



Billfish foraging along the northern coast of Chile during the Middle Holocene (7400–5900 cal BP)



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ARTICLE INFO

Article history:

Received 17 April 2015

Revision received 17 December 2015

Available online 21 January 2016

Keywords:

Archaic fishing
Maritime adaptation
Middle Holocene
Swordfish
Stripped marlin
Chile

ABSTRACT

Early maritime adaptation is well known from eastern South America; however, evidence for navigation and large marine fish exploitation, indicative of skilled foraging techniques, remains scarce. In the Atacama Desert, north central Chile, coastal archaeological sites show that during the Middle Holocene people relied mostly on marine resources. However, evidence from one of the shell middens (Zapatero – 7400–5900 cal BP) indicates that not only were shallow waters and marine mammals exploited, but that a dedicated fishery for large pelagic fish (mainly billfish) existed; with indications suggesting that large swordfish, weighing up to 300 kg, were being caught and brought back complete to the settlement. Although the peculiar topographic and oceanographic features of the area probably allowed pelagic fish to come well inshore, this is still the oldest evidence worldwide for such a fishery. These results provide new insights into maritime adaptation and seafaring along the Chilean coast from as early as the sixth millennium BCE.

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1. Introduction

Fishing is an ancient activity among modern humans dating back at least 70000 years (Henshilwood et al., 2001). However, despite growing evidence for the use of aquatic resources by Neanderthals in Europe (Richards et al., 2001; Brown et al., 2011; Hardy and Moncel, 2011), it is only from around 17000 years ago (during the Magdalenian period) that fishing spears and gorge hooks become increasingly common in the archaeological record (Cleyet-Merle, 1990; Gramsch et al., 2013).

Along the Pacific coast of the Americas, the oldest testimonies of fishing practice date back 12000 years on California's Channel Islands (Rick et al., 2001; Erlandson et al., 2011), and some 11000 years in northern Chile (Llagostera, 1979, 1992). Evidence for fishing large pelagic fish is, however, scarce worldwide, and is barely mentioned at all in the literature. Crockford (1997) does, however, report that bluefin tuna were being harvested off the coast of British Columbia as far back as 5000 years ago, and indeed the first swordfish remains recovered from archaic sites boarding

the Bay of Fundy, Gulf of Maine appear to be of a similar date (Bourque, 1995, 2012). Swordfish are also present from archaeological sites in the Channel Islands, California, though these date mainly from the Late Holocene (Bernard, 2004; Erlandson et al., 2009). There is no doubt that fishing regularly for large pelagic fish would have had strong implications for the fishermen's skills and abilities, especially concerning navigation and fishing tools (Acheson, 1981). Here, we report on the discovery of an important fishery of large pelagic fish, including striped marlin, swordfish, tuna and amberjack, dating from as early as the sixth millennium BCE along the north Chilean pacific coast. This is the oldest and first clear evidence for billfish foraging in western South America.

2. Environmental setting

The Atacama coastal desert is a cool, arid region lying in central-north Chile. It measures around 1000 km from north to south, west of the Andes, and stretches roughly between Iquique (20°S) and La Serena (30°S). The Andean foothills approach the coastline and there are little or no coastal plains. This is particularly the case in this study area, an area restricted to the vicinity and north of Taltal (~24–25°S).

Rain is scarce, and at the present time no permanent river, except the Loa River 250 km north of Antofagasta, brings fresh

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water to the sea. However, small springs of water are present in the foothills, which are thought to have always provided drinking water to the coastal inhabitants (Herrera and Custodio, 2014).

Sea bottom topography along this coast is characterized by an extremely narrow continental shelf of 10–20 km (Strub et al., 1998); at 30 km the bottom depth is approximately 1000 m.

For this latitude the sea temperature is rather cold (14–16 °C) due to the Humboldt Current driving Antarctic waters to the north, and the presence of local upwelling which also bring cool nutrient-rich waters to the surface (Thiel et al., 2007). This peculiar environment enables the Atacama coast to support an abundance of marine life.

Many of the species encountered along the Atacama coast are endemics from the warm-temperate south-eastern Pacific (WTSP) province (also called the Humboldt ecosystem) which stretches from Puerto Montt (40°30'S, Chile) to the peninsula Illescas (6°S, Peru). More specifically, the Taltal region represents the southern-most part of the Humboldtian ecoregion which extends from 12°S to 25°S (Spalding et al., 2007). Here the predominant small pelagic fish are the anchovy (*Engraulis ringens*), sardine (*Sardinops sagax*), and jack mackerel (*Trachurus murphyi*). The Taltal area is also renowned for its important and ancient small-scale fishery for red cusk eel, *Genypterus chilensis* (a benthic coastal fish) and its billfish (*Xiphias gladius* and *Kajikia audax*) fishery (Philippi, 1860, 1887; Gigoux, 1943). Recreational anglers once considered Tocopilla (22°S, Chile) as the best place in the world for big swordfish, and, indeed, the area between Coquimbo and Iquique is still the subject of intense harpoon billfishery. During austral summer and autumn, many small boats can be seen fishing, staying between 10 and 20 km from the coastline to pursue swordfish. Today, fish production in Taltal is concentrated on a few species: cusk eel, palm ruff (*Seriolella violacea*) and jack mackerel, specifically (Sernapesca, 2015).

3. Fish ecology and behavior

Reconstruction of fish procurement in the past relies heavily on our current knowledge of the biology, ecology, and ethology of the species represented in the archaeological context. This information helps us understand where, when, and how the fish were caught.

The jack mackerel is a medium sized schooling pelagic to oceanic fish which can be found at depths of up to 100 m. During the summer it comes closer to the shore, over the narrow continental platform, forming shoals often associated with its prey: sardine (*S. sagax*) and anchovy (*E. ringens*), and the stranding of these species has been known in the past centuries from northern Chile and southern Peru (Delfin, 1901: 42; Béarez, 2012). Due to its abundance, its capture along the shoreline was probably relatively straightforward using either nets or fishhooks.

The swordfish is a cosmopolitan species found in all warm and temperate oceans and seas. In the eastern Pacific its range extends from 50° north to 35° south. Its migration consists of movement toward temperate or cold waters for feeding in summer and back to warm waters in autumn for spawning and overwintering (Nakamura, 1985). It is generally considered an oceanic species although it is sometimes found in coastal waters, generally above the thermocline (Collette, 1995). Its preferred temperature range is from 18 to 22 °C; however, the species presents a higher tolerance to temperature variations than other billfish (Nakamura, 1985). In the Gulf of Maine, according to Bigelow and Schroeder (1953), females, much larger than the fully-grown males, are frequently encountered. The presence of swordfish was also recorded in Chile during the first naturalist work done by Molina (1782: 219). In contrast the striped marlin is restricted to the Indo-Pacific Ocean, specifically from 45° north to 30° south in the eastern Pacific (Nakamura, 1985). This oceanic species has been described by Philippi (1887) on

the basis of a specimen from Iquique (20°S). Striped marlin, like other billfish, roam throughout the epipelagic zone and do not maintain a specific home range (Nakamura, 1985). Among marlins, it is probably the more tolerant to temperate waters, hence its frequency in the southeastern Pacific.

Swordfish frequently bask on the surface with their dorsal and caudal fins protruding from the water, making them susceptible to harpooners. The striped marlin is a faster swimming fish, but it also frequently comes near to the surface with only the caudal fin lobe protruding, so it is easily distinguishable from the swordfish (Philippi, 1887).

4. Archaeological context

The presence of human populations living on the Atacama coast date from the Early Holocene (Llagostera, 1992). These populations were probably associated with the Huentelauquén Cultural Complex (11700–9500 cal BP) who settled along the coast at sites such La Chimba 13, El Obispo 1 and Los Médanos 2 (Llagostera et al., 2000; Castelleti et al., 2010; Salazar et al., 2013). This cultural complex is characterized mainly by a subsistence dependent on shellfish, shore fish (supplemented by sea lion and guanaco), and the presence of different forms of elaborate geometric sandstone artifacts (Llagostera et al., 2000; Llagostera, 2005). Their middens are composed of a variable density of shells: abalone (*Concholepas concholepas*), limpets (*Fissurella* spp.), and chitons (Polyplacophora).

During the Middle Holocene, new technological traditions emerged along the Atacama coast. Bird (1946) named it the 'Shell-Fishhook culture' due to its characteristic artifacts made of giant mussels, *Choromytilus chorus*. North of our study area this "culture" is related to the Chinchorro funerary tradition, renowned for having the oldest artificial mummification in the world (Marquet et al., 2012). In Taltal, no burials from this period are yet known, but archaeological sites show the appearance of specialized artifacts to capture and process coastal and marine resources: shell openers; fishhooks of different sizes, shapes and raw materials; fishing weights; projectile points; harpoons with bone barbs; fishing lures; and bags made of plant fibers, amongst others. No direct evidence of boat use exists during the archaic period in Chile. The oldest concrete evidence comes from a group of burial mounds at the mouth of the Loa River, dated around 215 AD, where a miniature reed raft model was discovered (Núñez-Atencio, 1986). Further indirect evidence, from the same period, comes from the remains of deep-water cusk-eels (*Genypterus* spp.) at the Punta Blanca site, just south of Tocopilla, that Llagostera (1990) associated to the use of rafts.

Communities increased in size during the Middle Holocene, as evidenced by the marked increase in the quantity and size of archaeological sites. Stratigraphic and contextual data suggests most of them were residential sites occupied in a semi-sedentary pattern. Faunal data indicates continuity in subsistence patterns from the start of the Middle Holocene. However, local diet did diversify during the Middle Holocene to include new species, focalizing on the abundant resources of high energy yields and relatively low cost procurement of the jack mackerel and sea lion, specifically.

5. Materials and methods

The fish remains were recovered during the excavation of an archaeological coastal site in northern Chile called Zapatero (Fig. 1). Situated some 50 km from the city of Taltal, just north of Paposo, the Zapatero site (24°55'42"S–70°30'58"W) was excavated during recent investigations along the coast of Taltal in 2012 (Fondecyt project 1110196).

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