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The White Shark (*Carcharodon carcharias*) in the Ancient Peruvian Ceremonial Centre of Huaca Pucllana

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ABSTRACT New data regarding the white shark (*Carcharodon carcharias*) at the archaeological complex Huaca Pucllana (200–700 AD) are presented on the basis of the recent discovery of teeth in ritual offering features. Previous information of this species from fossil, archaeological and modern records is reviewed. The use of the white sharks as an El Niño indicator is rejected. Past and present white shark distribution in the South East Pacific is reviewed, and the extermination of pinniped colonies as a factor in the poor modern record is discussed.

Key words: Carcharodon carcharias; ENSO; Huaca Pucllana; Lima culture; palaeoecology; Peru

Introduction

The white shark (*Carcharodon carcharias*) is a large apex predator species distributed in most of the world's oceans. Its habitat comprises coastal and offshore waters of continental and insular shelves. This shark species has a wide range of prey items, including birds, cetaceans, pinnipeds, osteichthyians, chondricthyians and chelonians (Compagno, 2001).

Archaeological remains of the white shark have been found in Argentina and Brazil (Cione & Barla, 2008). Remains found from Holocene terrestrial mammal hunter gatherers of the Pampas in Argentina suggest that teeth of the great white shark were used as tools or pendants (Cione & Bonomo, 2003).

Huaca Pucllana is an archaeological site of the Lima culture, dating to the Regional Development or Early Intermediate Period (approximately 200–700 AD). This culture occupied the area of the modern city of Lima, on the central coast of Peru, comprising lower valleys of the rivers Chancay, Chillón, Rímac and Lurín (Figure 1). The main existing Lima culture sites to date include Maranga, Catalina Huanca, Cajamarquilla, Pucllana in the Rímac valley, Pachacamac in the Lurín valley, Copacabana in the Chillón Valley and Cerro Trinidad in the Chancay valley. Archaeologists who investigated this culture include Julio C. Tello (1999), Pedro Villar Córdova (1935), Max Uhle (1970), Thomas C. Patterson (1966) and Isabel Flores (1981, 2005). Huaca Pucllana was mainly a village of farmers and fishermen. Inhabitants of this site built large adobe pyramids, where they worshiped deities symbolized by figures associated with the sea and marine life (waves, sharks, sea lions, etc.). Their government system was likely theocratic in line with other contemporary cultures such as Moche and Nazca kingdoms.

Extensive archaeological fieldwork performed at Huaca Pucllana has led to the discovery of different shark remains, including the white shark (*C. carcharias*), short-fin mako shark (*Isurus oxyrinchus*), copper shark (*Carcharhinus brachyurus*) and blue shark (*Prionace glauca*) which were used during ritual banquets (Apolín & Vargas, 2006). New research at an older section of the site has uncovered more white shark teeth, which are presented in the succeeding text.

Archaeological context of the white shark tooth remains

The Huaca Pucllana archaeological site consists of a truncated, staggered pyramid 400-m long, 80-m wide and 22-m high, built using clay bricks and filled with pebbles and gray sand. Adjacent to the pyramid is a

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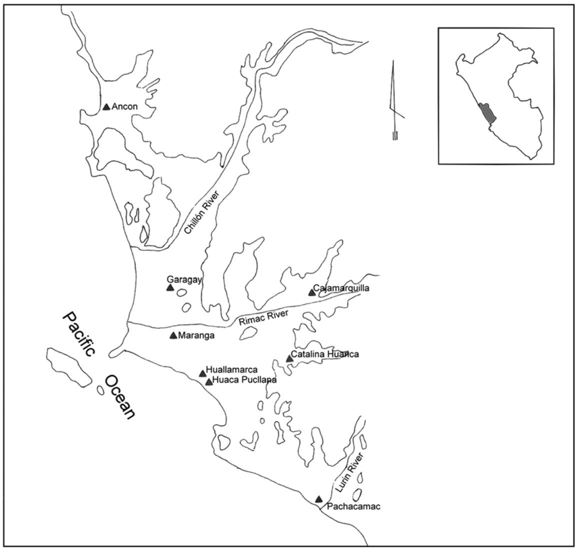

Figure 1. Map of the location of Huaca Pucllana in Lima, Peru. Solid pyramid symbols represent locations of other Lima culture archaeological sites.

series of low buildings, where courtyards, plazas and an enclosure system were discovered. These buildings had ritual and administrative functions. The whole complex covers a total of 6 ha and is currently within the city of Lima, surrounded by homes and apartments. One of the main features of the architecture of the Lima culture is its constant renewal process. Every decade or so, structures were raised with new construction. On previous floors, the remains of various ritual activities such as banquets, human sacrifices and breaking of vessels have been found associated with renovation process (Flores, 2005). The association of these remains with a period of architectural change is related to rites of passage, change of era and are usually linked to the lifetime of a ruler.

The shark teeth reported in this contribution were found in the ruins of a pyramid and its adjacent buildings, in a courtyard with benches located close to the apex of the pyramid facing west towards the Pacific Ocean. This court is composed of a bench on the east, which is accessed via a ramp located to the north. The open court space is occupied by a floor constructed with wooden poles; on the floor, several debris piles in poor condition were found. At the foot of a sidewalk, imprints of six medium-sized vessels were found. From one of these imprints, located the furthest south, the grouped white shark teeth were recovered. Similar debris features are located throughout the courtyard, including fine tableware, abundant remains of marine animals (fish, molluscs and crustaceans) and other foods. The feature's location in one of the highest parts of the pyramid reveals the importance of this court, which was subject to multiple renovations. The remains were located in the later renovation phases and belong to the final occupation of the site by the Lima culture.

Excavations in 2002 uncovered one tooth of a juvenile white shark in a similar offering context, associated with teeth of the copper shark (Apolín & Vargas, 2006). However, during subsequent excavations in 2008, six more teeth were discovered within the remains of a plaza in the fifth platform of the Pucllana Pyramid (Figure 2). In addition, a pot sculpture of a shark associated with other stages of construction was also discovered. Ethnohistorical records mentioned the importance of the sea in the ideology of the coastal towns. The sea was considered a female deity and part of a complex web of sacred beings and ancestors. They ruled the destinies of the people of the central coast of ancient Peru.

In association with the shark teeth reported here, abundant fish (Osteichthyes and Chondrichthyes) remains were also found at this locality and included the following species: *Engraulis ringens*, Ariidae indet., *Scomber* sp., *Isacia conceptionis*, *Cynoscion* sp., *Anisotremus* sp., Clupeidae indet., *Paralonchurus peruanus*, *Cilus* sp., *Mugil* sp., *Sciaena* sp., *Myliobatis chilensis*, *Myliobatis peruvianus*, *Stellifer* sp., *Peprilus* sp., *Cheilodactylus* sp., *Sardinops* sp. and Sciaenidae indet. According to information provided by Froese & Pauly (2011), the Peruvian anchovy, *E. ringens*, lives in a pelagic–neritic environment at depths between 3 and 80 m. The cabinza grunt, *I. conceptionis*, lives in a benthopelagic environment at depths between 0 and 50 m, and the Peruvian banded croaker, *P. peruanus*, lives in a demersal environment at depths of 10 m. Most teleostean species identified are typically found in the Peruvian current, which is within the limits of the continental shelf, 40 miles off the coast of central Peru (Schweigger, 1964). From the available data, and as discussed in Apolín & Vargas (2006), food from marine resources and valley cultigens were the main component in the ritualistic banquets at Huaca Pucllana.

Ceramics representing small reed boats with fishermen using lines and hooks to capture rays were also excavated from Pucllana. One particular ceramic jar represents a shark attacking a fisherman on a boat (Lumbreras, 2011). These depictions, previously considered part of the Andean mythology, may have been a reality in light of the white shark findings. It appears that fishing technology was very advanced, with reports of reed boats almost 3-m long having been constructed. With these vessels, the Lima culture

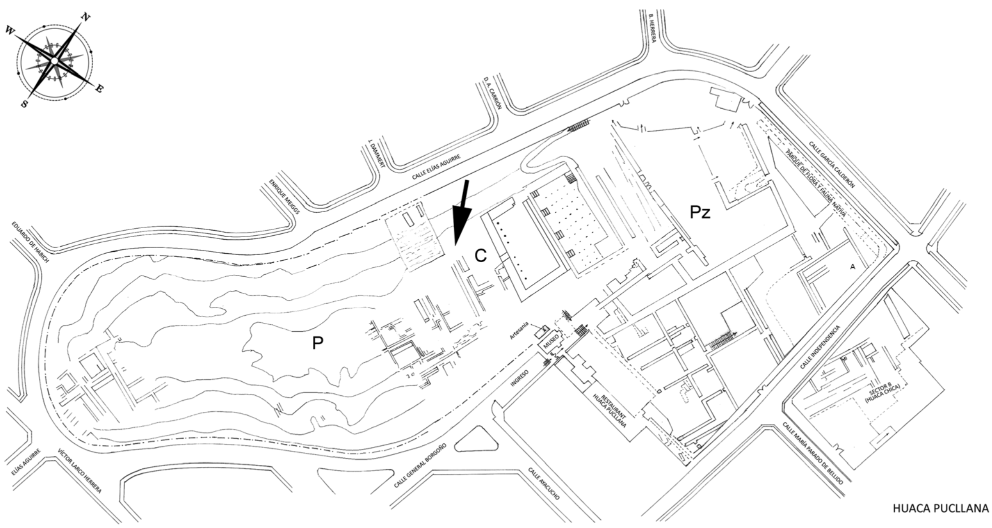

Figure 2. Chart of Huaca Pucllana. The arrow shows the location of the shark teeth found. P, Pyramid; C, Courtyard; Pz, Plaza.

people could travel far into the sea and capture large fish, such as sharks.

Very few archaeological sites in Lima have been dug as systematically as Huaca Pucllana, so it is possible that similar remains will be found in other temples of the Lima culture. However, in Pucllana, the representation and consumption of shark meat in celebrations associated with the change in architecture are common (Apolín & Vargas, 2006, Lumbreras, 2011).

The shark teeth

Chondrichthyes Huxley, 1880
Elasmobranchii Bonaparte, 1838
Lamniformes Berg, 1958
Lamnidae Müller and Henle, 1838
Carcharodon Smith, 1838
C. carcharias Linnaeus, 1758

Material

There were six almost complete upper teeth: anterior 1 (A1R), anterior 2 (A2R) and two lateral 1 (L1) from the right side and the anterior 1 (A1L) and anterior 2 (A2L) from the left side. All of these specimens were found in the fifth platform of the main pyramid of Huaca Pucllana (Figure 2), among the remains left in the hollow of a vessel at the base of a stool in the square facing west, towards the ocean. Specimens are housed at the Museo de Sitio Huaca Pucllana (Código Contextual de Campo 184, Nº de Catálogo 06).

Description

The nomenclature of Applegate & Espinosa-Arrubarrena (1996) for the dentition of *C. carcharias* was followed for the description of the present archaeological teeth.

In anterior 1 (Figure 3 A and B), the crowns are erect, with coarsely serrated cutting edges and with serrations being stronger at the base. The number of serrations on the mesial and distal edges of the teeth is 26 on the A1L and 24 on the mesial edge of A1R and 23 on its distal edge. Only one of the studied teeth preserves a complete root. The enameloid of the lingual side of both A1L and A2L (Figure 3 D and F) exhibit scratch marks that eroded the crown, making the root visible. Anterior 2 (Figure 3 C and D), the left second anterior tooth, contains the complete root, and 23 serrations were counted on its mesial and distal edges. The serrations of the right anterior teeth (Figure 3 G and H) are eroded compared with the left anterior; however, 18 serrations could be counted on its mesial edge and 21 on the distal edge. At the base of the mesial cutting edge of the crown there is a marked discontinuity in the serrations; at the distal border of the crown, the serrations are not coarse and appear eroded. The serrations are more visible on the labial side rather than the lingual side.

Two complete lateral teeth were recovered (lateral 1; Figure 3 I–L). The tips of the crowns are inclined distally, and the distal edges are

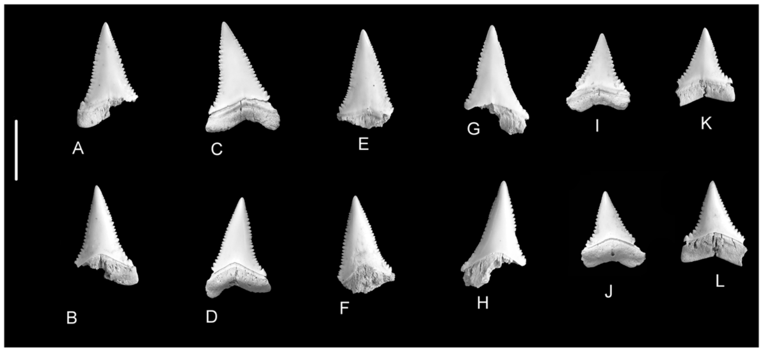

Figure 3. Teeth of the great white shark found at Huaca Pucllana. A and B (A1R): first anterior tooth in labial and lingual view, C and D (A2L): second anterior tooth in labial and lingual view, E and F (A1L): first anterior left tooth in labial and lingual view, G and H (A2R): second anterior right tooth in labial and lingual view, I and J (L1R): first lateral right tooth in labial and lingual view, K and L(L1r): fist lateral right tooth in labial and lingual view respectively. Scale bar equal 10 mm.

concave. The number of serrations on the mesial edge of each tooth was 14 and 21, respectively, and in the distal edge was 13 and 16, respectively. The roots are somewhat square-shaped with a depression at its midpoint.

Comments

The identification of the material to *C. carcharias* is based on the following diagnostic characters given by Cappetta (1987): teeth labio-lingually flattened, triangular crowns and cutting edge with strong and irregular serrae. The two well-formed lateral teeth previously described present the same degree of angulation towards the distal side of the jaw, differing only in the height of the crown. Given that these two specimens present the same morphology, development, angle degree and differ only in size, we believe that these teeth represent two different individuals. On the lateral tooth series of white sharks jaws, tooth positions can be differentiated in terms of angle degree towards the distal side of jaw and size (Applegate & Espinosa-Arrubarrena, 1996; Hubbell, 1996). Because of the small size and particular features, the teeth come from young animals. During ontogeny, the teeth of white sharks bear lateral denticles that are reduced in adults (Hubbell, 1996). These denticles are present in the specimens described here and are more visible in the A1R and the A2L (Figure 3 A–D).

On the basis of complete dentitions of white shark jaws, Shimada (2002) studied the relationship between tooth measurements and total body length using regression analysis. He suggested the use of crown height rather than tooth height, because the growth rate of tooth crown and root was not isometric. Also, he established a series of different formulas, depending on the tooth position, to predict the total length of white sharks. Measurements of the study specimens and estimated total length of sharks according to the tooth position are presented in Table 1.

Fossil history of the white shark in the Eastern South Pacific

The earliest fossil record of the genus *Carcharodon* comes from the latest Miocene and Early Pliocene of the Pisco formation (Muizon & DeVries, 1985; Ehret *et al*., 2009; Ehret *et al*., 2012). This species, *Carcharodon hubbelli*, exhibits intermediate characters of *Isurus* and *Carcharodon*, favouring the hypothesis of the evolution of *Carcharodon* from the *Isurus* lineage. During the Pliocene, *C. carcharias* is the most common species found in sediments of the Pisco formation (Hoffstetter, 1968; Muizon & DeVries, 1985) and from the Changuillo formation (Montoya *et al*., 1994). Other white sharks fossil records along the Pacific coast of South America are from the Early Pliocene and Late Pliocene of the Bahia Inglesa and Horcón formations, Chile (Walsh & Hume, 2001; Carrillo, 2011).

Table 1. Tooth measurements of the Huaca Pucllana white sharks, Carcharodon carcharias, and predicted total length

Tooth position	Regression equation ($X = CH$)	Crown height (CH) in mm	TL (cm)
Right Side			
A1	$Y = 5.234 + 11.522X$	14.4	170. 7
A2	$Y = -2.160 + 12.103X$	12.9	154.1
L1	$Y = 5.540 + 14.197X$	9.9	146.9
L1	$Y = 5.54 + 14.197X$	8.9	132.5
Left Side			
A1	$Y = 5.234 + 11.522X$	15.3	170.6
A2	$Y = -2.160 + 12.103X$	13.7	163.4

Regression equation after Shimada (2002).

Archaeological and contemporary occurrence in the South East Pacific

Remains of white shark teeth have been found in archaeological sites at Asia, central coast of Peru, in association with diverse species of fishes and molluscs (Busse, 1972). According to Palacios & Guerrero (1992), pottery remains found at the Potrero Tenorio site in central Peru show the stylized shape of sharks that could be based on a white shark.

Contemporary records of white sharks in Peru have been published twice. Hildebrand (1946) reported a 5-m long white shark with a weight of 1200 kg, caught outside Ancon Bay. Schweigger (1964) mentioned the presence of a specimen, under 5-m long, near Miraflores in 1949. Chilean records of white sharks are known from two fatal attacks on humans at Totoralillo and El Panul during 1963 and 1980 (Cea & McCosker, 1984). Sielfeld & Vargas (1992) summarized the previously known records of white sharks from Talcahuano and Valparaiso.

Discussion

An early assessment of the distribution of *C. carcharias* in South America and, in particular, the abundance in the western South Atlantic (Brazil and Argentina) was summarized by Cione & Barla (2008). Cione & Bonomo (2003) also suggested the possibility of using white shark teeth as pendants or tools by the hunter gatherers of the Pampas of Argentina. The scratch marks present on A1L could represent the use of white sharks for purposes other than ritual banquets. The other fish species found in context with the shark teeth are typically found in the cold Peruvian current. On the basis of the pottery remains found at Potrero Tenorio, Palacios & Guerrero (1992) concluded that the presence of white sharks and other shark species along the Peruvian coast could be used as indicators of incursions of warm waters during El Niño (ENSO) events. However, the white shark is a cosmopolitan, functionally endothermic species found in all oceans. The circumglobal presence of this species is most likely related to the presence of prey rather than the influence of temperature *per se* (Bruce, 2008). On the basis of reports of strandings, captures and sightings of white sharks in British Columbia, Martin (2005) concluded that there is no correlation between the presence of white sharks and ENSO events in the eastern Pacific.

Total length for the two shark specimens was estimated at 161.1 and 132.5 cm, respectively. According to the growth curves presented by Cailliet *et al*. (1985), these specimens represent two juvenile sharks with estimated centrum band deposition of 1 and 0, respectively. Taking into account the estimated total length, weight was estimated using data published by Mollet & Cailliet (1996) at 35.6 and 21.6 kg, respectively. On the basis of information from sightings and catches in the western North Atlantic, Casey & Pratt (1985) showed that juvenile white sharks live in neritic waters or very close to beaches and feed mostly on fishes (Kerr *et al*., 2006; Kabasakal & Gedikoglu, 2008).

The contemporary record of white sharks for the eastern South Pacific, as compared with the archaeological and paleontological records, is very meagre. The species is currently listed as present in Peruvian waters (Chirichigno, 1980); however, this may be based on previous reports of Hildebrand (1946) and Schweigger (1964). Sánchez (1975) mentions the presence of white shark as 'common' on the Peruvian coast without referring any specific record. Thus, it can be concluded that the presence of white shark in Peru should be considered rare.

Cione & Barla (2008) suggest that the decline of white sharks records in southern South America are linked to the decline of pinnipeds during the 19th and 20th centuries, when the sealing industry brought their populations to near extinction in Argentina. A similar situation could be hypothesized in Peru, where pinnipeds were highly exploited (Majluf & Reyes, 1989). However, recent information on tagged white sharks shows that this species will hunt for different food resources when the main prey item disperses (Bruce *et al*., 2006). The intense upwelling in the Peru current, in the South East Pacific, sustains a highly diversified ecosystem that includes more than 500 species of fishes (Chirichigno, 1980), 30 species of cetaceans (Reyes, 2009) and three species of pinnipeds (Majluf & Reyes, 1989), all of which are different prey items for white sharks when the pinnipeds are scarce.

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References

Apolín J, Vargas P. 2006. Importancia del tiburón en la Cultura Lima: Un estudio de las figuras de selacios y sus restos biológicos. *Cuadernos de Investigación/INC* **1**: 3–16.

Applegate S, Espinosa-Arrubarrena L. 1996. The fossil history of *Carcharodon* and its possible ancestor, *Cretolamna*: A study in tooth identification. In Great White Sharks: The Biology of Carcharodon carcharias, A Kimley, D Ainley (eds.). Academic Press: San Diego, California; 19–36.

Bruce B. 2008. The biology and ecology of the white shark. In Sharks of the Open Ocean, M Camhi, E Pikitch, E Babcock (eds.). Blackwell Publishing: Iowa; 69–76.

Bruce B, Stevens J, Malcom H. 2006. Movements and swimming behaviour of white sharks (*Carcharodon carcharias*) in Australian waters. *Marine Biology* **150**: 161–172.

Busse H. 1972. El Mar en la Era Precerámica. In Historia Marítima del Perú. Instituto de Estudios Histórico Marítimos del Perú (ed.). Editorial Ausonia: Lima; 237–325.

Cailliet G, Natanson L, Welden B, Ebert D. 1985. Preliminary studies on the age and growth of the white shark, *Carcharodon carcharias*, using vertebral band. *Memoirs of the Southern California Academy of Science* **9**: 49–60.

Cappetta H. 1987. Chondrichthyes II. Mesozoic and Cenozoic Elasmobranchii. Handbook of Paleoichthyology. Vol. **3B**. München: Germany.

Carrillo JD. 2011. Significado paleoambiental y paleoecológico de la fauna marina del Plioceno de la Formación Horcón, Región de Valparaíso, Chile Central. Tesis, 154 pp. Universidad de Valparaíso.

Casey J, Pratt H. 1985. Distribution of the white shark, *Carcharodon carcharias*, in the Western North Atlantic. *Memoirs of the Southern California Academy of Science* **9**: 2–14.

Cea AC, McCosker J. 1984. Attacks on divers by white sharks in Chile. *California Fish and Game* **70**(3): 173–179.

Chirichigno N. 1980. Clave para identificar los peces marinos del Perú. *Instituto del Mar del Perú, Informe* **44**: 1–387.

Cione A, Barla MJ. 2008. Causes and contrast in current and past distribution of the white shark (Lamniformes: *Carcharodon carcharias*) off southeastern South America. *Revista del Museo Argentino de Ciencias Naturales* **10**(2): 175–184.

Cione A, Bonomo M. 2003. Great white shark teeth used as pendants and possible tools by Early-Middle Holocene terrestrial mammal hunter-gatherers in the Eastern Pampas (Southern South America). *International Journal of Osteoarchaeology* **13**: 222–231.

Compagno L. 2001. Sharks of the World. An annoted and illustrated catalogue of shark species in date. *FAO Species Catalogue for Fishery Purposes, Rome* **1**(2): 1–269.

Ehret D, Hubbell G, Macfadden B. 2009. Exceptional preservation of white shark *Carcharodon* (Lamniformes, Lamnidae) from the Early Pliocene of Peru. *Journal of Vertebrate Paleontology* **29**(1): 1–13.

Ehret D, Macfadden B, Jones D, DeVries T, Foster D, Salas-Gismondi R. 2012. Origin of the white shark *Carcharodon* (Lamniformes: Lamnidae) based on recalibration of the Upper Neogene Pisco Formation of Peru. *Palaeontology* **55**(6): 1139–1153.

Flores I. 1981. Investigaciones arqueológicas en la Huaca Juliana, Miraflores. *Boletín de Lima* **3**(13): 65–70.

Flores I. 2005. Huaca Pucllana esplendor de la cultura Lima. Instituto Nacional de Cultura. Lima: Perú.

Froese R, Pauly D (eds.) 2011. FishBase. World Wide Web electronic publication. www.fishbase.org, version (08/2011)

Hildebrand SF. 1946. A descriptive catalog of the shore fishes of Peru. *Bulletin of the United States National Museum* **189**: 1–530.

Hoffstetter R. 1968. Un gisement de vertébrés tertiaires à Sacaco (Sud- Pérou), témoin néogène d'une migration de faunes australes au long de la côte occidentale sud-américaine. *Comptes Rendus de l'Académie des Sciences, Paris, France* **267**: 1273–1276.

Hubbell G. 1996. Using tooth structure to determine the evolutionary history of white sharks. In Great White Sharks: *The Biology of Carcharodon carcharias*, A Kimley, D Ainley (eds.). Academic Press: San Diego, California; 9–18.

Kabasakal H, Gedikoglu S. 2008. Two new born great white sharks, *Carcharodon carcharias*, (Linnaeus, 1758) (Lamniformes, Lamnidae) from Turkish waters of the North Aegean Sea. *Acta Adriatica* **49**(2): 125–135.

Kerr L, Andrews A, Cailliet G, Brown T, Coale KH. 2006. Investigations of d14C, d13C, and d15N in vertebrae of white shark (*Carcharodon carcharias*) from the eastern North Pacific Ocean. *Environmental Biology of Fishes* **77**: 337–353.

Lumbreras L. 2011. Jacinto Jijón y Caamaño Estudios sobre Lima Prehispánica: Maranga. Quito: Ecuador.

Majluf P, Reyes J. 1989. The marine mammals of Peru: A review. In The Peruvian Upwelling Ecosystem: Dynamics and Interactions, D Pauly, P Muck, J Mendo, I Tsukayama (eds.). ICLARM Conference Proceedings: Manila 18; 344–363.

Martin AR. 2005. Northerly distribution of White Sharks, *Carcharodon carcharias*, in the Eastern Pacific and relation to ENSO events. *Marine Fisheries Review* **66**(1): 16–26.

Mollet H, Cailliet G. 1996. Using allometry to predict body mass from linear measurements of the white shark. In Great White Sharks. The Biology of Carcharodon Carcharias, AP Klimley, DG Ainley (eds.). Academic Press: San Diego, California; 81–89.

Montoya M, García W, Vidal J. 1994. Geología de los cuadrángulos de Lomitas, Palpa, Nasca y Puquio. *INGEMMET, Boletín A* **53**: 1–100.

Muizon C, DeVries TJ. 1985. Geology and paleontology of late Cenozoic marine deposits in the Sacaco area (Peru). *Geologische Rundschau* **74**: 547–563.

Palacios J, Guerrero C. 1992. Potrero Tenorio: Un enterramiento ritual de ofrendas del estilo Nievería en el Valle del Rímac. *Pachacamac, Revista del Museo de la Nación* **1**(1): 75–100.
Patterson TC. 1966. Pattern and Process in the Early Intermediate Period of the Central Coast of Peru. University of California Publications in Anthropology, 3. Berkeley and Los Angeles: California.
Reyes J. 2009. *Ballenas, Delfines y otros Cetáceos del Perú. Una fuente de Información*. Squema-Ediciones: Lima: Perú.
Sánchez J. 1975. Animales Marinos Peligrosos. In Historia Marítima del Perú. Instituto de Estudios Histórico Marítimos del Perú (ed.). Editorial Ausonia: Lima; 464–483.
Schweigger E. 1964. El Litoral Peruano. Universidad Nacional Federico Villareal. Lima: Perú.
Shimada K. 2002. The relationship between the tooth size and total body length in the white shark, *Carcharodon carcharias* (Lamniformes, Lamnidae). *Journal of Fossil Research* **35**(2): 28–33.
Sielfeld W, Vargas M. 1992. Tiburones y Rayas del Pacífico Sur Oriental. Imprenta UNAP. Iquique: Chile.
Tello JC. 1999. Wallamarka. Arqueología del Valle de Lima. Cuadernos de Investigación del Archivo Tello, Nº 1. Museo de Arqueología y Antropología de la Universidad Nacional Mayor de San Marcos: Lima: Perú.
Uhle M. 1970. Las civilizaciones primitivas en los alrededores de Lima. In 100 años de arqueología en el Perú, R Ravines (ed.). Instituto de Estudios Peruanos: Lima; 379–391.
Villar Córdova P. 1935. Las culturas Prehispánicas del Departamento de Lima. Homenaje al IV Centenario de la Fundación de Lima o antigua "Ciudad de los Reyes": Lima: Perú.
Walsh S, Hume J. 2001. A new Neogene marine avian assemblage from North-Central Chile. *Journal of Vertebrate Paleontology* **21**(3): 484–491.

