz, E. J. 1999. Vertebrate remains from Sitio Siches (PV 7-19), Peru. Ms. on file, Zooarchaeology Laboratory, Georgia Museum of Natural History, University of Georgia, Athens.

Reitz, E. J. 2001. Fishing in Peru between 10000 and 3750 BP. International Journal of Osteoarchaeology 11:163–171.

Reitz, E. J. 2002. The use of archaeofaunal data in fish management. Pp. 19–33 *in* R. C. G. M. Lauwerier and I. Plug, eds. The Future from the Past. Oxbow Books, Oxford.

Reitz, E. J. 2003. Resource use through time at Paloma, Peru. Bulletin of the Florida Museum of Natural History 44(1):65–80.

Reitz, E. J. 2004. "Fishing down the food web": a case study from St. Augustine, Florida, USA. American Antiquity 69:63–83.

Reitz, E. J. 2014. Continuity and resilience in the central Georgia Bight (USA) fishery between 2760 BC and AD 1580. Journal of Archaeological Science 41:716–731.

Reitz, E. J., S. D. deFrance, D. H. Sandweiss, and H. E. McInnis. 2015. Flexibility in southern Peru coastal economies: a vertebrate perspective on the Terminal Pleistocene/Holocene transition. The Journal of Island and Coastal Archaeology 10:155–183.

Reitz, E. J., H. E. McInnis, D. H. Sandweiss, and S. D. deFrance. 2016. Terminal Pleistocene and Early Holocene fishing strategies at Quebrada Jaguay and the Ring Site, southern Perú. Journal of Archaeological Science: Reports 8:447–453.

Reitz, E. J., H. E. McInnis, D. H. Sandweiss, and S. D. deFrance. 2017. Variations in human adaptations during the Terminal Pleistocene and Early Holocene at Quebrada Jaguay (QJ-280) and the Ring Site, southern Perú. The Journal of Island and Coastal Archaeology 12:224–254.

Reitz, E. J., and M. A. Masucci. 2004. Guangala Fishers and Farmers: A Case Study of Animal Use at El Azúcar, Southwestern Ecuador; Pescadores y Agricultores Guangala: Un Estudio de Caso de Uso Animal en El Azúcar, Suroeste de Ecuador. University of Pittsburgh Memoirs in Latin American Archaeology 14, Pittsburgh, PA, 184 p.

Reitz, E. J., and D. H. Sandweiss. 2001. Environmental change at Ostra Base Camp, a Peruvian Pre-ceramic site. Journal of Archaeological Science 28:1085–1100.

Reitz, E. J., and M. Shackley. 2012. Environmental Archaeology. Springer Science+Business Media, New York, 516 p.

Reitz, E. J., and E. S. Wing. 2008. Zooarchaeology, Second Edition. Cambridge University Press, Cambridge, 533 p.

Richardson, J. B. III. 1973. The Preceramic sequence and the Pleistocene and Post-Pleistocene climate of northwest Peru. Pp. 199–211 *in* D. Lathrap and J. Douglas, eds. Variations in Anthropology: Essays in Honor of John C. McGregor. Illinois Archaeological Survey, Urbana.

Richardson, J. B. III. 1978. Early man on the Peruvian north coast, early maritime exploitation and Pleistocene and Holocene environment. Pp. 274–289 *in* A. L. Bryan, ed. Early Man in America from a Circum-Pacific Perspective. Occasional Papers No. 1, Department of Anthropology, University of Alberta, Edmonton, Canada.

Richardson, J. B. III, and D. H. Sandweiss. 2008. Climate change, El Niño, and the rise of complex society on the Peruvian coast during the Middle Holocene. Pp. 59–75 *in* D. H. Sandweiss and J. Quilter, eds. El Niño, Catastrophism, and Culture Change in Ancient America. Harvard University Press, Cambridge, MA.

Richardson, J. B. III, D. H. Sandweiss, and E. Paredes. 1996. Proyecto Arqueológico Siches, Informe, Mayo de 1996. Ms. on file, Division of Archaeology, The Carnegie Museum of Natural History, Pittsburgh, PA.

Rodbell, D. T., G. O. Seltzer, D. M. Anderson, M. B. Abbott, D. B. Enfield, and J. H. Newman. 1999. An ~15,000-year record of El Niño-driven alluviation in southwestern Ecuador. Science 283:516–520.

Rollins, H. B., J. B. Richardson III, and D. H. Sandweiss. 1986. The birth of El Niño: Geoarchaeological evidence and implications. Geoarchaeology 1:3–16.

Rollins, H. B., D. H. Sandweiss, U. Brand, and J. C. Rollins. 1987. Growth increment and stable isotope analysis of marine bivalves: implications for the geoarchaeological record of El Niño: Geoarchaeology 2:181–197.

Rollins, H. B., D. H. Sandweiss, and J. C. Rollins. 1990. Mollusks and coastal archaeology; A review. Pp. 467–478 *in* N.P. Lasca and J.D. Donahue, eds. Decade of North American Geology, Centennial Special Volume 4: Archaeological Geology of North America. Geological Society of America, Boulder.

Sánchez Mosquera, A. 1993. Primer gran paso de nuestra historia marítíma. Revista del Instituto de Historia Maritima VIII (15):9–42.

Sandweiss, D. H. 1992. The archaeology of Chincha fishermen: specialization and status in Inka Peru. Bulletin of the Carnegie Museum of Natural History 29:1–162.

Sandweiss, D. H. 1996. Mid-Holocene cultural interaction on the north coast of Peru and Ecuador. Latin American Antiquity 7:41–50.

Sandweiss, D. H. 2003. Terminal Pleistocene through Mid-Holocene archaeological sites as paleoclimatic archives for the Peruvian coast. Palaeogeography, Palaeoclimatology Palaeoecology 194:23–40.

Sandweiss, D. H. 2009. Early fishing and inland monuments: challenging the maritime foundations of Andean civilization? Pp. 39–54 *in* J. Marcus, C. Stanish, and R. Williams, eds. Andean Civilization: Papers in Honor of Michael E. Moseley. Cotsen Institute of Archaeology, Los Angeles.

Sandweiss, D. H. 2014. Early coastal South America. Pp. 1048–1064 *in* C. Renfrew and P. Bahn, eds. The Cambridge World Prehistory. University of Cambridge Press, Cambridge.

Sandweiss, D. H., K. A. Maasch, C. F. T. Andrus. E. J. Reitz, J. B. Richardson III, M. Riedinger-Whitmore, and H. B. Rollins. 2007. Mid-Holocene climate and culture change in coastal Peru. Pp. 25–50 *in* D. G. Anderson, K. A. Maasch, and D. H. Sandweiss, eds. Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions. Academic Press, New York.

Sandweiss, D. H., K. A. Maasch, and D. G. Anderson. 1999. Transitions in the Mid-Holocene. Science 283:499–500.

Sandweiss, D. H., K. A. Maasch, F. Chai, C. F. T. Andrus, and E. J. Reitz. 2004. Geoarchaeological evidence for multidecadal natural climatic variability and ancient Peruvian fisheries. Quaternary Research 61:330–334.

Sandweiss, D. H., H. McInnis, R. L. Burger, A. Cano, B. Ojeda, R. Paredes, M. Sandweiss, and M. Glascock. 1998. Quebrada Jaguay: Early maritime adaptations in South America. Science 281:1830–1832.

Sandweiss, D. H., and K. M. Rademaker. 2013. El poblamiento del sur peruano: costa y sierra. Boletín de Arqueología PUCP 15:275–293.

Sandweiss, D. H., J. B. Richardson III, E. J. Reitz, J. T. Hsu, and R. A. Feldman. 1989. Early maritime adaptations in the Andes: preliminary studies at the Ring Site, Peru. Pp. 5–84 *in* D. S. Rice, C. Stanish and P. R. Scarr, eds. Ecology, Settlement and History in the Osmore Drainage, Peru. BAR International Series 545i, Oxford.

Sandweiss, D. H., J. B. Richardson III, E. J. Reitz, H. B. Rollins, and K. A. Maasch. 1996. Geoarchaeological evidence from Peru for a 5000 Years B.P. onset of El Niño. Science 273:1531–1533.

Sandweiss, D. H., J. B. Richardson III, E. J. Reitz, H. B. Rollins, and K. A. Maasch. 1997. Determining the early history of El Niño, response. Science 276:965.

Sandweiss, D. H., H. B. Rollins, and J. B. Richardson III. 1983. Landscape alteration and prehistoric human occupation on the north coast of Peru. Annals of Carnegie Museum 52:277–298.

Santander, H. 1980. The Peru Current system. 2: biological aspects. Pp. 217–227 *in* Proceedings of the Workshop on the Phenomenon Known as ‘El Niño’. UNESCO, Paris.

Scartascini, F. L. 2017. The role of ancient fishing on the desert coast of Patagonia, Argentina. The Journal of Island and Coastal Archaeology 12:115–132.

Schwarz, F. A., and J. S. Raymond. 1996. Formative settlement patterns in the Valdivia Valley, SW coastal Ecuador. Journal of Field Archaeology 23:205-224.

Scheib, C.L., et al. 2018. Ancient human parallel lineages within North America contributed to a coastal expansion. Science 360:1024–1027.

Schmid, E. 1972. Atlas of Animal Bones for Prehistorians, Archaeologists, and Quaternary Geologists. Elsevier, Amsterdam, 159 p.

Schweigger, E. 1964. El Litoral Peruano. Universidad Nacional “Frederico Villarreal”, Lima, Peru, 414 p.

Shannon, C. E., and W. Weaver. 1949. The Mathematical Theory of Communication. University of Illinois Press, Urbana, 117 p.

Sheldon, A. L. 1969. Equitability indices: dependence on the species count. Ecology 50:466–467.

Silver, I. A. 1963. The ageing of domestic animals. Pp. 250–268 *in* D. Brothwell and E. Higgs, eds. Science in Archaeology. Praeger, New York.

Stothert, K. E. 1988. La Prehistoria Temprana de la Peninsula de Santa Elena, Ecuador: Cultura Las Vegas. Museos del Banco Central del Ecuador, Guayaquil: Miscelánea Antropológica Ecuatoriana Serie Monográfica 10, 271 p.

Stuiver, M., and P. J. Reimer, 1993. Extended ^{14}C data base and revised CALIB 3.0 14C age calibration program. Pp. 215–230 *in* M. Stuiver, M., A. Long, A. and R. S. Kra, eds. Calibration 1993. Radiocarbon 35: 215–230.

Watson, J. P. N. 1978. The interpretation of epiphyseal fusion data. Pp. 97–102 *in* D. R. Brothwell, J. D. Thomas, and J. Clutton-Brock, eds. Research Problems in Zooarchaeology. University of London Institute of Archaeology Occasional Publications No. 3.

Webb, S. C., R. E. M., Hedges, and R. Robinson. 1998. The seaweed fly *Thoracochaeta zosterae* (Hal.) (Diptera: Sphaerocidae) in inland archaeological contexts: δ^{13}C and δ^{15}N solves the puzzle. Journal of Archaeological Science 25:1253–1257.

White, T. E. 1953. Method of calculating the dietary percentages of various food animals utilized by aboriginal peoples. American Antiquity 19:396–398.

Wing, E. S. 1986. Methods employed in the identification and analysis of the vertebrate remains associated with sites of the Paiján Culture. Ms. on file, Environmental Archaeology Laboratory, Florida Museum of Natural History, University of Florida, Gainesville.

Wing, E. S., and E. J. Reitz. 1982a. Pisces, Reptilia, Aves, Mammalia. Pp. 191–200 *in* D. Bonavia, ed. Precerámico Peruano: Los Gavilanes, Mar, Desierto y Oásis en la Historia del Hombre. Editorial Ausonia-Talleres Gráficos, Lima, Peru.

Wing, E. S., and E. J. Reitz. 1982b. Prehistoric fishing economies of the Caribbean. Journal of New World Archaeology 5(2):13–33.

APPENDIX 1
VERTEBRATE ECOLOGICAL GROUPS

This review is restricted to vertebrates found in archaeological assemblages pertinent to the Sitio Siches study (Table 3). Scientific names assigned during the original study are used whenever there is uncertainty about the current valid taxonomic affiliation of the animal. When a name which is no longer valid is used here, it is because that was the attribution conferred at the time of the original zooarchaeological study.

Ecological group classifications rely heavily on Chirichigno's (1982:xvi) division of the central and southeastern Pacific coast of the Americas into two extensive fishing areas and several subareas. She designates the Panamanian province as Area 77 and the Peru-Chilean province as Area 87 (Fig. 1). Of specific interest are Subareas 77C, 87A, and 87B. Subarea 77C is primarily the Ecuadorian coast extending down to Paita, Perú (1° 38′ N to 5° S). 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 and Subarea 87C includes most of the Chilean coast.

MAMMALS, BIRDS, AND REPTILES

Foxes (*Lycalopex* cf. *sechurae*), passerine birds (Corvidae, Mimidae), cañan lizards (*Dicrodon* sp.), and non-poisonous snakes (Colubridae) are among the terrestrial forms. The range of desert foxes includes southwestern Ecuador and coastal northwestern Perú (Eisenberg and Redford, 1999:284–285). They are found in areas with high daytime temperatures (28° C) and annual rainfall below 300 mm. Desert foxes are common components of many archaeological sites in this region. Foxes in the zooarchaeological studies reviewed here originally were attributed to *Dusicyon* sp. or *D*. cf. *sechurae* by several different researchers, all of whom used the reference materials in the FLMNH Environmental Archaeology Laboratory. *Dusicyon* was subsequently changed to *Pseudalopex* and recent work distinguishes two species in the genus now known as *Lycalopex* (*L. sechurae* and *L. culpaeus*). This leaves the original attribution uncertain, though the specimens in every case are clearly foxes and their presence in assemblages from the coastal zone of northwestern Perú and southwestern Ecuador suggests they are *L. sechurae* (Eisenberg and Redford, 1999:285).

Cañan lizards (*Dicrodon holmbergi*) are common along the dry coast of Ecuador and northern Perú (Carrillo de Espinoza, 1970:29). Males may reach 51 cm in length, with females being smaller. These lizards are active during the day when they dig extensive burrows (Holmberg, 1957; Carrillo de Espinoza, 1970:29). These herbivorous lizards prefer algarroba fruits. They are highly prized for their nutritive qualities and as an aphrodisiac, a potential thought to derive from the algarroba (Holmberg, 1957). Holmberg (1957) describes the capture of *Dicrodon holmbergi* by Peruvians of the north coast using small nets and corrals.

Marine mammals (Pinnipedia, Otariidae, *Otaria flavescens* [formerly *O. byronia*], Mysticeti, Delphinidae, *Lontra felina*) are largely pelagic and usually are classified as members of the mixed-water ecological group. Eared (Otariidae) and earless (Phocidae) seals were classified as Pinnipedia at one time and this is the terminology used during the original study of the zooarchaeological assemblages when it was not possible to distinguish between the two families. All of the marine carnivores are commonly associated with cool waters, they also frequent coasts with warm waters and estuaries depending upon the seasonal habits of each species. Southern sealions (*Otaria flavescens*) usually are found from Perú south, but a dead individual was found in the Galapagos Islands, suggesting they enter warmer waters occasionally (Nowak and Paradiso, 1983:1100). Whales and dolphins generally are associated with a variety of water temperatures. For example, all five species of the spinner or striped dolphin genus *Stenella* are found in deep, clear, offshore waters in primarily, but not exclusively, tropical and subtropical seas (Nowak and Paradiso, 1983:878). Marine otters (*Lontra felina*) are found along the Pacific coast from northern Perú to Tierra del Fuego (Nowak and Paradiso, 1983:1015) and are considered cool-water animals.

Most oceanic and shore birds are associated with a variety of coastal and oceanic settings, though they may be taken from terrestrial settings, too (Koepcke, 1970). Some birds are typical of the Peruvian coast or the open ocean. These include Inca terns (*Larosterna inca*), penguins (*Spheniscus humboldti*), giant fulmars (*Macronectes giganteus*), diving petrels (*Pelecanoides garnotii*), boobies (*Sula* spp.), and buzzard eagles (*Geranoaetus melanoleucas*). These are considered members of the cool-water group. Cormorants (*Phalacrocorax* spp.) and pelicans (*Pelecanus* spp.) are common coastal Peruvian birds and members of the guano bird complex. They, as well as rails (Rallidae), sandpipers (Scolopacidae), gulls (Laridae), and herons (*Ardea cocoi*), also are common in tropical settings, however. Shearwaters (*Puffinus* cf. *griseus*) are seasonally common in Perú. These birds are considered members of the mixed-water ecological group. All of these birds could be taken from either aquatic or terrestrial locations.

Cheloniidae are known from the Pacific coast. Green sea turtles (*Chelonia mydas*) are pelagic in Areas 77 and 87, though they are infrequent in Subarea 87C (Chirichigno, 1982:493–494). Hawksbills (*Eretmochelys imbricata*) and Pacific ridleys (*Lepidochelys olivacea*) are found only in Area 77 (Chirichigno, 1982:493–494). According to Schweigger (1964:304), *C. mydas* is perhaps the most frequent of the sea turtles along Perú's coast, where it is fished in June and July. Schweigger reports *L. olivacea* only from the Gulf of Guayaquil. Sea turtles are classified as mixed-water vertebrates and might be considered terrestrial if they primarily were targeted on beaches, though Schweigger (1964:304) was not sure that sea turtles did nest on Peruvian beaches.

FISHES

Sharks (Carcharhinidae, *Galeocerdo* spp., *Mustelus* spp., *Rhizoprionodon* spp., *Sphyrna* spp.) and rays (Rajiformes, Dasyatidae, Myliobatidae, *Rhinobatos* spp.) inhabit a variety of marine habitats. Most are classified in the mixed-water ecological group. Although the eagle ray family (Myliobatidae) includes three species found exclusively in Area 77, two species are found in Area 87. The two species in Peruvian waters are the Chilean eagle ray (*Myliobatis chilensis*, Subareas 87B, C) and the Peruvian eagle ray (*M. peruvianus*, Subareas 87A, B, C). The Peruvian eagle ray prefers Subarea 87B. Eagle rays are pelagic and are found near the ocean floor (Chirichigno, 1982:354–355). One of the two eagle ray attributions in the assemblages reviewed was of the Peruvian eagle ray, which is classified as a cool-water form.

Ladyfishes (*Elops affinis*) are found in Areas 77–87A, B over benthic platforms with mud or sand bottoms. They are particularly characteristic of estuaries (Chirichigno, 1982:2) and are classified as members of the warm-water group.

Although bonefishes (*Albula vulpes*) are found in Areas 77–87A, B over benthic platforms with mud or sand bottoms, they are particularly characteristic of shallow coastal waters, brackish estuaries, and warm bays (Chirichigno, 1982:1; Froese and Pauly, 2004). Bonefishes are more common in Area 77 than in Area 87 and are not mentioned by Schweigger (1964). They are classified as members of the warm-water ecological group.

Eels (Anguilliformes, Muraenidae) are found in Areas 77–87, depending upon the specific attribution (Chirichigno, 1982:20–32). The most common moray eel in Peruvian waters is the red moray (*Gymnothorax wieneri*); the white spotted moray

(*Muraena albigutta* or *argus*) prefers warmer waters (Schweigger, 1964:239). Members of both the order and the family are considered part of the mixed-water group.

Anchovies (Engraulidae) are pelagic in coastal waters near the surface (Mann, 1950). As with herrings, members of this family are found in both tropical and temperate waters, including estuaries. Most anchovies are more typical of Area 77 than of Area 87, but *Engraulis ringens* (Subarea 87B) is a classic member of the Peru Current community on which it depends (Chirichigno, 1982:10–20; Froese and Pauly, 2004). Schweigger (1964:238) argues *E. ringens* is not found north of Punta Aguja (ca. 6° S; see also, Froese and Pauly, 2004). It is not tolerant of warm or brackish waters. Elsewhere, however, members of this family may be the most common estuarine species. In one Georgia (USA) estuary, engraulids are the most abundant fish family (DEIS, 1978:D-452) and the bay anchovy (*Anchoa mitchilli*) is extremely common in bays and close inshore waters in the northern Gulf of Mexico (Hoese and Moore, 1977:137). *A. curta*, *A. naso*, and *A. panamensis* are found more commonly north of 6° S (Schweigger, 1964:238) in Subareas 77A, B (Chirichigno, 1982:12–15). For example, the longnose anchovy (*A. nasus*) is a wide-ranging, schooling species found in coastal waters and brackish bays in Subareas 77B, C–87A, B. Although anchovies may be found in warm-tropical/estuarine waters, sometimes abundantly, they are classified here as cool-water forms because of their traditional association with Peruvian zooarchaeological assemblages and their abundance in fine-screened Peru-Chilean province faunal assemblages recovered from sites south of Lima, Perú. In contrast, engraulids in Subarea 77C probably are not species associated with the Peru Current but are more likely to be species commonly found in lagoons and warm waters.[3]

Herrings (Clupeidae) are pelagic and may be found in coastal waters near the surface (Mann, 1950). Depending on the species, they are found in both warm and cool waters, including estuaries. Peruvian members of this family are highly characteristic of the upwellings of the Peru Current where they form an important part of the commercial fishery and food chain. Many are pelagic (*Ethmidium maculatum*, *Etrumeus teres*, *Sardinops sagax*) and are not common in shallow waters such as estuaries. Clupeids identified in sites located in Subarea 77C are more likely to be species commonly found in estuaries and warm waters with a principal fishing zone of 77. This includes herrings such as *Harengula peruana*, *Ilisha furthii*, *Neoopisthopterus tropicus*, and *Opisthonema* spp. (Chirichigno, 1982:2–10). One species in particular, *Sardinops sagax*, follows warm El Niño waters southward (Chavez et al., 2003; Sandweiss et al., 2004). Although some herring species may be found in tropical or estuarine waters, they are classified here as members of the cool-water ecological group because of the close association of Peruvian herring species with the Peru Current and their abundance in fine-screened Peruvian archaeological assemblages associated with the cooler waters of Subarea 87B.

Sea catfishes (Ariidae) are found in shallow, near-shore waters, often over muddy bottoms (Eschmeyer et al., 1984:96). Most are found in Area 77 (Chirichigno, 1982:34–41). *Arius kessleri*, *A. multiradiatus*, *A. seemanni* (*A. jordani*), *A. troscheli*, *Bagre panamensis*, *B. pinnimaculatus*, and *Galeichthys peruvianus* are reported as far south as Area 87, though only the Peruvian catfish (*G. peruvianus*) is principally from Subarea 87A. According to Schweigger (1964:238–239), the Peruvian sea catfish is the most frequent of the sea catfishes in Perú and is found all along the coast of Perú where bottoms are muddy. It is found in coastal waters, but not brackish ones, south of 3° S (Froese and Pauly, 2004). Although sea catfishes are found in open waters, they are far more characteristic of lagoons and even are found in upper reaches of streams flowing into lagoons or in fresh water. They are classified here as members of the warm-water group, acknowledging that they are found elsewhere. Andrus et al. (2002) note that *G. peruvianus* tolerate a wide range of temperatures and do not migrate even in response to seasonal or ENSO-related sea surface temperature (SST) changes.

Although two species of hakes (*Merluccius* spp.) are found in Area 77, three are typical of Subareas 87A, B, C (Chirichigno, 1982:64–66). None of the hakes are common in lagoons and they are classified here as part of the cool-water fauna.

Cusk-eels (Ophidiidae) range throughout Areas 77–87 (Chirichigno, 1982:56–63). Depending upon the species, their primary fishing zone may be Area 77 through Subarea 87D. The primary fishing zone for black cusk-eels (*Genypterus maculatus*) is Area 87B, C (Chirichigno, 1982:60). Black cusk-eels are classified in the cool-water group.

Although mullets (*Mugil* spp.) are found from Area 77 through Area 87C, this is a cosmopolitan family with members ranging from coastal settings into brackish lagoons and fresh waters (Chirichigno, 1982:242–244). They are found in warm or temperate continental waters and where sandy bottoms are close to the shoreline (Schweigger, 1964:290). Roe mullets may be quite common in the surf and juveniles in lagoons. Mullets are reported from locations near Chiclayo and the River Zana (Schweigger, 1964:290). They are best caught with nets because their small mouths make taking a hook difficult. Fingerling mullets are taken in near-shore grassy locations with nets and scoops. They are considered warm-water fishes.

Snooks (*Centropomus* spp.) range throughout Areas 77–87A and are quite common in lagoons (Chirichigno, 1982:133). They are considered warm-water fishes.

Members of the sea bass (Serranidae) and grouper (Epinephelidae) families once were considered members of the same large and complex family (Serranidae) with members found in many habitats, though most commonly in Area 77 (Chirichigno, 1982:137–152). The family has undergone considerable taxonomic revision, but the older taxonomy is maintained here to be consistent with the original zooarchaeological studies. Groupers (*Epinephelus* spp.) are found over hard bottoms in Areas 77–87A, B (Chirichigno, 1982:142–144). Six species of *Epinephelus* range into Subareas 87A, B, but none have either Subareas 87A or 87B as their primary fishing zone. The range of sea perches (*Hemanthias peruanus*) extends from 77–87A, B, C with the principal fishing zone in Area 77. The sea bass *Paralabrax* spp. also is found over hard bottoms. Most are present only in Area 77, but *P. callaensis* (77B, C–87A), *P. humeralis* (77–87A, B, C), and *P. furcifer* (77–87A) are found in Peruvian waters (Chirichigno, 1982:147–149). Cabrillas (*P. humeralis*) have Subareas 87A, B as a principal habitat and are not typical of warm waters. Cabrilla typically are bottom feeders, especially in rocky locations (Schweigger, 1964:245, 247). *Epinephelus* and *Hemanthias* are classified as part of the warm-water ecological group and *Paralabrax* is classified as a member of the cool-water group.

Jacks (Carangidae) are fast-swimming carnivores found in shallow, near-shore waters, usually in schools. Very few carangids are common in Peruvian waters, though *Selene peruvianus*, *Trachinotus paitensis*, and *Trachurus murphyi* are found there. The genus *Caranx* is limited to warm waters and several species are found in Area 77 (Chirichigno, 1982:159–172; Schweigger, 1964:250). Although some leatherjackets (*Oligoplites* spp.) and lookdowns (*Selene* spp.) are found from Area 77 into Subarea 87A, their primary fishing zone is Area 77 (Chirichigno, 1982:166–168). In contrast, the primary fishing zones for jurels (*Trachurus murphyi*) are Subareas 87B, C (Chirichigno, 1982:171). *Caranx*, *Oligoplites*, and *Selene* are classified as warm-water animals and *Trachurus murphyi* is classified as a cool-water form. The other jacks are classified as mixed-water because their primary fishing zones are so broad.

Area 77 is the principal fishing zone for snappers (Lutjanidae, *Lutjanus* spp.), though five species range into Subareas 87A, B (Chirichigno, 1982:178–182). Because this particular attribution is confined to an Ecuadorian zooarchaeological assemblage, the taxon is classified here in the warm-water ecological group.

Mojarras (Gerreidae, *Eucinostomus* spp.) are found in Areas 77–87A. Their primary fishing zone is in Area 77 and they are classified here as members of the warm-water ecological group.

Most grunts (Haemulidae) are found in Area

77 rather than in Area 87 (Chirichigno, 1982:183–194). Sargos (*Anisotremus* spp.) are found over rocky or rock-sand bottoms in shallow waters where they eat invertebrates (Eschmeyer et al., 1984:217). *A. scapularis* is principally caught in Subareas 87B, C, though it is found from Areas 77C–87A, B, C. *A. scapularis* lives all along the coast from Paita in Perú to Taltal, Chile (Schweigger, 1964:257). *Conodon*, on the other hand, is typical of Area 77, though *C. macrops* may be found in Subarea 87A. *Conodon* is typically found in lagoons. According to Schweigger (1964:256), this fish has no commercial value in Perú. *Haemulon* also is more typical of Area 77, though *H. steindachneri* may be found in lagoons of Subarea 87A. Cabinza (*Isacia conceptionis*) is an omnivorous, schooling haemulid found in coastal waters near the surface very close to the shoreline in Subareas 87B, C. It is found all along the Peruvian coast and into Chile (Schweigger, 1964:256). *Orthopristis* also is found primarily in Area 77, though *Orthopristis chalceus* may be found in Subareas 87A, B. The primary fishing zone for *Orthopristis* is Area 77. *Conodon*, *Haemulon*, and *Orthopristis*, therefore, are classified as warm-water forms. *Anisotremus scapularis* and *Isacia conceptionis* are considered cool-water animals.

Porgies (*Calamus* spp.) are members of the Sparidae family. They are found over benthic platforms in Areas 77–87A, B with a preference for Area 77 (Chirichigno, 1982:195). They are not mentioned by Schweigger (1964) and are considered members of the warm-water ecological group.

Drums (Sciaenidae) are members of the shallow water, near-shore community (Eschmeyer et al., 1984:218) both in estuarine settings and as members of the Peru Current community. Many members of this family are particularly prominent in some early Peruvian zooarchaeological assemblages. The principal fishing zone for silver perch (*Bairdiella ensifera*) includes Areas 77–87A, though the fish is found in Subarea 87B (Chirichigno, 1982:196–197). Schweigger (1964) does not mention *Bairdiella* in his survey of the Peruvian coast but it is listed in FishBase (Froese and Pauly, 2004) as a species that inhabits tropical lagoons and other brackish settings in Perú. Two members of the genus once known as *Sciaena* (now classified as *Cilus gilberti* and *Corvina deliciosa*) range from Area 77 through Area 87 but are more typical of Area 87 than of Area 77 (Chirichigno, 1982:216–218). They prefer coastal waters over sandy bottoms (Schweigger, 1964:261). It may be that corvinas (*Cilus gilberti*) prefer cooler waters and lornas (*Corvina deliciosa*) tolerate slightly warmer conditions (Chirichigno, 1982:217). Seatrouts (*Cynoscion*) are wide-ranging and may be found from Area 77 through 87C, though they are more typical of Area 77. The range for weakfishes (*Cynoscion analis*) is 77C through 87A, B, C, but their principal fishing zone is Subarea 77C–87A (Schweigger, 1964:259; Chirichigno, 1982:198–202). *Cynoscion analis* is common in coastal waters and young will enter brackish waters in lagoons and shallow bays (Froese and Pauly, 2004). Another species of weakfish (*Cynoscion stolzmanni*) is particularly interesting because of its large size, reaching a maximum Total Length of 115 cm (Froese and Pauly, 2004). They are found in tropical brackish lagoons, as well as coastal waters (Froese and Pauly, 2004). The range of steeplined drums (*Larimus acclivis*) and shining drums (*Larimus effulgens*) is 77–87A, with a principal fishing zone in 77C–87A (*L. acclivis*) and 77B (*L. effulgens*). Their range overlaps with that of Pacific drums (*Larimus pacificus* [*gulosus*]), which are found from 77B, C through 87A, B with a principal fishing zone in Area 77–87A. All three species are found over soft bottoms in coastal waters and brackish waters of lagoons and bays (Froese and Pauly, 2004). *Larimus pacificus* is considered an uncommon species today (Froese and Pauly, 2004). Members of the kingfish genus *Menticirrhus* are wide-ranging and may be found from 77A, B, C and 87A, B, C depending on the species. Only *M. ophicephalus* and *M. paitensis* have a primary fishing range as far south as 87A but the principal fishing zone for *M. ophicephalus* extends to 87B. The range of tallfin croakers (*Micropogonias altipinnis*) is from Area 77 into Subareas 87A, B, C, but the principal fishing zone is Subarea 77C (Chirichigno, 1982:198–202). Two of the four *Micropogonias* species are typical of lagoons in Area 77 and this genus is not mentioned by Schweigger (1964). FishBase (Froese and Pauly, 2004) indicates that *Micropogonias altipinnis* is found in Perú along coastal sandy shores and in brackish lagoons. Two other genera of croaker also are found in Area 77. One of these, *Odontoscion xanthops*, is found only in Area 77. Members of the other genus, *Ophioscion* spp., are found primarily in Zone 77, though one species (*O. sciera*) is found in lagoons as far south as 87B (Chirichigno, 1982:211). Cocos (*Paralonchurus* spp.) are found along sandy coasts and in bays from Area 77 through Area 87, but most are typical of Subareas 77C thru 87. The principal catch zone for *P. peruanus* is Subarea 87A (Schweigger, 1964:258; Chirichigno, 1982:213–214) and FishBase (Froese and Pauly, 2004) lists its range as 3° to 13° S. Star drums (*Stellifer* spp.) are wide-ranging drums found in Areas 77–87A, B, C. It is typical, however, of lagoons and the primary fishing zone in Area 77, though *S. minor* is fished principally in Subareas 87A, B (Chirichigno, 1982:221). Polla drums (*Umbrina xanti*) are found over sandy bottoms in Areas 77–87A, B and are fished primarily in 77–87A (Chirichigno, 1982:225).

Although these drums are wide-ranging, some are more characteristic of warmer waters. *Bairdiella* spp., *Cynoscion analis*, *Larimus* spp., *Micropogonias* spp., *Odontoscion* spp., *Ophioscion* spp., and *Umbrina xanti* are classified here as warm-water forms. *Cilus gilberti* (formerly *Sciaena gilberti*), *Corvina deliciosa* (formerly *S. deliciosa*), and *Paralonchurus* spp. are considered cool-water animals. *Cynoscion* spp., *Menticirrhus* spp., and *Stellifer* spp. are considered mixed-water fishes.

Morwongs (*Cheilodactylus* spp.) are considered members of the cool-water community. They are found only in Area 87, with the primary fishing zone in Subareas 87B, C (Chirichigno, 1982:238–239).

Two other fishes are classified as members of the mixed-water ecological group, though a case could be made that they should be considered warm-water animals. Three species of sea chub (*Kyphosus* spp.) are mostly found in Area 77; however, *K. analogus* ranges from Area 77 into Subarea 87B (Chirichigno, 1982:228–229). Spadefishes (*Chaetodipterus zonatus*) also range from Area 77 through Subarea 87B (Chirichigno, 1982:231). The primary fishing zone for both is Area 77 and they have only been identified in zooarchaeological assemblages from sites north of Lima.

Members of the wrasse family (Labridae) commonly are found in warm, tropical waters associated with coral reefs (Randall, 1968); however, two genera are found in cool Peruvian waters. The genus *Bodianus* ranges from Areas 77–87 and is commonly fished throughout the area (Chirichigno, 1982:247–253). The genus *Pimelometopon* is most commonly fished in Subareas 87B, C (Chirichigno, 1982:247–253). According to Schweigger (1964:265), *Bodianus* prefers the warmer northern waters and *Pimelometopon* is more wide ranging. Many members of this family are found in cool waters. Labridae is classified as a cool-water taxon.

Parrotfishes (Scaridae) also are typical members of tropical coral reef communities (Randall, 1968). The species identified, pocochos (*Nicholsina denticulatus* [formerly *Xenoscarus denticulata*]), range from Areas 77–87A, B, but are primarily fished in Area 77 (Chirichigno, 1982:254). Scarids are considered warm-water fishes.

Several other fishes are classified as cool-water fishes. Rollizos (*Pinguipes chilensis* [occasionally *Mugiloides chilensis*]) and viejas (*Labrisomus philippi*) range through Subareas 87B, C (Chirichigno, 1982:256, 267). Mackerels (*Euthynnus* spp., *Sarda* spp., *Scomber* spp., *Scomberomorus* spp., *Thunnus* spp.) are pelagic fishes found in a variety of temperature conditions (Chirichigno, 1982:274–278). Some members of this family are uncommon in lagoons and are typical members of the Peru Current food chain. Other members characterize warm-water locations and are common in sites from later sites on the northern coast of Ecuador (Byrd, 1976:84; Lippi, 1983; Sánchez, 1993). Palmeras (*Seriolella violacea* [formerly *Neptomenus violacea*]) range from Areas 77C through 87A, B, C (Chirichigno, 1982:290). Their primary fishing zone is Subarea 87B.

Flounders (Bothidae) are carnivorous bottom fishes common in shallow, near-shore waters. Most are found in Area 77, though several species are found in Area 87 as well (Schweigger, 1964:293; Chirichigno, 1982:294–306). The only flounders with Subareas 87A, B as a principal fishing zone are *Etropus ectenes* and *Paralichthys adspersus*, but because most identifications are to family, flounders are considered members of the mixed-water group.

Two other fishes are typical of lagoons and are classified as warm-water species. Sleepers (Eleotridae) are found only in Area 77, where they may be found in lagoons and even fresh water (Chirichigno, 1982:270). Puffers (*Spheroides annulatus*) are found in Areas 77–87A, B but Area 77 is the principal fishing zone (Chirichigno, 1982:294–306). According to Schweigger (1964:298), they only are found north of Paita.

SUMMARY OF ECOLOGICAL GROUPS

Certain vertebrates are considered typical of warm waters (Table 3). Members of the warm-water ecological group include bonefishes (*Albula vulpes*); sea catfishes (Ariidae); some groupers (e.g., *Epinephelus* spp.); grunts (e.g., *Conodon* spp., *Haemulon* spp., *Orthopristis* spp.); drums (e.g., *Larimus* spp., *Umbrina* cf. *xanti*); mullets (*Mugil* spp.); and puffers (*Spheroides* sp.). These animals are usually minor components of zooarchaeological assemblages from sites within the Peru-Chilean province, though members of these families often are abundant elsewhere in the hemisphere in assemblages where tropical waters or lagoons are common (e.g., Wing and Reitz, 1982b; Cooke, 1992).

Other vertebrates are typical of the cool waters associated with the Peru Current and often are very common in zooarchaeological assemblages within the Peru-Chilean province. At many coastal sites the most abundant members of the cool-water ecological group are penguins (*Spheniscus humboldti*); boobies (*Sula* spp.); herrings (Clupeidae); anchovies (Engraulidae); some groupers (e.g., *Paralabrax* spp.), grunts (e.g., *Anisotremus scapularis*, *Isacia conceptionis*), drums (e.g., *Paralonchurus peruanus*, *Corvina deliciosa*, *Cilus gilberti*); and mackerels (Scombridae). In the protocol used here, the dominance of some of these animals in zooarchaeological assemblages from sites located south of Lima and absence from sites north of Lima is considered a valid reason for including an animal in the cool-water group (Reitz, 2001; Reitz et al., 2015; Reitz et al., 2016; Reitz et al., 2017).

Several marine vertebrates are typical of cool waters but also are found in warm settings, or the reverse. These variable species are classified as members of the mixed-water ecological group. These animals are tolerant of a wide range of environmental conditions and are widely distributed throughout the study area.