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Earthquakes and coastal archaeology: Assessing shoreline shifts on the southernmost Pacific coast (Chonos Archipelago 43°50′–46°50′ S, Chile, South America)

Omar Reyes [a, *], César Méndez [b], Manuel San Román [a], Jean-Pierre Francois [c]

[a] Centro de Estudios del Hombre Austral, Instituto de la Patagonia, Universidad de Magallanes, Avenida Bulnes 01890, casilla 113D, Punta Arenas, Chile
[b] Departamento de Antropología, Facultad de Ciencias Sociales, Universidad de Chile, Ignacio Carrera Pinto 1045, Ñuñoa, Santiago, Chile
[c] Departamento de Ciencias Geográficas, Facultad de Ciencias Naturales y Exactas, Universidad de Playa Ancha, Leopoldo Carvallo 270, Playa Ancha, Valparaíso, Chile

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ABSTRACT

Subduction, isostatic rebound, and changes in global sea levels, combined with the last glaciation, have shaped the geography of the channels of Western Patagonia. Current archaeological research in this area includes some ten sites that allow us to characterize the occupation of this territory by marine hunter-gatherers. The studied archaeological sites also inform about the various geomorphological changes that the coastline has undergone. Archives dating back six thousand years ago and archaeological contexts yield new insights about the location, distribution, and position of the shoreline and its changes over time. We present a set of data, including new sites and AMS radiocarbon determinations, which supports the hypothesis that landforms have risen or subsided, and provide the bases for a working model in which archaeological ages can inform the chronology of changes in the region's coastal morphology. This paper suggest that human occupations between 6200 and 4400 cal BP recorded on high terraces of the Guiatecas Archipelago indicate higher local sea-levels, while the sites immediately on the waterfront are 2000 years younger. On the other hand, sites younger than 3300 cal BP on the modern coastline of the Chonos archipelago undergo permanent shaping, mainly due to local tectonics affecting vertical movement. Considering previously published and new data provided in this paper, we suggest preliminary uplift rates between 0.57 and 5.42 m/ka for the Guaitecas Archipelago, 0.31–1.48 m/ka for the northern sector of the Chonos Archipelago, and 0.85 m/ka in the central sector.

1. Introduction

On a global scale, post-glacial coastline changes are mainly associated with eustatic changes in sea levels that have been extensively documented (Siddall et al., 2003). Important studies also discuss the consequences that this process has produced in reshaping the coast, and its effects on communities dwelling in littoral environments (e.g. Fairbanks, 1989; Isla, 1989; Long, 2001; Murray-Wallace, 2007; Nakada and Lambeck, 1988). From the viewpoint of archaeology in the Americas, these changes hide and destroy material evidence accounting for how early human populations related with coastal environments since the terminal Pleistocene (e.g. Bailey and Parkington, 1988; Clark et al., 2014; Dillehay et al., 2008; Fedje and Christensen, 1999; Gusick and Faught, 2011; Punke and Davis, 2006; Reeder-Myers et al., 2015; Richardson, 1981; Sandweiss, 2008). Likewise, various studies have used evidence from archaeological records to infer the occurrence of associated catastrophic events (e.g. tsunamis or big storms) capable of shaping coastal geomorphology (Nichol et al., 2003; Carson, 2004; McFadgen and Goff, 2007). Consequently, a detailed study of coastal adaptations should be initiated with a thorough understanding of the processes involved in sea level change and the geoforms (i.e. marine terraces) produced by such processes, thereby providing the basis for assessing the incidence of local and regional factors involved. The Pacific coast of South America provides a unique context for evaluating human dispersal processes because it was the last continental coastal setting to be settled. Its lower latitudes were settled at 13,000 calibrated years

* Corresponding author.
E-mail addresses: omarreyesbaez@gmail.com (O. Reyes), cmendezm@uchile.cl (C. Méndez), manuel.sanroman@umag.cl (M. San Román), geofrancois@gmail.com (J.-P. Francois).

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before present (cal BP) as suggested coastal resource exploitation (Sandweiss et al., 1998; Dillehay et al., 2012; Méndez, 2013), and there is even older evidence at 14,600 cal BP in Monte Verde at 40° S as indicated by algae transport (Dillehay et al., 2008). While archaeological data has been used in studying coastal geomorphological change in areas along eastern Patagonia (e.g. Favier-Dubois and Kokot, 2011) and the Pacific of South America (e.g. May et al., 2015), the southernmost fringe of the Pacific littoral remains understudied and presents particular challenges, coastal remodeling being one of the most significant approaches.

In the Western Patagonian Channels of southernmost South America, specifically the area of the Magellan Strait and the Otway and Skyring Sounds, geo-archaeological studies reveal interesting associations between changes in the coastline throughout the post-glacial and the location of archaeological sites across an elevation gradient (McCulloch and Morello, 2009; San Román, 2013). In particular, these studies demonstrate a positive correlation between the elevation of archaeological sites and the chronology associated with changes in regional sea level evinced by geomorphological studies (Milne et al., 2005). These studies corroborate the occurrence of a marine transgression during the Mid-Holocene, originally determined only by numerical models (Clark et al., 1978). It may therefore be proposed that in areas where there are no comprehensive studies on coastal geomorphology and evolution, archaeological information might be used for an initial approach in order to estimate changes in sea levels; although acknowledging some of the problems this approach entails, such as the lack of direct association between the age of the site and the age of the landform.

The Chonos Archipelago (43°50′ - 46°50′ S), located in the northern part of the Western Patagonian channels (Fig. 1), constitutes a unique region where three tectonic plates converge, resulting in earthquake subduction (Lomnitz, 1970; Melnick et al., 2008; Ramos, 2005). This coincides with high levels of volcanic activity (Naranjo and Stern, 2004) and frequent large tsunamis (Abe, 1979). Moreover, during the Last Glacial Maximum (LGM) this area was covered by large glaciers whose advances and retreats shaped landscapes through various processes including isostatic rebound (Aniya, 1999; Haberle and Bennett, 2004; Heusser, 2002; Glasser and Ghiglione, 2009; Reed et al., 1988). All the above factors, combined with global changes in sea levels, produce singular challenges for discovering archaeological sites (Reyes et al., 2015, 2016) because it is significantly difficult to model and interpret old coastal shorelines. The conditions described for this area are different from those of other coastal zones in Patagonia, for example the Magellan Strait. The spatial distribution of the archaeological sites in the Chonos Archipelago is largely determined by an abrupt change in landscape at 41°S. The tectonic subsidence of the central area, glacial incision and the emergence of a series of inner seas and channels constitute elements not only conditioned human occupation of this region, but also influenced the survival of evidence of such occupation and the ability of archaeologists to detect it.

In previous works we have documented the characteristics of the available archaeological and bio-anthropological record (Reyes et al., 2011, 2013), as well as the chronology of occupation of the Chonos Archipelago by marine hunter-gatherers (Reyes et al., 2015). We have also highlighted the importance of addressing study of the cultural record of this zone in the context of human occupation of the southernmost part of South America (Orquera et al., 2011; Piana et al., 2012; San Román et al., 2016) and the importance of the archaeological record to inform geomorphological changes in the area (Reyes et al., 2016). The objective of the present work is to discuss how the archaeological record can be used to trace changes in the coastline during the post-glacial in an area where few data exist. This article summarizes the characteristics of the preservation of cultural deposits in the Chonos Archipelago, their location in relation to ancient and modern coastlines,

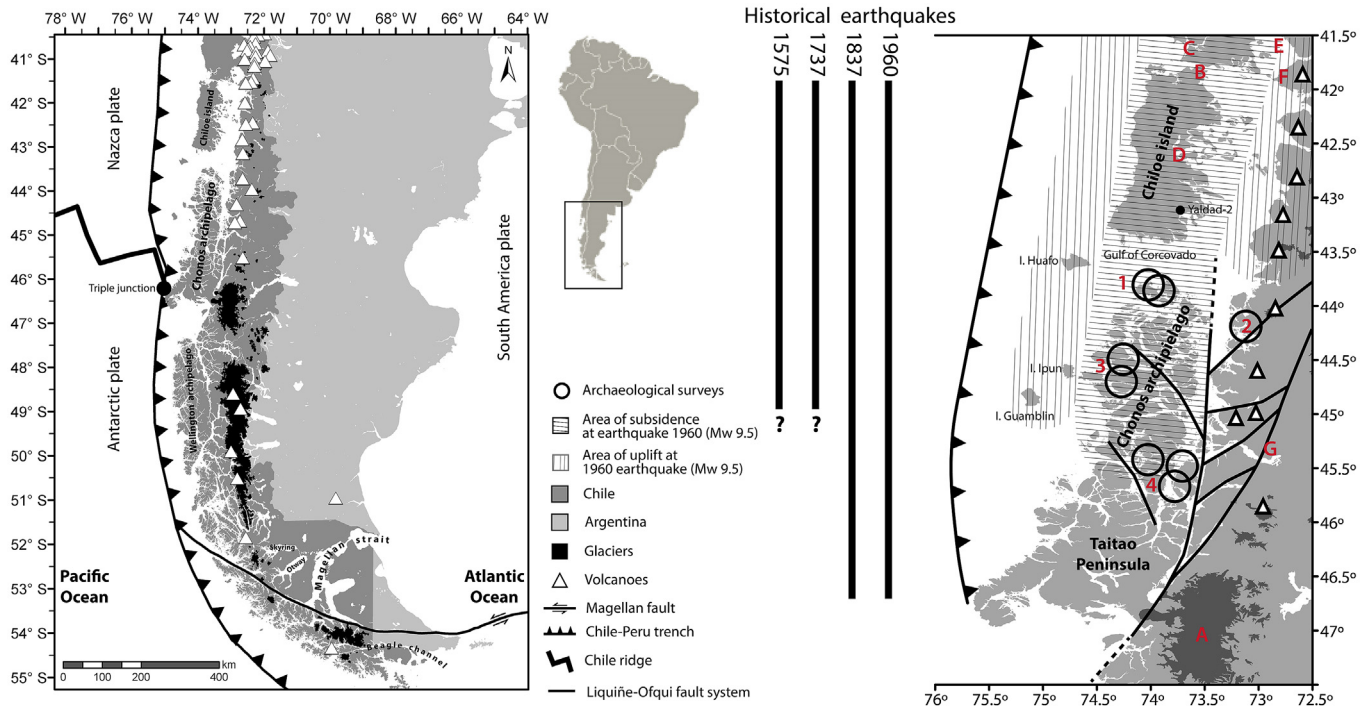

Fig. 1. General map of southernmost South America indicating the main geographical and tectonic features of the area and the main sites discussed in the text; (1) Guaitecas Archipelago, (2) Gala Sound (continental border), (3) central-west Chonos area, (4) central-south Chonos area, (A) Northern Icefield, (B) Chacao Channel, (C) Maullín, (D) Nercón, (E) Reloncaví Sound, (F) Hualaihué, (G) Aisén Fjord.

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