Faunal use during the Archaic period based on macro remains from Cruz Verde, North Coast of Peru

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Abstract

The Cruz Verde site, located on the north coast of Peru, has a preceramic mound formed between 4.200-3.800 BC. This paper presents the results of a zooarchaeological analysis of the macro remains excavated from this mound to identify changes in faunal use and its characteristics of the Archaic period. There is a distinct difference in the two phases, from the phase CV-Ia, when marine mammals, seabirds, and fish are used equally, to the phase CV-Ib, when cartilaginous fish, mainly *Carcharhinus* sharks, are used intensively. The ecological and biological habits of the fish species that increase during phase CV-Ib suggest that the intensive resource exploitation in the estuarine brackish waters began. Referring to the data reported from other sites on the North Coast, the cartilaginous fish use tradition is a characteristic of the North Coast of Peru at least from Archaic to Formative period. On the other hand, the excavated cartilaginous fish taxonomy shows that there are differences in the fish species used in the Archaic and Formative periods. It can be pointed out that there are variations in the cartilaginous fish use tradition on the North Coast.

Key words: Zooarchaeology, archaic period, macro remains, cartilaginous, maritime ecology.

Resumen

El sitio Cruz Verde, ubicado en la costa norte del Perú, cuenta con un montículo precerámico formado entre 4.200-3.800 años a.C. Este trabajo presenta los resultados del análisis zooarqueológico de los macrorestos excavados en este montículo para identificar los cambios en el uso de la fauna y sus características en el periodo Arcaico. Se observa una clara diferencia en las dos fases, desde la fase CV-Ia, en la que se utilizan por igual mamíferos marinos, aves marinas y peces, hasta la fase CV-Ib, en la que se utilizan intensamente los peces cartilaginosos, principalmente los tiburones *Carcharhinus*. Los hábitos ecológicos y biológicos de las especies de peces que aumentan durante la fase CV-Ib sugieren que comenzó la explotación intensiva de recursos en las aguas salobres del estuario. Refiriéndose a los datos reportados de otros sitios de la costa norte, es claro que la tradición de uso de peces cartilaginosos es una característica de la costa norte del Perú por lo menos desde el período arcaico hasta el formativo. Por otro lado, la taxonomía de los peces cartilaginosos excavados muestra que hay diferencias en las especies de peces utilizados en los períodos arcaico y formativo. Se puede señalar que existen variaciones en la tradición de uso de peces cartilaginosos en la costa norte.

Palabras clave: Zooarqueología, período arcaico, macrorestos, cartilaginosos, ecología marítima.

Introduction

This paper presents the results of taxonomical identification analysis of animal remains excavated from Mound A-2 at the Cruz Verde site on the north coast of Peru, and clarifies animal use at the site during the Archaic period. The purpose of this study is to examine the resource use strategies and their temporal changes in the ancient maritime communities on the north coast, which have recently been reported as different from those on the central coast. The Archaic Period (5.000BC-3.000BC) is regarded as a period which had a great progress in sedentarization and domestication of plants and animals, and such changes in lifestyle and resource use strategies have been discussed in connection with social and economic development (e.g., MacNeish et al, 1980; Rick, 1988; Lynch, 1980; Dillehay ed. 2011). This shift from a highly mobile, hunter-gatherer-based lifestyle to a more sedentary lifestyle should not only have changed subsistence economy, but also should have changed the basis of social organization in terms of cooperation and distribution of resources. The Archaic period has thus been regarded as an important period during which the bases of Andean tradition was formed (e.g., Moseley, 1975; Moseley and Feldman, 1988; Dillehay ed. 2011). This study is essential to understanding the diversity of economic activities that took place in the coastal areas of the Andean archaic period.

Previous studies on the animal use in the archaic period

While studies on the cultivation of plants and the domestication of camelids have been accumulated in the inland and highland regions of Andes, there have been many discussions on the maritime settlements supported by abundant marine resources and its social complexity (e.g., Lanning, 1967; Moseley, 1975: Moseley and Feldman, 1988; Fung, 1988; Engel, 1981; Quilter, 1989). Among them, Michael E. Moseley, who comprehensively compiled data on natural artifacts and livelihoods in the central coast of Peru, focused on the existence of ritual structures that began to be constructed in the early Formative period, and suggested that the settlement of the area due to abundant marine resources and population growth through fishing led to the emergence of complex societies that constructed huge ritual structures (e.g., Moseley and Feldman, 1988; Engel, 1981; Quilter, 1989). Among them, Michael Moseley (1975) suggested that the population growth due to sedentarization and abundant marine resources led to the emergence of complex societies that constructed huge ceremonial architecture in the Formative period. Although his argument remained within the framework of neo-evolutionism perspective, which emphasizes a subsistence economy with large productivity, it has had a significant impact on the development of subsequent research[1] (e.g., Hirota, 2003; Prieto, 2015: 1104-1106; Beresford-Jones et al, 2018). Although there are some problems that cannot be overlooked, such as a time gap of more than

[1] There are some hypotheses that tries to emphasize the importance of the production and use of fishing nets made of plant fiber, which led to the reorganization of labor organization (Hirota, 2003; Beresford-Jones et al, 2018), or in response to previous discussions that have assumed intensive exploitation on anchovy as a major food resource, some have pointed out the utilization of a wide range of animal and plant resources with and the low percentage of anchovy as a food resource (Prieto, 2015: 1104-1106).

1.000 years between the establishment of sedentary community and the appearance of ceremonial architectures, there can be no dispute that the exploitation of marine resources played a certain role in the formation process of Andean civilization of the coastal region.

An important factor in the discussion is the anchovy (*Engraulis ringens*), which is abundant in the Andean coast (Moseley and Feldman, 1988). Unlike other small fish, anchovy feeds directly on phytoplankton, which is why its population is so large, and the Peruvian coast, where planktons are abundant due to upwelling current, is famous as one of the best fishing grounds in the world (Watanabe, 2012). Fishing nets were considered necessary for anchovy fishing, and together with the use of cotton (*Gossypium barbadense*) as a material for nets, they have been regarded as a characteristic of maritime settlements in the archaic period. In fact, the predominant use of anchovy and cottons have been reported at many archaeological sites along the central coast of Peru during this period (e.g., Chu, 2011; Ugent et al, 1984: 420; Shady and Leyva eds. 2003, Vega-Centeno, 2005: 186; Quilter, 1989; Pozorski and Pozorski, 2003). Even at the Paloma site on the central coast, a well-known fishing settlement dating back to 5700 years BC, more than half of the excavated fish remains are anchovy (Reitz, 2003). To some extent, it is acknowledged that the use of marine resources, mainly net fishing for anchovy, was a major factor in the sedentary process[2]. Thus, previous studies on the archaic period of the Peruvian coast have tended to pair fishing settlement with anchovy utilization. However, most of the discussions have focused on the central coast, where most of the research has been concentrated.

On the other hand, recent investigations on the north coast have revealed a different picture from that of the central coast. The Huaca Prieta site on the north coast, made prominent by Junius Bird (Bird et al, 1985) when he reported abundant organic artifacts such as gourd vessels and textiles, was resurveyed in the late 2000 (Dillehay ed. 2017). The major repercussions of this survey were the discovery of a long-term accumulation of human activity at the site dating back to the Late Pleistocene (14.500 cal. BP) (Dillehay et al, 2012b) and the identification of a variety of the oldest food plants, including maize, at Huaca Prieta and the adjacent Paredones site (Grobman et al, 2012; Bonavia et al, 2017). Maize has been dated to 6.775-6.504 cal. BP (Grobman et al, 2012: 1758), which is well beyond the case of the Los Gavilanes site (1.800 years BC) in the Initial Formative period of the Central Coast. The study revealed that there is a need to reconsider the use of plants. The analysis of excavated animal bones reveals a complex animal use centered on seabirds (e.g., *Phalacrocoracidae*) and sea lions (*Otariidae*), along with a rich variety of fish species (Vásquez et al, 2017). Regarding to fish, sharks of the *Carcharhinidae* family are the most frequently excavated (Vásquez et al, 2017: 358), which is very different from the mentioned aspect of the archaic period of the central coast. However, the archaeological data from the Huaca Prieta and Paredones sites divide the approximately 2300 years from 7572 cal BP to 5308 cal BP into two phases, Phase II~III (Phase I includes the Late Pleistocene, and Phases IV

[2] According to A. Chu, who investigated the Banduria site, anchovy was excavated in large numbers, but at the same time many medium-sized fish species were also utilized, indicating that a variety of resource use was conducted in accordance with ecological niches (Chu 2011).

and V correspond to the Initial Formative period) (Dillehay et al, 2012a: 62-65), a scale is a bit too macroscopic to clarify the Archaic period's dynamics.
The dominant use of sharks on the north coast of Peru reported not only from Huaca Prieta, but also from Padre Alban, Alto Salaverry (Pozorski. 1979), the Huaca Prieta survey data reported by Bird (Bird et al, 1985) in the Initial Formative period (3.000-1.800 BC), Gramalote (Pozorski, 1979; Prieto, 2015) and Puemape (Elera, 1998) in the Early Formative period (1.800-1.000 years BC). It suggests that this pattern of animal use was long term tradition and had some regional spread. In fact, a review of archaeological data of animal and plant remains from the lithic to formative periods shows that this tradition of shark use was characteristic of the north coast of Peru, north of the Santa River confirming the regional diversity in animal use in the Peruvian coast (Shoji, 2014: 51-72). Gabriel Prieto has also renewed the image of the fishermen of the north coast during the Formative period by deriving the presence of shark-based fishing activities from Gramalote archaeological project (Prieto, 2015: 1107-1112; 2021).

As described above, archaic period studies of the Peruvian coast have focused on animal use, with emphasis on anchovy, in the process of the establishment of fishing settlements and social development based on studies of the central coast. On the other hand, it is becoming clear that there is a diversity in animal use in the coastal areas stretching from north to south, but there has been insufficient discussion to comprehensively understand for the regional pattern and meaning of subsistence activities in these coastal areas. If the strategies of food procurement in the Andean region differ from region to region, it also implies that there is a diversity in the formation process of Andean society. In this paper, we focus on the north coast, where the transition of animal use has only been roughly understood, and present the results of taxonomical identification analysis of animal remains excavated from the Cruz Verde site. Through comparisons with other archaeological sites, the paper will also clarify the transition and characteristics of animal use during the Archaic period on the north coast of Peru.

Formation Process and Chronology of A-2 Mound at Cruz Verde

The Cruz Verde site is located in the lower Chicama Valley coastal region. It is located on a slight rise in the coastal terrace about 200 m distance from the present-day coastline, about 6 km north of the mouth of the Chicama River and 4 km southwest of the nearest village, Magdalena de Cao (Fig. 1). The coastal area of the Chicama River basin also contains several mounds formed in Archaic period, including the afore mentioned Huaca Prieta and Paredones (Bird et al, 1985; Dillehay ed. 2017), about 3 km south of the Cruz Verde site, and 12 km north of the Huaca Pulpar (Engel, 1957) are located 12 km to the north. The Cruz Verde site consists of three mounds: one slightly steeply sloping mound on the southwestern side (mound A-2), a group of slightly flattened mounds about 200 m away (mounds B-1~3), and a flat plain (plain area A-1) that extends between them (Fig. 2). From the plain area A-1, pottery from the early Middle Formative period has been excavated, indicating that small-scale residential occupations were here (Shoji and La Rosa, 2017). In addition, although most of the other mounds were formed by Preceramic

occupations, the surface and upper layers of the mounds also show occupations in the Regional Development period and the Regional State period, indicating that long-term and intermittent activities were taking place at this site, according to the archaeological surveys conducted in 2016 and 2017 (La Rosa and Shoji, 2017; 2018).

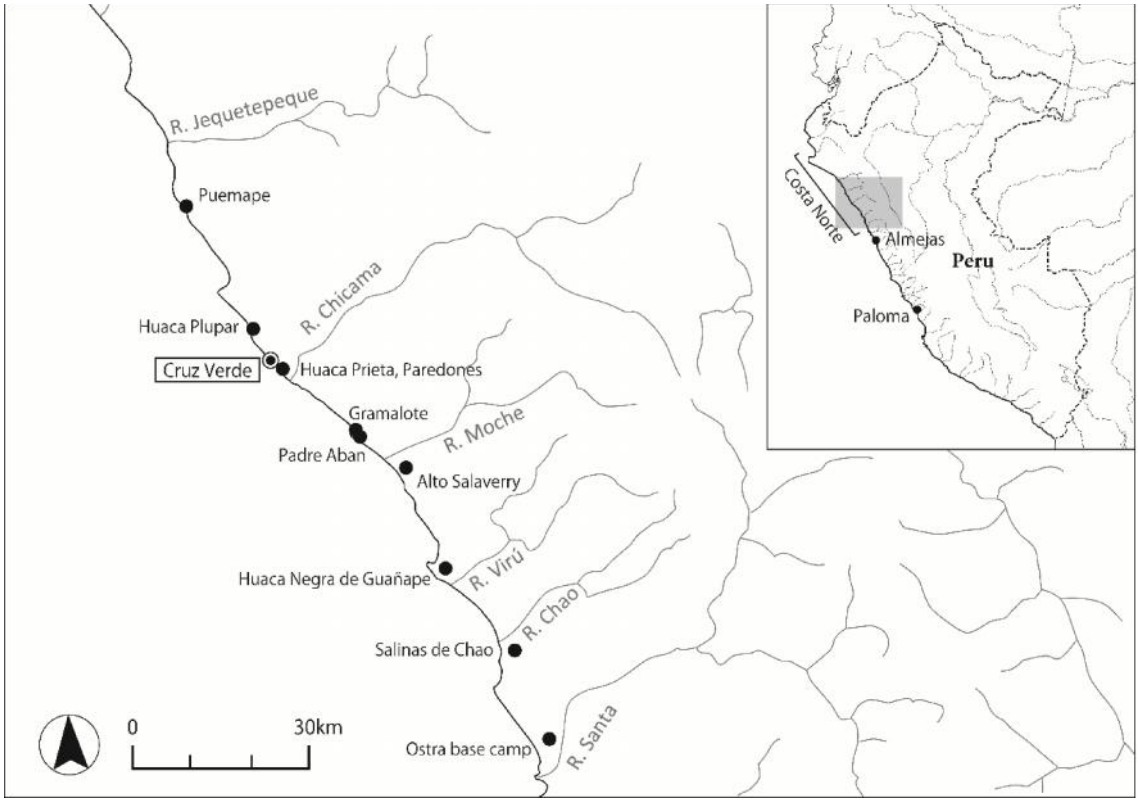

Figure 1. Location of Cruz Verde and other archaeological sites on the north coast of Peru.

In particular, the intensive excavation of mound A-2 revealed a repetitive mound formation process, in which anthropogenic sedimentary layers were repeatedly built up. In addition, the mound's sedimentary layers contained large quantities of natural remains and artifacts such as stone and bone tools with intensive use-wear, as well as a clay floor covering the mound and several burials that were embedded in the mound formation process. These indicate that the A-2 mound was formed by composite activity, disposal, burial, and the clay floor constructing activity. However, changes in the mound formation process, as described below, were also clearly identified. This artificial process of mound formation was also revealed in the reexamination of Huaca Prieta mentioned above. According to Dillehay and collaborators, the mounds at Huaca Prieta was not naturally deposited through the accumulation of residential activity, but was the result of planned "mounding", with the start of constructing date back to 7500 cal BP (Dillehay et al, 2012a: 65). Although there are differences in the archaeological materials and burials excavated at the Huaca Prieta and Cruz Verde, the fact that they share similar mound formation process suggests that a mound-building tradition was shared in the lower Chicama River basin, where the archaic mound complexes were distributed.

Summarizing the stratigraphic data of formation process of the A-2 mound, it is possible to establish two constructive phases in the Cruz Verde. The absolute ages of the two constructive phases were determined by radiocarbon dating of carbonized and uncarbonized plant remains collected from favorable archaeological contexts corresponding to the two phases: phase CV-Ia (4.200-4.000 BC) and phase CV-Ib (4.000-3.800 years BC). These results suggest that mound formation process at Cruz Verde correspond to "Phase III" (~6.538-5.308 cal. BP) of Huaca Prieta and Paredones (Dillehay et al, 2012a: 65), which is the expansion phase of the mounds. In other words, the stratigraphic data at Cruz Verde provides a more detailed time frame for the macroscopic chronology (Dillehay et al, 2012a: 62-65), which is more suitable for observing large changes, and allows us to capture more detailed changes in human activity during the archaic period.

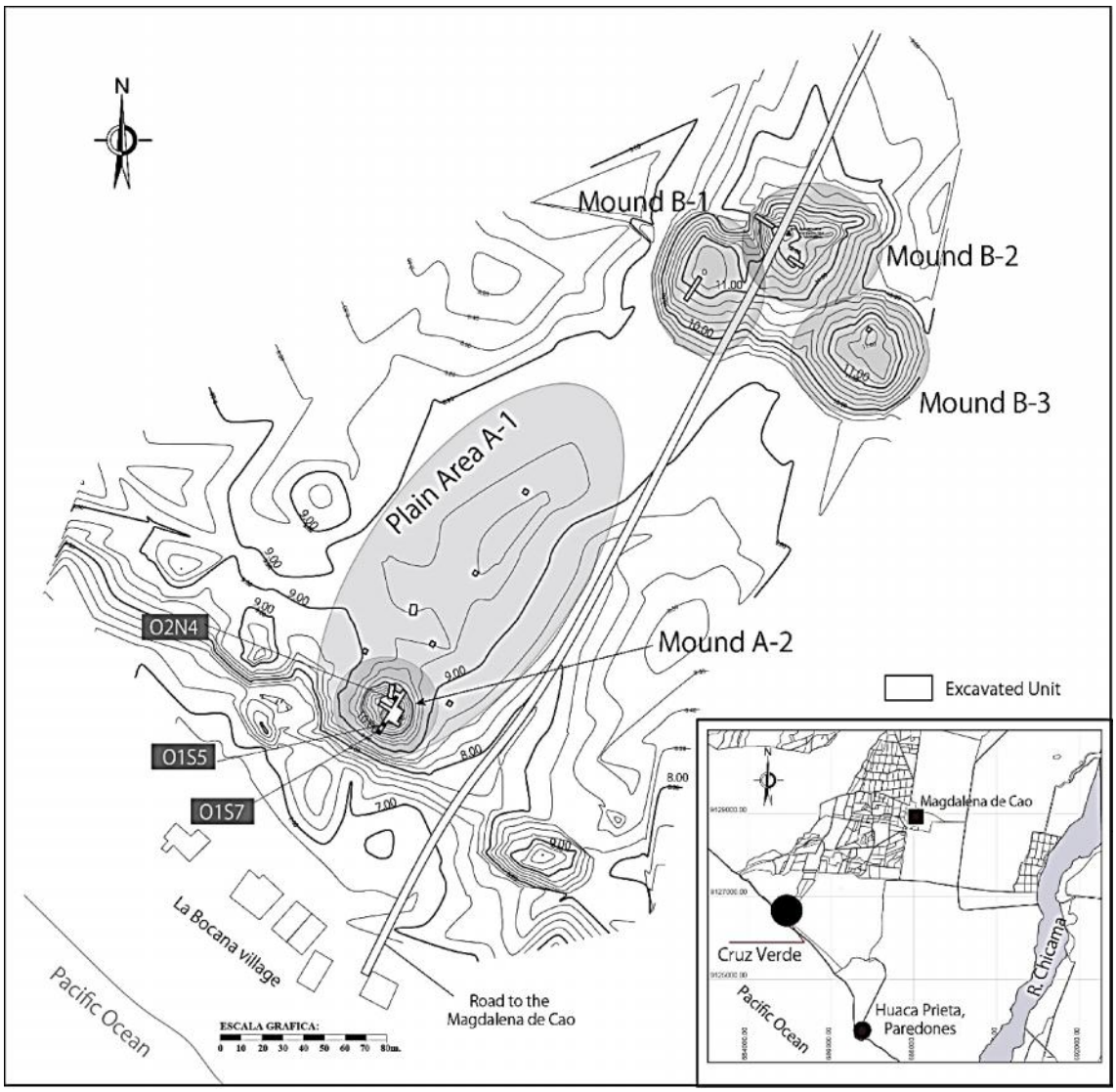

Figure 2. Topographical map and the excavation units at Cruz Verde.

Let us briefly describe the characteristics of each phase at the Cruz Verde site. In CV-Ia, the formation of the mound began directly above the ground layer, and

the cultural layer repeatedly accumulated containing large amount of natural remains, used artifacts with compacted surface. On the other hand, during phase CV-Ib, such surfaces were artificially prepared with whitish clay floor and formation process was repeated more frequently. Another important feature of this period is burials. Excavated 8 burials indicate that burial activities are often integrated into the formation process of this mound. Since it is clear that the edges of the floor sloped gently as the mound rose and fell, and no stone structures such as retaining walls were observed, it is thought that this structure was just only a “mound”, and its upper surface was an open space covered by a clay floor in phase CV-Ib.

Archaeological context of materials and methodology

In this paper, we focus on the animal remains deposited in these archaeological layers through the mound formation process described above. The large amount of food residues, including animal bones and plant micro remains, clearly indicates that there was an inextricable link between the mound formation process and the disposal activity. The overlapping and continuous archaeological contexts at Cruz Verde allows us to follow the changes in animal use during the archaic period.

The division of the north coast and the central coast used in this paper is a convenient division of the Peruvian coastal region, which extends from north to south. North of the Santa River correspond to “north coast” and south of the Santa River correspond to “central coast”. These divisions are not only a matter of convenience, but there are also distinct differences in geographical characteristics. One of these is the difference in coastal topography. On the central coast, the coastline is a series of narrow, intricate inlets, whereas on the northern coast, they are spread out as gentle, wide bays. In addition, on the central coast, the coastline is often sheer like a cliff, forming a steep slope topography, while on the northern coast, the slope from the coastline to the interior is extremely gentle, showing a topographic aspect of an expanding coastal plain. These topographical differences will be touched upon again when discussing changes in the archaic period animal use at Cruz Verde.

The animal bones analyzed in this paper are from three of the 2 m^2 excavation grids on the A-2 mound: O2N4, O1S5, and O1S7 (Fig. 2). The total volume of excavated soil of the three grids was 5.298 m^3 for the phase CV-Ia and 5.091 m^3 for the phase CV-Ib, respectively. The reasons for selecting the materials excavated from these grids were their location on the south and north sides across the center of the mound and the ability to deal with materials excavated from a series of stratigraphy up to the ground layer.

All of these materials were collected based on archaeological stratigraphy in the excavation. In addition, all of the excavated soil was screened by stratigraphic level with a mesh size of 12 mm to make a standard of material collecting. In order to collect animal bones of small and juvenile fish, typically sardine or anchovy, it is necessary to conduct sampling using a sieve with a mesh size less than 1 mm. This paper will focus on the animal use and its changes on the North Coast in the Archaic period as seen from the macro remains of animals,

and such sampling data for small fish will be supplemented in another separate paper. The data indicate that a variety of small fish, such as anchovy, were used, but the rough composition of animal species and its proportion are similar to the results of macro remains.

Species identification analyses of fish, birds, and mammals were conducted by Víctor Vásquez and Teresa Rosales (Vásquez and Rosales, 2018) through comparisons with the correction of the recent specimens stored at the Bioarchaeological and Paleoecological Research Center (ARQUEOBIOS) and the animal bone specimens excavated at the Los Gavilanes site. These identification analyses were conducted for each archaeological layer and grid from which the animal bones were excavated, and the number of each identified species was calculated in each of the CV-Ia and CV-Ib to discuss taxonomical abundance of each phase. The number of identified materials (NISP), which calculates the total number of identified materials regardless of whether they are complete or fragments, was used for quantitative analysis, and comparisons were made to determine the relative dominance of animal species within the fish, bird, and mammal taxonomic groups and their changes over time.

Result: Species composition of fish, birds, and mammals through time

The analysis identified 3.935 animal bones from the CV-Ia and CVIb phases. The total number of identified animal species was 33, including 19 species of fish, 9 species of birds, and 5 species of mammals. 1.969 items were excavated from the CV-Ia layers, and 1966 items from the CV-Ib layers (Table 1).

The most abundant fish species identified in both periods was *Carcharhinus* genus (*Carcharhinus* spp.), with 213 materials in CV-Ia and more than four times as many (860) in CV-Ib (Fig. 3). Although species identification of the *Carcharhinus* genus is difficult, two animal bones in CV-Ia and 11 in CV-Ib were identified as bull sharks (*Carcharhinus leucas*)[3]. In general, these *Carcharhinus* species are large, ranging in adult size from 1 to 3 m in length. They are widely distributed along the Peruvian coast, with many species able to invade and live in brackish and fresh water (IMARPE, 2015; Compango, 1984). The second most abundant species are *Sphyrna* genus (*Sphyrna* sp.), also Carcharhiniforms, with 104 materials identified in CV-Ia and 200 in CV-Ib. There were 31 animal bones identified to species as smooth hammerhead (*Sphyrna zygaena*) in CV-Ia and 132 in CV-Ib, which together indicate that a certain amount of the *Sphyrna* genus was utilized over two time periods. The other cartilaginous fish with the great number of identified materials is *Rhizoprionodon* sp. belonging to the family *Carcharhinidae*, with 17 materials in CV-Ia and 104 in CV-Ib. All of the above-mentioned cartilaginous fishes are large species, exceeding 1 m in length. Smaller cartilaginous fishes such as *Myliobatis* sp. and *Squatina armata* were recovered, but their numbers are not large fishes in both periods (Fig. 4). Given the differences in individual size between the two taxa and the number of bones per individual, this concentration toward the cartilaginous fishes in animal use were probably significant in a food source.

[3] The identification was made with reference to an exhaustive comparative study of extant specimens and archaeological materials by Jiménez (Jiménez, 2017: 122).

Tabla 1. NISP of the animal remains recovered in Cruz Verde

Familia	Género y Especie	Nombre Común	fase CV-Ia		fase CV-Ib		TOTAL	
			NISP	%	NISP	%	NISP	%
Peces								
Triakidae	*Galeorhinus* sp.	cazón	14	0.7	2	0.1	16	0.4
	Mustelus sp.	tollo	4	0.2	4	0.2	8	0.2
Carcharnidae	*Carcharhinus leucas*	cazón de leche	2	0.1	11	0.6	13	0.3
	Carcharhinus spp.	tiburón	213	10.8	860	43.7	1073	27.3
	Rhizoprionodon sp.	tiburón hocucón	17	0.9	104	5.3	121	3.1
Sphyrnidae	*Sphyrna zygaena*	tiburón martillo	31	1.6	132	6.7	163	4.1
	Sphyrna sp.	tiburón martillo	104	5.3	200	10.2	304	7.7
Squatinidae	*Squatina armata*	angelote	13	0.7			13	0.3
Rhinobatidae	*Rhinobatos planiceps*	guitarra			2	0.1	2	0.1
Myliobatidae	*Myliobatis* sp.	raya águila	9	0.5	1	0.1	10	0.3
	Cartilaginosos no identificado		2	0.1	8	0.4	10	0.3
Mugilidae	*Mugil cephalus*	lisa común	26	1.3	1	0.1	27	0.7
Bothidae	*Paralichthys* sp.	lenguado común	6	0.3	3	0.2	9	0.2
Carangidae	*Trachurus symmetricus*	jurel			2	0.1	2	0.1
Sciaenidae	*Paralonchurus peruanus*	suco	14	0.7	25	1.3	39	1.0
	Sciaena starksi	robalo	10	0.5	90	4.6	100	2.5
	Sciaena deliciosa	lorna	28	1.4	25	1.3	53	1.3
	Sciaena gilberti	corvina	20	1.0	11	0.6	31	0.8
	Sciaena sp.		8	0.4	1	0.1	9	0.2
Pomadasyidae	*Anisotremus scapularis*	chita	28	1.4	2	0.1	30	0.8
	peces no identificado		55	2.8			55	1.4
Aves								
Spheniscidae	*Spheniscus humboldtii*	pingüino	6	0.3	7	0.4	13	0.3
Laridae	*Larus* sp.	gaviota	38	1.9	32	1.6	70	1.8
	—		3	0.2			3	0.1
Procellariidae	*Pterodroma* sp.	petrel	36	1.8	5	0.3	41	1.0
Pelecanidae	*Pelecanus* sp.	pelícano	55	2.8	30	1.5	85	2.2
Sulidae	*Sula* sp.	piqueo	27	1.4	3	0.2	30	0.8
Phalacrocoracidae	*Phalacrocorax bougainvillii*	guanay	539	27.4	195	9.9	734	18.7
Scolopacidae	—				2	0.1	2	0.1
	Aves no identificado		134	6.8	43	2.2	177	4.5
Mamiferos								
Otariidae	*Otaria* sp.	lobo marino	455	23.1	152	7.7	607	15.4
Delphinidae	*Delphinus* sp.	delfín	38	1.9	6	0.3	44	1.1
Pinnipedia	Pinnipedia				3	0.2	3	0.1
Balaeniidae	—	ballena	2	0.1	1	0.1	3	0.1
	Mamiferos no identificado		32	1.6	3	0.2	35	0.9
	TOTAL		1969		1966		3935	

*Nombres comunes tomados de la base Fish (https://www.fishbase.se/search.php)

The number of bony fishes is not so large, but in CV-Ia, 26 mullet (Mugil cephalus), 28 lorna (*Sciaena deliciosa*), 20 corvina (*Sciaena gilberti*), and 28 peruvian grunt (*Anisotremus scapularis*) were identified. A diversity of species tends to be uniformly excavated. In CV-Ib, on the other hand, despite an increase in the number of robalo (*Sciaena starksi*) (90 bones), the number of all the fish species found in CV-Ia decreased significantly, showing a concentration toward certain fish species. The only species that showed no significant change in the number were lorna (*Sciaena deliciosa*) and peruvian banded croaker (*Paralonchurus peruanus*), which were identified in 25 materials. A comparison of the proportion of cartilaginous and other fish species shows a concentration toward cartilaginous. In addition, compared to the CV-Ia period, the proportion of *Carcharhinus* sharks became larger in the CV-Ib period, indicating stronger use of this species.

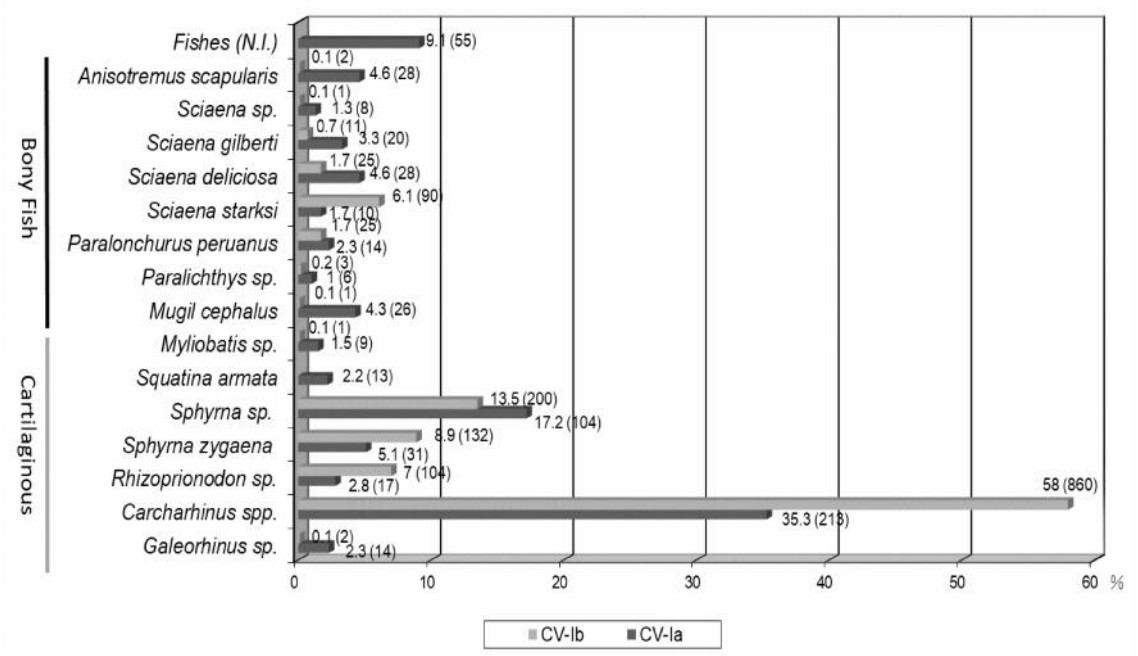

Figure 3. Proportion of the fish species NISP in each phase at Cruz Verde

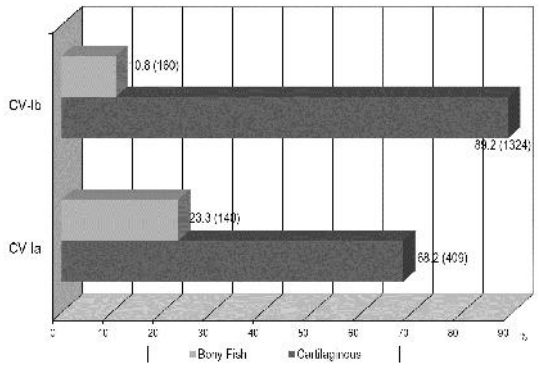

Figure 4. Proportion of the bony fish and Cartilaginous fish in each phase at Cruz Verde.

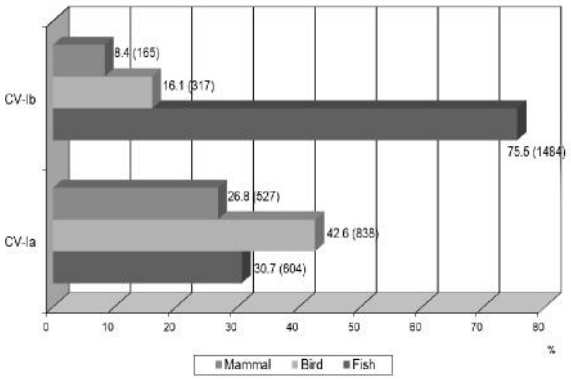

Figure 5. Proportion of the mammal, bird and fish remains in each phase at Cruz Verde.

The dominant bird species is the cormorant (*Phalacrocorax bougainvillii*), followed by the *Pelecanus* genus (*Pelecanus* sp.) (Table 1). Their abundance, with 539 and 55 materials in CV-Ia, is greatly reduced to 195 and 30 in CV-Ib, respectively. All the excavated bird species are found in coastal areas and wetlands today.

Sea lion (*Otaria* sp.) was the most abundant mammal species in both periods, especially in CV-Ia, 455 materials were identified. Even the number of identified materials decreased in CV-Ib, *Otaria* sp. was the most abundant mammal species, with a total of 152 bones. Dolphin (*Delphinus* sp.) is also prominent in the CV-Ia, with 38 materials, but its number decreases in CV-Ib (Table 1).

Finally, we examine the proportion of identified materials in each of the three taxonomic groups (fish, birds, and mammals) by two phases (Fig. 5). As can be seen in Fig.5, a large proportion of mammals and birds were used during CV-Ia, and in line with the animal species discussed earlier, the main used resources were sea lion and cormorant. The meat resource from the sea lion, a large animal weighing more than 300 kg, was an important part of the food procurement strategy. In contrast, the phase CV-Ib, the proportion of mammals and birds species was greatly reduced, and fish became the major source of food. The aforementioned details of fish species indicate that the utilization of fish was focused on cartilaginous fishes especially *Carcharhinus* sharks (*Carcharhinus* spp.).

As seen above, although sardine and anchovy are not included in the analyzed data, Cruz Verde is unique in that many species of large fauna, which are minor in the central coast of Peru. Furthermore, a comparison of the two phases reveals a change in animal use that was more intensive in the procurement of *Carcharhinus* sharks during CV-Ib, whereas during CV-Ia, the animal use was a combination of sea lion and cormorant plus sharks and bony fishes.

Comparison and discussion with other sites on the north coast

Food procurement strategies and changes at the Cruz Verde Site

The analysis in this paper confirms that there was a distinct change in animal use from the phase CV-Ia to CV-Ib, the Archaic period. However, in both phases, there was a strong concentration toward large animal species, indicating that food procurement strategies were oriented toward the exploitation of large food resources during the Archaic period.

Although we do not have a definitive answer to the question of how these animal species were procured, at least no spearpoint lancets, harpoons, or other hunting-oriented tools have been reported from the analysis of lithics, bone artifacts, and shell artifacts. This is in light of the fact that many spearpoint lancets were reported from the mountainous areas during the same period and before (Chauchat, 1988; Chauchat et al, 1998; Dillehay ed. 2011), indicating a significant difference in hunting traditions in the two regions. A similar situation to the Cruz Verde site was reported at the Huaca Prieta and Paredones sites, which are located in the same Chicama river basin and reveal traces of long-

term human activity of 15.000 cal. BP~3.500 cal. BP (Dillehay ed. 2017). Dillehay and collaborators, argue that the absence of fishing and hunting tools such as hooks, harpoons, fishing nets, and fishing lines, both before (15.000 cal. BP~8.000 cal. BP) and after (8.000 cal. BP~3.500 cal. BP) the mound construction, is evidence of simple technologies in terms of "tools"[4] (Dillehay ed. 2017) were used for a variety of food strategies (Dillehay et al, 2017; Vásquez et al, 2017: 365). They focus on the micro-ecological niches of the coastal zone, represented by the wetlands and lagoons formed in coastal areas by river inflows, the brackish waters of estuaries, and the lagoons formed by high tides. Traditional fishing methods, such as trapping and striking fish or other animals left in shallow water or invade brackish water, have been confirmed from his interviews, and he pointed out that these fishing methods have been maintained for a long time (Dillehay et al, 2017). It can also be assumed by current hunting methods that sea lions can be easily captured by driving individuals up on the beach from the seaward side and hunting them by striking them with stones or sticks, and seabirds can be captured in the same way by simple trapping in coastal areas (Dillehay et al, 2017: 7, Supplementary: Section S3). Although shell-made fishhooks have been recovered at the Cruz Verde site, they are weak and it would be impractical to hoist large sharks with these hooks, so it is likely that large fish, bird, and mammal species were captured using similar methods.

In addition, Dillehay and collaborators emphasize that a wide variety of plant remains assumed to have been cultivated in the costal wetland and river valleys, along with a small but significant number of animal species identified as inhabiting the mountainous areas. It indicates that resources from diverse environments were exploited through the simple technology and exchanges[5] (Dillehay et al, 2017: 11). Moreover, this food procurement strategy was long sustained by the abundance of adjacent diverse ecological environments (rivers, estuaries, wetlands, lagoons, tidal pools, etc.) which is specific to the Chicama valley coastal area, and did not require the development of fishing and hunting gear (Vásquez et al, 2017: 365). Similarly, at the Cruz Verde, the analysis shows that the diverse resources of the coastal micro-ecological niche were used in a complex manner. This is especially true for animal use during CV-Ia. On the other hand, our analysis does not suggest only a continuity in food procurement strategy as pointed out by them. At the Cruz Verde site, animal use clearly changed in the phase CV-Ib, with a more concentrated procurement of *Carcharhinus* sharks. We also noted above that in other bony fishes, there is an increase in fish utilization of robalo (*Sciaena starksi*). These data suggest that a focus on one particular animal species may begin to be taken up during CV-Ib.

The result of the shellfish analysis excavated at Cruz Verde shows a similar change between CV-Ia and CV-Ib. Analysis of the taxonomical abundance, the species diversity index, and the size distribution among individuals of two bivalve and one sea snail species (*Protothaca thaca*, *Choromytilus chorus*,

[4] "Simple means without elaborate technology" is also supplemented (Vásquez et al, 2017: 365).
[5] Dillehay reserves judgment at present on whether coastal groups went to procure the resources of mountainous and river valley areas themselves, or whether they obtained them through exchange (Dillehay et a, 2017).

Thais chocolata), reveal a concentration toward specific species during CV-Ib and a change in the size of the population in the ecosystem[6] (Shoji, 2018). In light of this change in shellfish use, it is highly likely that some environmental change during CV-Ib triggered the changes in animal use shown in this paper. In fact, an increase in the magnitude and frequency of El Niño events is evident from sclerochronological analysis of shellfish, but this data will be discussed in another paper that we are preparing.

Cartilaginous Use Traditions and Changes on the North Coast

The analysis and discussion revealed that animal use at Cruz Verde in the Archaic period shifted from a heavy use of sea lion and cormorant to an intensive use of Cartilaginous fish species. Although the background and changes in hunting and fishing techniques involved in this shift in animal use are unclear, it is clear that a food procurement strategy focused on specific fish species of the *Carcharhinus* genus was selected during CV-Ib. Although the case of Cruz Verde suggests a contrasting result to the case of the Central Coast during the same period, where anchovy and other bony fishes mainly used, the aforementioned sampling bias problem makes the final conclusion should be awaited until the result of sampling which cover small size fish bones. However, given the large differences in the individual sizes of these fish species, it can be pointed out that the specific of large animals, represented by *Carcharhinus* genus, was significant converting as a food resource. Furthermore, no cartilaginous fishes have been reported from the Paloma site, where it is known that large quantities of anchovy were used on the central coast during the Archaic period (Reitz, 2003: 70), and even at the Almejas site, where 21 materials have been reported, they represent only about 0.01% of the total (Pozorski and Pozorski, 2003: 63). In other words, it is clear that animal use on the north coast differed from that on the central coast during the Archaic period with respect to medium and large fish species, for which sampling bias is relatively unlikely to occur.

In addition, even during the Formative period, when the anchovy utilization became more pronounced on the central coast (e.g., Shady and Leyva eds. 2003; Vega-Centeno, 2005; Chu, 2011), intensive utilizations of cartilaginous fishes were reported along the north coast (e.g., Pozorski, 1979; Elera, 1998; Prieto, 2015). It means that the trend of animal use in the north coast of Archaic period continued over the long term (Shoji, 2014). However, given the case of the Cruz Verde site, it is possible to point out differences in the cartilaginous use traditions in terms of their fish species. To determine the diachronous and synchronic characteristics of Archaic animal use at Cruz Verde, we compared cartilaginous species recovered from each of the North Coast sites (Fig. 6, Table 2). As we have seen in the previous section, there is a strong tendency of use for the *Carcharhinus* genus at the Cruz Verde, Huaca Prieta, and Paredones sites, which belong to the Archaic period. Other cartilaginous fishes

[6] In this discussion (Shoji, 2018), the A-2 mound was divided into three chronological phases CV-Ia, CV-Ib, and CV-Ic to account for the earliest dated burials, but because no cultural layer supporting the earliest date other than burials was recognized and re-measurement reviled the previous date of burials was wrong, the chronological view was revised into two periods. The phase CV-Ia in this paper corresponds to the phase CV-Ib of a previously published paper (Shoji, 2018), and the phase CV-Ib in this paper corresponds to the phase CV-Ic of the same previously published paper.

used at these sites are concentrated in the large species, adult size of more than 1.5 m, such as *Sphyrna* genus and *Galeorhinus* genus. In contrast, in the early Formative period, the three cartilaginous species that dominated in the Archaic period were no longer reported at the Padre Aban, Alto Salaverry, and Puemape sites, and instead, various small cartilaginous fishes such as smooth-hound (*Mustelus* sp.), guitarfish (*Rhinobatos planiceps*) and ray (*Myliobatis* sp.) were reported in large numbers. Specifically, *Mustelus* genus is the most abundant species reported in these sites. (Pozorski 1979, Elera 1998).

Table 2. Cartilaginous fish remains from the archaeological sites on the north coast of Peru

				Archaic period				Initial Formative period		Early Formative period		
		average size	maximum size	Cruz Verde CV-Ia	Cruz Verde CV-Ib	Huaca Prieta (Phase III)	Paredones (Phase III)	Padre Alban	Alto Salavery	Puemape	Gramalote	Gramalote (Phase 1~3)
Order or Family	Genus and Species	(adult female)	(adult female)	*4200-4000* BC	*4000-3800* BC	6538-5308 cal BP	6538-5308 cal BP	1980-1729 BC	–	Early Puemape	1590-1100 BC	1500-1250 BC
Carcharhinidae	*Prionace glauca*	200	400									16214
Carcharhinidae	*Carcharhinus* sp.	84-267*	150-400*	215	871	494	102					38
Carcharhinidae	*Rhizoprionodon* sp.	103	154	17	104	4	1					
Sphyrnidae	*Sphyrna* sp.	265-270**	400**	135	332	111	23					
Triakidae	*Galeorhinus* sp.	130-150	193	14	2	124	25					
Triakidae	*Mustelus* sp.	43-90*	64-130*	4	4	2		105	68	692	304	648
Squatinidae	*Squatina armata*	86-108	114	13		4	11			28		
Lamnidae	–	270-300**	488**			1						105
Hexanchidae	*Notorhynchys cepedianus*	220	395									1
Rhinobatidae	*Rhinobatos planiceps*	40-70	-		2	8		11	18		57	
Myliobatidae	*Myliobatis* sp.	38-70	-	9	1	17	5				18	1901
Rajiformes	–	-	-					11	27			
	total	-	-	407	1316	765	167	127	113	720	379	18907
	References	IMARPE 2001, 2015	IMARPE 2015	-	-	Vásquez et al. 2017	Vásquez et al. 2017	Pozorski 1979	Pozorski 1979	Elera 1998	Pozorski 1983	Prieto 2015, 2021

*Mentioning IMARPE 2015, we calculated average size, maximum / minimum of maximum size in the 7 species of *Carcharhinus* and 3 species of *Mustelus*.

**Size of *Sphyrna zygaena* and *Isurus oxyrinchus* are mentioned by IMARPE 2015.

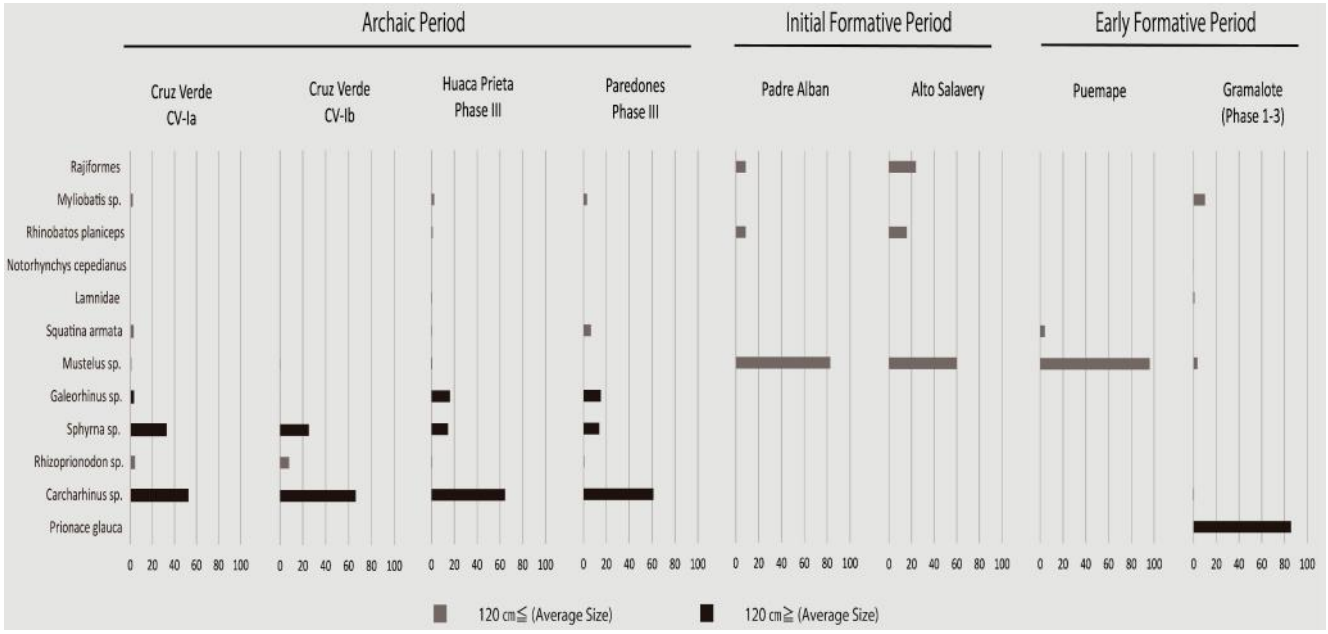

Figure 6. Proportion of Cartilaginous fish remains in each site on the north coast of Peru

While the Puemape, the site of Early formative period indicates this type of cartilaginous use, a somewhat unique animal use is seen at the Gramalote site. At this site, a small-scale survey and analysis by Shelia Pozorski (1979) reported animal use of the same species of sharks as the three Initial and Early Formative sites mentioned above. However, a recent large-scale excavation revealed a very large number of blue sharks (*Prionace glauca*) (Prieto 2015: 568-598). This species is a large cartilaginous fish, and it is clear that animal use at Gramalote was specialized for large cartilaginous species even in the early Formative period. On the other hand, after the blue shark, the most frequently excavated fish species are smooth-hound (*Mustelus* sp.) and ray (*Myliobatis* sp.), while the number of *Carcharhinus* genus is low (38 bones). In addition, the fact that the *Galeorhinus, Sphyrna* and *Rhizoprionodon* genus, reported in the archaic sites, have not been excavated indicates that even if animal use was specialized in large cartilaginous fishes at Gramalote, it was very different from that of the Archaic period.

The above comparison between sites on the north coast reveals a shift in the long-standing cartilaginous use tradition from the archaic period, when large cartilaginous such as *Carcharhinus* genus was used mainly, to the Formative period, when relatively small cartilaginous or large blue sharks were used. In other words, the use of animals specialized in *Carcharhinus* sharks during CV-Ib at Cruz Verde was a characteristic of the north coast in the archaic period. Although it is not entirely certain whether the change from CV-Ia to Ib is due to changes in the ecosystem around the site caused by climate change or not, the ecological and biological habits of each fish species are noteworthy.

While the large cartilaginous fish, the blue shark, is classified as offshore species which may venture inshore, too[7] (IMARPE, 2015: 66; Compagno et al, 1984: 522), most species of the *Carcharhinus* genus are classified as inshore species, and their range of activity has been reported in coastal areas (IMARPE, 2015: 37-49). Also, for the *Sphyrna* genus, the hammerhead shark, the habitat of young individuals seems to move closer to the coast as sea temperatures increase (González-Pestana, 2019: 15-16). In particular, some species of the *Carcharhinus* genus can invade not only seawater, but also brackish water in estuaries and freshwater in rivers, and the bull shark identified at the Cruz Verde site, with a total of 13 identified bones, is a typical example of this. Bull sharks inhabit coastal waters from 1 to 50 m depth and once a year invade brackish waters, bays, estuaries of large rivers, and lagoons for the purpose of breeding (IMARPE, 2015: 46; Compagno et al, 1984: 479-480). In these brackish waters, bull sharks give birth to young, which spend their juvenile life in this environment until the season when sea water temperatures drop (Curtis et al, 2011). Although it should be noted that the current range of bull sharks is limited to the extremely north tropic area of the Peru, the possibility that this species inhabited south part of the north coast during the Archaic period cannot be ruled out. This is because it has been suggested that sea temperatures were maintained at higher levels during the archaic period

[7] The ecology and biology of blue sharks in the Peruvian coast is not known enough, but it is known from another locality that female individuals approach the coastal zone during the matting period (Prieto, 2015: 625).

(e.g., Sandweiss et al, 2007), and that increased sea temperatures due to El Niño phenomenon may have facilitated the invasion of bull sharks. Based on the absence of fishing gear such as harpoons and large, robust hooks, as Dillehay and collaborators pointed out (Dillehay et al, 2017), it is possible that bull sharks were relatively easily caught in shallow brackish water areas such as estuaries and lagoons. In addition, based on the ecological changes during CV-Ib suggested by shellfish analysis (Shoji, 2018) and the strong preference for brackish water areas of robalo, a bony fish that is also increased the number during this period, it is possible that environmental changes such as increased river water volume and expansion of brackish water areas were occurring. In other words, it is highly likely that animal use in the diverse ecological niches as a characteristic of the Archaic north coast was maintained by food procurement strategies associated with environmental changes, such as the development of brackish water areas and the selection of relatively simple technologies.

Furthermore, such environmental adaptation to brackish water is constrained by the topographic differences between the north and central coasts. This is because, as mentioned above, the north coast of Peru has a very gently sloping coastal plain, which is topographically characterized by the potential for an increase in brackish water due to rising rivers. On the central coast, on the other hand, there are large undulating landforms that make it difficult for lagoons and wetlands to develop, so even if rivers rise, there is little room for the formation of large brackish water areas. It is also clear that the north coast is more susceptible to ENSO caused by equatorial currents. Thus, it can be assumed that the unique characteristics of animal use on the north coast are the result of geographical and environmental conditions. More empirical data should be collected and discussed in this regard.

In recent years, there has been much discussion on how sharks are hunted in the North Coast, mainly from the perspective of the Archaic and Early Formative periods (Dillehay et al, 2017; Prieto et al, 2021; Vásquez et al, 2021). In contrast to the estimation of hunting methods in lagoons (backwater estuarine) as hypothesis by Dillehay (Dillehay et al, 2017), Gabriel Prieto, who investigated Gramalote, proposed another hypothesis based on noosing techniques using with bait and rattle to attract sharks from reed boats (Prieto, 2016; 2021). Prieto argues that the use of lagoons, which are formed occasionally by storm surges, cannot explain the intensive use of sharks, which are very abundant as main source (Prieto, 2021). In contrast, Vásquez and collaborators, argue that the evidence for the existence of reed boats is insufficient and that sharks were not the only main source at the Huaca Prieta (Vásquez et al, 2021). It seems that the debate continues to run parallel. In the case of the Cruz Verde site, there is a clear concentration toward the use of *Carcharhinus* sharks during CV-Ib, and there is no doubt that they were considered an important resource during this period. The behavioral ecology of the identified fish species suggests concentrated exploitation in the brackish water areas, and as mentioned earlier, I am in support of the presence of fishing in brackish water estuarine areas. In light of the large number of species *Carcharhinus* genus, it is more likely that the fishermen used lagoons that expanded for a period of time due to some precipitation events caused by El Niño phenomenon rather than occasional storm surges. However, this does not mean that the same hunting method was

used at the Gramalote site during the Formative period. It does not necessarily mean that the same methods were used at both sites, nor does it mean that one negates the existence of the other. As mentioned earlier, there is a clear difference in the species of sharks excavated from Gramalote and other Archaic sites. Different species of fish have different ecological biological habits, and fishing methods should be developed and selected according to their habits. Whether fishing off shore or in estuarine waters must be established from the archaeological data of each period and site. This will require isotope ecology to reconstruct the life history of excavated sharks and basic zooarchaeological, screlochronological research to determine the relationship between age and vertebrae size.

Concluding remarks

The macro remain analysis of animal bones from Cruz Verde reveals the following changes in animal use on the north coast during the Archaic period: During CV-Ia (4.200-4.000 years BC), marine mammals such as sea lions and seabirds such as cormorant accounted for a high proportion of animal use. In contrast, during CV-Ib (4.000-3.800 years BC), we can reconstruct animal use with a concentration on *Carcharhinus* sharks, and there were distinct changes in food procurement strategies. This trend in the use of large mammals, birds, and fish was again confirmed to be significantly different from the animal use emphasizing anchovy, which was also practiced on the central coast during the Archaic period. This is a warning against discussing animal use in the coastal areas of the Archaic period, especially regarding the establishment of fishing settlements, based only on the case of the central coast, and it is clear that animal use in the coastal area was diverse. This suggests the need to follow the process of sedentarization, changes in food procurement strategies, and social changes in each region. It is also important to consider the possibility that the socio-economic organization based on the food procurement labor, which were unique to each region, influenced the establishment of sites in the formative period of each region. In fact, it has been pointed out that there were differences between the North Coast and Central Coast regions in the amount and size of ceremonial architecture constructed in the Initial Formative period, as well as in the presence or absence of well-organized platforms and circular plazas (Tsurumi and Morales, 2018:4). In addition, the changes in animal use during the Archaic period on the north coast revealed in this paper suggest a shift in food procurement strategy toward the intensive use of the *Carcharhinus* genus, while relying on large food resources.

Furthermore, comparisons of sites along the north coast revealed a significant change in the fish species used in the long-term cartilaginous use traditions from the Archaic to the Formative period. The shift from a concentration of large cartilaginous species such as *Carcharhinus* genus, which was evident in CV-Ib, to a tendency to use smaller cartilaginous species or large blue sharks in the early Formative period. We also confirmed that the utilization of *Carcharhinus* genus is characteristic of the archaic period of the north coast. The ecological and biological habits of these fish species also point to the possibility that this animal use was the result of exploitation focused on brackish water areas such as estuaries and lagoons.

On the other hand, the analysis in this paper is based on macro remains of animal species and does not reflect the results of micro remain sampling to collect small and juvenile fish such as anchovy. Although the presence of cartilaginous fishes ensures that there are differences in animal use between the north and central coasts, the role played by small and juvenile fish must also be clarified for the north coast, too. Quantitative sampling and analysis have already been conducted, and we will present it to compare with the animal species identified in this paper in another paper.

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