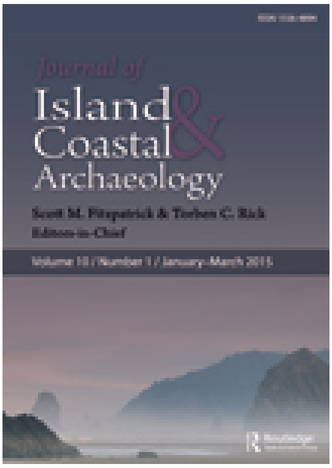

The Journal of Island and Coastal Archaeology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uica20

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Published online: 03 Mar 2015.

Journal of Island & Coastal Archaeology, 00:1–25, 2015

ISSN: 1556-4894 print / 1556-1828 online
DOI: 10.1080/15564894.2014.1001920

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ABSTRACT

This article presents the current advances in archeological research on the Western Patagonian Channels, specifically the Chonos Archipelago (43°50'–46°50' S). Based on a large spatial scale, we aim to contribute to the discussion of the dispersion and characteristics of the occupation of the Pacific coast of southernmost South America. Results show that all of the contexts recorded do not exceed 3600 cal BP. Site formation processes that may have acted in the preservation of the archeological record of this area led us to question if this region was among the last to be settled (as suggested by current chronological data), or if the dynamic tectonic activity that permanently transforms this coast is playing a major role in concealing earlier evidence, thereby introducing a significant research bias.

Keywords archipelagic settlements, Late Holocene, maritime hunter-gatherers, site formation processes, Western Patagonian Channels

INTRODUCTION

The permanent degradation and transformation of coastlines caused by the fluctuations of sea levels since the end of the Pleistocene and throughout the Holocene (Aniya 1999; Fairbanks 1989; Isla 1989; Long 2001; Nakada and Lambeck 1988) has been problematic for the archaeological identification and interpretation of sites on the

Received 13 January 2014; accepted 15 July 2014.
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American coasts (e.g., Bailey 2004; Erlandson 2001; Gusick and Faught 2011; Richardson 1981). These transformations influenced the dependency relationship of these communities with their maritime or coastal environment (Bailey and Parkington 1988; Erlandson and Fitzpatrick 2006). Understanding changes in accessibility of these spaces and the local redistribution of exploitable resources on timescales of hundreds or thousands of years requires paleogeographical and paleoenvironmental reconstructions in order to guide the search for archaeological evidence. The degree of preservation of these spaces is also strongly associated with the changes in the landscape, which were frequently catastrophic (Lomnitz 1970). Only with this information can the regional cultural development of coastal settlements be interpreted (Dillehay et al. 2008; Fedje and Christensen 1999; Mackie et al. 2011; Thompson and Worth 2011).

On the margin of the American Pacific there are vast areas, some of which have not yet been investigated, with coastlines subject to permanent changes and erosional processes (Punke and Davis 2006; Rick et al. 2006). The materials that define the occupation of these coastal spaces, the technological assemblages, and the evidence of the consumed resources, are frequently recovered from intertidal zones or degraded coasts (Erlandson and Moss 1999). Therefore, it is necessary to develop strategies for the location, recording, dating, and interpretation of the material evidence of these settlements to understand the cultural dynamics that define coastal adaptation (e.g., Bailey 2004; Erlandson 2001; Yesner 1980). Such strategies will enable us to measure the unequal distribution of the archaeological records in the region. The implications are twofold. At the regional level and for Patagonia, it is possible to document a diversity of spaces occupied by maritime hunter-gatherers in areas not previously examined. This fact is important because the archipelagic geography of the study area is singular for its extension, restriction of access, and weather conditions. Additionally, at a mega scale, our results contribute to the discussion of the variability of the evidence and the temporality of the settlement on the continent's Pacific margin (e.g., Dillehay 2009; Erlandson 1993).

Taking into account sea-level changes, the active local seismic dynamics, and the effects of these on coastal archeological sites, we have surveyed a previously understudied zone of the northern archipelagos of the Western Patagonian Channels. In this article, we present the first archaeological assessment of the human settlement in the Chonos Archipelago (43°50'—46°50' S; see Figure 1), which includes: 1) the description of the research method; 2) the identification and systematic recording of the archaeological sites associated with these coastlines; 3) the description and assessment of the geomorphological changes that affect the latter; and 4) the study of the archaeological collections. This assessment enables us to advance an initial panorama of the settlement, both spatially and chronologically, in the context of marine adaptation on the southern tip of the American continent.

CULTURAL CONTEXT

On the southern tip of the Chilean Pacific coast, there is a long and complex net of channels, fjords, and thousands of islands known as the "Austral Archipelagos" or the "Western Patagonian Channels" (Bird 1988; Emperaire 1963; Steffen 1910). This area extends more than 1,600 km north-to-south and reaches from the Reloncaví Sound to Cape Horn (41°30'-55°60' S). The coastline totals more 19,000 km with a surface area of 240,000 km^2, which should be added to ˜240 km of coastline north of the Beagle Channel and south of Tierra del Fuego, in Argentina. In this vast archipelagic area, the distinguishable maritime adaptations commence approximately at 6400 BP (7300 cal BP) toward the southernmost tip of the continent according to data obtained in the Beagle Channel (Orquera et al. 2011; Orquera and Piana 2009).

In this regional context, several topics have been discussed. Among them, the geographical origin of the maritime adap-

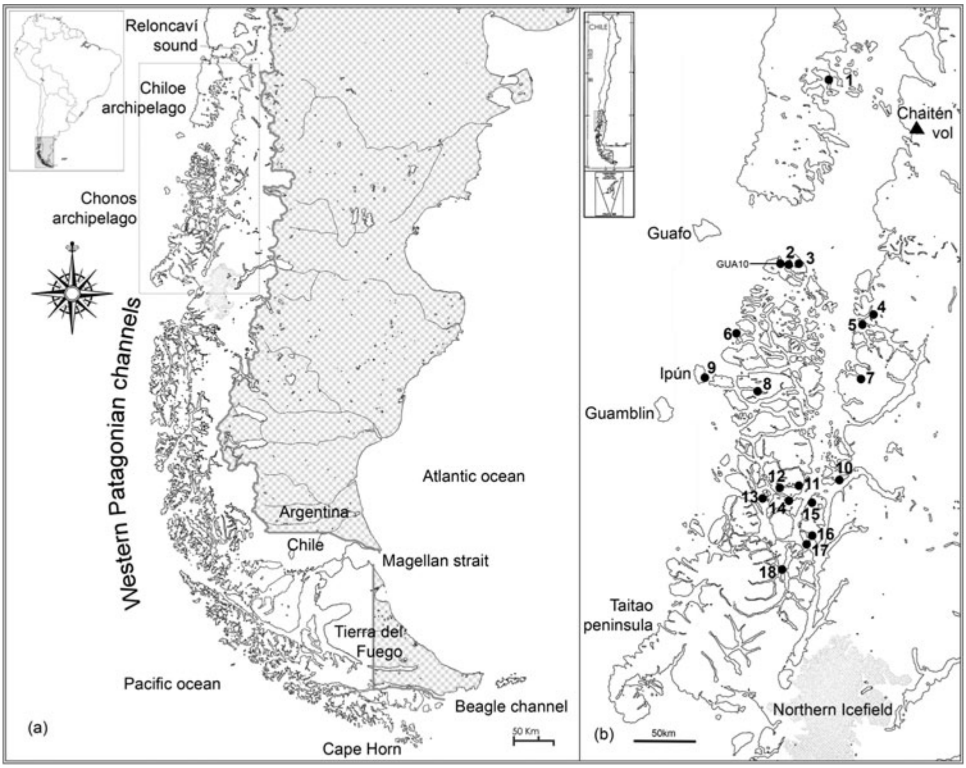

Figure 1. *(a) Western Patagonian channels, (b) Chonos archipelago and sites mentioned in this study: 1. Puqueldón, 2. Repollal, 3. Puquitín 01, 4. Seno Gala 1, 5. Isla Harris, 6. Isla Sin Nombre, 7. Canalad 1, 8. Isla Benajamín 01, 9. Ipún 1, 10. Isla Elena 1, 11. Isla Victoria 2, 12. Canal Cuche 1, 13. Isla Caniglia, 14. Canal Darwin (# 1, 2), 15. Nahuelquín (#1, 2, 3), 16. Posa Las Conchillas, 17. Isla Acuao 1, and 18. Isla Goñi 1.*

tation stands out, whether it occurred in the southern area (the Strait of Magellan/Beagle Channel) or the northern area (Chiloé/Reloncaví Sound) (Legoupil 2003; Legoupil and Fontugne 1997; Orquera and Piana 1988; Prieto et al. 2013; Rivas et al. 1999). What was the dispersion speed of this adaptation phenomenon (Bird 1938; Orquera et al. 2011)? Was there continuity or discontinuity of cultural traditions in this vast archipelagic territory (Legoupil 1997, 2003; Morello et al. 2002; Ocampo and Rivas 2004; Orquera et al. 2011; Piana and Orquera 2007)? The study of these topics has been based on archaeological research conducted in the two geographical extremes of this area, which also correspond to the sectors with the easiest access because of their proximity to population centers. Our research, which focused on undocumented sectors of the Western Patagonian Channels, aims to include vast coastal and insular unexamined spaces in the regional archaeological discussion (Erlandson 1993). The earliest archaeological site recorded in the Chonos Archipelago corresponds to GUA 10, yielding a 5020 $\pm$ 90 BP ^{14}C age (5730 cal BP; Porter 1993), which currently stands as an isolated locality without a regional context. Additionally, our research represents an important step towards characterizing the variability of maritime hunter-gatherer settlements and calibrating the formation processes that inhibit or enable the identification of the archaeological record in a changing coastline landscape.

STUDY AREA

The Chonos Archipelago consists of a group of more than 150 islands that form a dense net of channels and fjords with narrow and abrupt coastlines. The archipelago expands between the south of the Chiloé Archipelago in the Gulf of Corcovado (43°50'S) and the Taitao Peninsula (46°50'S). It covers an area of ~54,000 km^2 that is nearly 360 km long north-to-south and 150 km east-to-west. This territory is located to the west of the Andes Mountains and was intensely shaped by Quaternary glacier action (Bennett et al. 2000; Glasser et al. 2004; Heusser 2002; McCulloch et al. 2000). The abrupt topography includes slopes of hundreds of meters, with depths of 200 and 700 mbsl in the fjords and channels. This region also presents an active subduction zone dominated by tectonic plates known as the *Chilean Triple Junction* (the Nazca, South American and Antarctic plates) and large faults that converge in the Taitao Peninsula (46°–47° S; Díaz-Naveas and Frutos 2010; Ramos 2005). The faults are responsible for major earthquakes and tsunamis, which continually modify the coast (Lomnitz 1970; Plafker and Savage 1970). In the Andes, there is a chain of large volcanoes that reflect this tectonic activity (Naranjo and Stern 2004) and which are responsible for a substantial portion of the sediment of the nearby valleys.

The weather in the area is typically oceanic with a strong influence of the western winds, which cause significant precipitation (>3000 mm per year) to the west of the Andes (Garreaud 2009). The annual average temperatures are approximately ~10°C (DGA 2003). The dense vegetation dominated by *Nothofagus*, *Weinmannia*, and conifers characterizes the interior area of the fjords in the form of temperate rainforest, which is typical of cold and humid regimes (Villagrán 1988). Between 43°30' and 45° S, the vegetation is defined as temperate *Pilgerodendron* and *Astelia* coniferous coastal forest, whereas south of 45° to 51° S, it is defined as temperate *Donatia* and *Oreobolus* coastal peatland (Luebert and Pliscoff 2006). The vegetation is controlled latitudinally and altitudinally by strong temperature gradients and precipitation (Abarzúa et al. 2004; Sepúlveda et al. 2009).

The rich fauna in the study area is represented by a diversity of sea mammals: 18 species of cetaceans, two pinnipeds, two seals, and two mustelids (Aguayo et al. 2006; Zamorano et al. 2010), in addition to 22 species of mollusks (bivalves and gastropods), crustaceans and echinoderms (Osorio and Reid 2004), 29 species of fish (Navarro and Pequeño 1979), and 46 species of birds (Vuilleumier 1985). In contrast, the terrestrial fauna on the islands are scarce (small rodents). On the continental coastline, the *pudú* (*Pudu pudu*), the *huemul* (*Hippocamelus bisulcus*) and, occasionally, the puma (*Felis concolor*) are found (González et al. 2009).

MATERIALS AND METHODS

A coastal survey was conducted to the west of Traiguen Island, the Darwin and Cuche Channels, and the Smith Islands (Quetros, Renaico, Chaculay, and Elena), the latter located at the Aisén fjord. It was performed by sea because navigation is the only means of transport that can access the channels and coasts in this territory (Figure 2). This survey included 250 km of coastline in an area of 60 km west-to-east and 50 km north-to-south. Coastal sites are primarily composed of lithic remains, bones, and mollusk shells or their periostracae, which represent the archaeological evidence of camp sites of maritime hunter-gatherers. Many of these sites have been submerged and "washed away" by the tides, thus their remains are mainly recorded in the intertidal area. In these cases, systematic collection was performed during the low tide. Primarily, lithic material showed significant signs of erosion on the surfaces (Schiffer 1996).

In order to detect subsurface cultural deposits in low- or zero-visibility conditions as a result of dense vegetation, borehole excavations were performed using an AMS, Inc.,

Figure 2. *Image of the maritime surveys along Chonos Archipelago, Gala sound.*

kit with 60 mm diameter French and Dutch augers. Sediment cores from deposits more than 5 m deep were extracted. The borehole excavations detected highly obtrusive deposits (Lightfoot 1986), such as shell heaps and paleosols, and proved to be an efficient tool to calculate the volume of the anthropic deposits (stratigraphic expression) and to recover deep organic samples for dating. Thus, it is possible to establish sedimentation rates and to assess the accumulation of waste deposits.

The human bone remains analyzed correspond to a sample ($n = 10$) of the Chonos Collection of the Universidad de Chile, which was recovered in the 1980s and 1990s (Ocampo and Aspillaga 1984; Sáez 2008), but also includes new findings ($n = 10$; Reyes et al. 2013). All of the remains were recovered in caves/rockshelters or shell middens. Without exception, these remains have been looted, fragmented, or removed, and their integrity is low. In exceptional cases, it was possible to conduct basic bioanthropological analyses (to determine sex, age, and minimum number of individuals (MNI) (Buiskstra and Ubelaker 1994). Therefore, our efforts focused on determining radiocarbon chronology directly from the human remains and performing isotopic analyses (δ^{13}C collagen and δ^{15}N collagen) to characterize the diet. All ^{14}C and stable isotope samples were carefully extracted to avoid contamination. These analyses were performed by the Center for Applied Isotope Studies, University of Georgia, using the method of Cherkinsky et al. (2010). Crushed bone samples were diluted in 1N acetic acid to remove carbonates (surface absorbed and secondary). Periodic evacuation insured that evolved carbon dioxide was removed from the interior of the sample, and that fresh acid was allowed to reach even the interior micro-surfaces. Chemically cleaned samples were reacted under vacuum with 100% H3PO4 in order to dissolve the bone mineral and release carbon dioxide from bioapatite for carbon isotope ratio analysis. Residues were filtered and rinsed with deionized water and under slightly acid condition (pH = 3), heated at 80°C for 6 hours to dissolve collagen and leave humic substances in the precipitate. The collagen solution was filtered to isolate pure collages and dried out. The dried collagen was combusted at 575°C in evacuated/sealed Pyrex ampoule in the present CuO. The carbon dioxide and nitrogen were cryogenically separated. The isotopic ratios of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) were measured separately, with a Finnigan MAT 252 Isotope Ratio Mass Spectrometer following an off-line sample preparation. The dual-inlet rationing system alternately measures unknown sample and known reference gas to achieve a high-precision stable isotope measurement. Calibration is made using NIST standard hydrocarbon oil, NBS-22 (Noakes et al. 2006). The ratios are expressed in per thousand (‰) using the δ notation, and are measured with respect to the limestone Vienna Pee Dee Belemnite (V-PDB), in the case of $\delta^{13}C_{collagen}$, and to atmospheric air nitrogen (AIR), in the case of $\delta^{15}N$ (Schwarcz and Schoeninger 2011). Error is less than 0.1‰ for $\delta^{13}C$ and less than 0.2‰ for $\delta^{15}N$. All of the dates were calibrated at 2σ range with OxCal 4.2 (Bronk Ramsey 2009) with the ShCal13 curve (Hogg et al. 2013) and are expressed as calibrated years before present (cal BP).

The analyses of lithic material included a sample of the artifacts recovered at different sites of the intertidal zone, both within the surveyed area and from the Curry Collection of the Instituto de la Patagonia, Universidad de Magallanes. Given the selective nature of the sample, the analyses consisted primarily of a techno-typological classification, which, however, included the observation of technical attributes to understand the manufacturing method of some of the tools (Inizan et al. 1995). Special attention was given to the signs of abrasion on the surfaces of the artifacts because these occurred frequently as a result of their intertidal exposure.

RESULTS

The archeological survey on the Chonos Archipelago allowed recording 10 shell middens, two emerged intertidal management features (locally known as fishing pens), and three rockshelters with scattered human bone assemblages in their interiors (Table 1).

Based on these results, and those of other researchers (Porter 1993; Reyes et al. 2007; Stern and Curry 1995; Stern and Porter 1991), it could be established that the location of these sites was limited to the intertidal zone or a few meters from it (basal deposits between 0 and 3 masl) because the rugged geography and dense vegetation constrained settlement possibilities. Such sites are frequently observed in association with creeks.

There is a high probability that numerous sites remain undiscovered along our route. The first factor influencing site detection is related to the rugged topography of the cliffs along the coasts, which limits accessibility. To this factor we must add the weather conditions, which frequently make navigation difficult. A third factor is the dense vegetation that covers the coastline, which prevents access and affects visibility. To compensate for these, the borehole technique was an efficient way to sample in search for anthropogenic sediments and remains. However, this technique is limited to in situ deposits and within the range of the available extensions (6 m). Coring was unevenly performed along the coast, favoring areas suitable for disembarkation and where topography and vegetation cover allowed (Figure 2). Bays and beaches protected from the wind, locations near fresh water sources, and areas with plain topography were the most frequent places for sites. Inland incursions did not surpass 40 to 50 meters from the line of maximum tide. Once a site was discovered, coring was used in defining its extension and depth of deposits with an average of five borehole samples per site. A fourth factor is related to the degradation of the

Table 1. **Summary of site contexts discussed in this study.**

Site	Latitude and longitude	Base deposit altitude (in masl)	Distance from shoreline (in m)	Chronology (in cal yr BP)*	Discovery and recovery techniques	Preservation	Site type
Posa Las Conchillas	45°39'S–73°46'W	−1	0	3400–1270	Stratigraphic characterization, and borehole tests	Tidal erosion	Shell midden and intertidal lithic scatter
Canal Cuche 1	45°22'S – 73°56'W	2	5	1910	Borehole tests	Minor alterations	Shell midden
Canal Darwin 1	45°26'S – 73°56'W	2	5	530	Borehole tests	Minor alterations	Shell midden
Canal Darwin 2	45°27'S – 73°56'W	1	0	3600	Stratigraphic characterization, intertidal collections, and borehole tests	Tidal erosion	Shell midden and intertidal lithic scatter
Isla Caniglia	45°26'S – 74°06'W	2	3	Modern	Borehole tests	Minor alterations	Shell midden
Seno Gala 1	44°09'S – 73°06'W	−1	0	1330–1270	Test pits, intertidal collections, and borehole tests	Minor alterations and tidal erosion	Shell midden and intertidal lithic scatter
Isla Ipún 1	44°35'S – 74°43'W	UK	UK	1470–770	Chonos collection	Anthropogenic disturbance	Cave with disperse surface human remains
Isla Victoria 2	45°14'S – 73°55'W	UK	15	2350–1760	Chonos collection	Anthropogenic disturbance	Cave with disperse surface human remains
Nahuelquín 1	45°27'S – 73°21' W	2	5	1760–500	Stratigraphic characterization, excavation, intertidal collections, and borehole tests	Minor alterations	Shell midden and intertidal lithic scatter

(Continued on next page)

Table 1. **Summary of site contexts discussed in this study.** ***(Continued)***

Site	Latitude and longitude	Base deposit altitude (in masl)	Distance from shoreline (in m)	Chronology (in cal yr BP)*	Discovery and recovery techniques	Preservation	Site type
Nahuelquín 2	45°27'S – 73°42'W	2	15	Undated	Surface record	Minor alterations	Emerged intertidal management feature
Nahuelquín 3	45°28'S – 73°41'W	2	10	Undated	Surface record	Minor alterations	Emerged intertidal management feature
Isla Acuao 1	45°39'S – 73°48'W	−1	0	1530	Intertidal collections	Major tidal erosion	Shell midden and intertidal bone scatter
Isla Elena 1	45°20'S – 73°24'W	1	0	1830–1660	Surface record and collections	Anthropogenic disturbance	Cave with disperse surface human remains
Isla Benjamín 01	44°43'S – 74°13'W	UK	UK	700–660	Chonos collection	Anthropogenic disturbance	Cave with disperse surface human remains and a shell midden
Isla Goñi 1	45°56'S – 73°58'W	−1	0	Undated	Curry's collection	Major tidal erosion	Stratigraphic deposit and intertidal lithic scatter
Seno Canalad	44°32'S – 73°15'W	UK	UK	680	Chonos collection	Anthropogenic disturbance	Cave with disperse surface human remains

Isla Harris	44°14'S – 73°12'W	UK	UK	600	Chonos collection	Anthropogenic disturbance	Cave with disperse surface human remains and a shell midden
Isla Sin Nombre	44°20'S – 74°24'W	UK	UK	780	Chonos collection	Anthropogenic disturbance	Cave with disperse surface human remains
Puqueldón	42°36}S – 73°40'W	UK	UK	180–170	Chonos collection	Anthropogenic disturbance	Shell midden
Puquitín	43°50'S – 73°50'W	UK	UK	960	Chonos collection	Anthropogenic disturbance	Cave with disperse surface human remains and a shell midden
Repollal 02	43°51'S – 73°55'W	1	10	740	Chonos collection	Anthropogenic disturbance	Shell midden
Repollal Caverna	43°50'S – 73°55'W	1	UK	680	Chonos collection	Anthropogenic disturbance	Cave with disperse surface human remains

Notes: UK: unknown, precise information is not available, data from Chonos collection, Universidad de Chile. The shoreline was defined according to the current maximum tide. *Chronology was estimated based on calibrated medians of maximum and minimum ^{14}C dates according to data presented in Table 2. In the cases where shell and charcoal was available, chronology was based on the latter.

Figure 3. *Images expressing geomorphological changes conditioning the archaeological record in Chonos archipelago, (a) uplifted intertidal management feature Nahuelquín 3 at Traiguén Island (human scale: 1.75 m), (b) subsided forest at Taitao peninsula resulting from tectonic movement, (c) intertidal eroded shell midden, Posa Las Conchillas.*

archaeological sites as a result of coastline changes, primarily because of frequent uplift or subsidence caused by the intense seismic activity (Figure 3). This factor becomes evident when observing sunken shell middens, which have been eroded by the tides, submerged lithic scatters, and highly fragmented bioanthropological remains, which display signs of energetic sea action on the exposed profiles. Yet another example corresponds to intertidal management features of uncertain date that are currently exposed (Reyes et al. 2011). Paradoxically, in this context of low visibility, shell middens are rather visible because their "whitened" eroded profiles can be observed from afar among the dense vegetation.

Archeological Sites and Chronology

In general, our research and as well as that of others in the region (Ocampo and Aspillaga 1984; Porter 1993; Reyes et al. 2007; Stern and Curry 1995; Stern and Porter 1991) has facilitated defining four types of archeological sites. The first, intertidal management features, are located on narrow bays and correspond to two stone structures aligned in semicircular arrangements (maximum length of 25 and 70 m, respectively; Reyes et al. 2011). These structures have been observed along the Western Patagonian Archipelagos (Álvarez et al. 2008) and resemble those described by Caldwell et al. (2012) for the Northwest Coast of North America, which act as fish pens taking advantage of high tides. However, the difficulty to date them and the fact that these two structures are located above the current maximum tide, suggest further studies are needed for assigning a specific function. The second type corresponds to large shell middens ranging from 2 to 8 m high and occupying variable extensions of hundreds of square meters. Shell middens primarily yield mollusk valves, such as mussels (*Choromytilus chorus*, *Aulacomya ater*), limpets (*Fissurella* sp.), and locos (*Concholepas concholepas*), crustaceans (*Austromegabalanus psittacus*), and various echinoderms. Generally these sites are only products of marine recollection waste, hunting, and fishing. However, occasionally, they yield lithic artifacts, human burials, and hearths. Given the humidity of many of these deposits, the exoskeletons of the invertebrates cannot be differentiated and are degraded into a calcium carbonate mass. A third type of site is lithic scatters, which are located in the intertidal zone and under the water. These scatters primarily include axes/wedges, bifacial points, net weights, byproducts or debitage and, sporadically, human bone fragments. Occasionally, these sites are associated with nearby shell middens located over the tide line. However, this contiguity does not entail that the scatters and the middens are contemporary. Finally, caves and rockshelters, adjacent to the coast, were occasionally used to deposit the human remains. These sites may either represent ossuaries (some containing more than 20 individuals) or isolated deposits. The remains are found distributed on the surface without any pattern or traces of anatomical position. All of the remains have suffered severe anthropogenic deterioration, such as fragmentation and removal of anatomic portions (particularly skulls). Because of the deteriorated condition of these remains, the lack of a proper record (many have been recovered by non-professionals), and the absence of associated cultural materials, it is unlikely to establish funerary patterns (i.e., grave goods and the disposition of the bodies). In this region, such funerary practices were already noted in the seventeenth century and subsequently (Byron 1901; Cooper 1946; Simpson 1875).

We developed a systematic radiocarbon dating program considering samples (n = 37) from different locations at Chonos Archipelago in order to understand the chronological dimension of the regional occupation (Table 2). The oldest dates were obtained on charcoal and shell materials for Canal Darwin 2 (3360 ± 25 BP; 3690–3490 cal BP) and the base samples from Posa Las Conchillas (3110 ± 25 and 3180 ± 25 BP; 3390–3260 and 3450–3360 cal BP, respectively). However, there were no human remains found for this period. The dated human remains could be separated in three age intervals. The oldest interval, dated between 2330 ± 25 BP (2430–2210 cal BP) and 1590 ± 25 BP (1530–1410 cal BP), consists from eight samples found on the surface in caves. The interval between 1050 ± 30 BP and 650 ± 25 BP has nine samples, also found on the surface in the caves with shell middens. Finally, the youngest dates between 430 ± 25 BP (530–340 cal BP) and 210 ± 25 BP (300 cal BP–modern) were obtained for the samples buried in the shell middens on the coast.

To measure the maximum antiquity of the sites and their deposition rates, auger excavations were performed to reach the bases of the shell middens ($N = 7$). The Posa Las Conchillas site displays an ordered sequence with regards to shell dates and two charcoal dates obtained from the higher levels (Figure 4). Two additional charcoal dates on isolated speckles from the area influenced by intertidal erosion, signal an older occupational event, which is interpreted as possibly disturbed. This suggests that the thick stratigraphic sections of the shell deposits provide a certain stability that enables the measurement of sedimentation rates. On this site, we estimate a 2.3 cm/yr deposition rate for the formation of the shell mound. Although this rate has not been constant and the heap was formed discontinuously, this averaged measurement reveals the summed volume of the discard episodes over ~2100 years. In addition to indicating the intensity of recollection/discard, this accumulation may be explained by several factors like the limited space availability due to abrupt topography, protection from winds and therefore from strong tidal action, good drainage conditions provided by shell middens, local productivity, or activity area redundancy, among other factors, that made these particular locations be considered as persistent places (Piana and Orquera 2010; Thompson and Pluckhahn 2012; Wandsnider 1992).

Table 2. **^{14}C dates from the sites mentioned in this study.**

Site	Lab #	Sample	Depth (in cm)	^{14}C yr BP	$\delta^{13}C$ ‰	Material	2-sigma calibrated range (cal BP)
Posa Las Conchillas	UGAMS 7751 *	PLC 1-1	60	1580 ± 25	+ 1.3	Shell	1528–1409
Posa Las Conchillas	UGAMS 7752 *	PLC 1-2	160	1670 ± 25	+ 1.4	Shell	1689–1523
Posa Las Conchillas	UGAMS 7752ch *	PLC 1-2	160	1320 ± 25	-26	Charcoal	1298–1181
Posa Las Conchillas	UGAMS 7753 *	PLC 1-3	360	1760 ± 25	0	Shell	1768–1569
Posa Las Conchillas	UGAMS 7753ch *	PLC 1-3	360	1450 ± 25	-25.6	Charcoal	1385–1301
Posa Las Conchillas	UGAMS 7754 *	PLC 1-4	740	1810 ± 25	+ 1.4	Shell	1820–1636
Posa Las Conchillas	UGAMS 7754ch *	PLC 1-4	740	3180 ± 25	-24.8	Charcoal	3448–3363
Posa Las Conchillas	UGAMS 7755 *	PLC 1-5	780 [base]	1800 ± 25	+ 0.4	Shell	1820–1628
Posa Las Conchillas	UGAMS 7755ch *	PLC 1-5	780 [base]	3110 ± 25	-25.5	Charcoal	3385–3262
Canal Cuche 1	UGAMS 7749 *	CUCHE-1	360 [base]	2420 ± 25	+ 1.1	Shell	2685–2352
Canal Cuche 1	UGAMS 7749ch *	CUCHE-1	360 [base]	1960 ± 25	-25.4	Charcoal	1988–1835
Canal Darwin 1	UGAMS 8116 *	DAR-1	80	520 ± 25	+ 0.7	Shell	622–510
Canal Darwin 2	UGAMS 7750 *	DAR-2	500 [base]	3360 ± 25	-0.2	Shell	3688–3486
Isla Caniglia	UGAMS 8118 *	CAN-1	40 [base]	Modern	+ 0.9	Shell	-
Nahuelquín 1	UGAMS 04950 **	NAH 1-2	300 [base]	1820 ± 25	-1.2	Shell	1824–1698
Seno Gala 1	BETA 230515 ***	SG1-01	55 [base]	1340 ± 40	-23.6	Bone (Pudu pudu)	1315–1177
Seno Gala 1	BETA 230493 ***	SG1-02	56 [base]	1430 ± 40	-25.5	Charcoal	1392–1288
Isla Ipún 1	UGAMS 10450	IPUN ind 1	surface	870 ± 25	-12.8	Bone (human)	904–726
Isla Ipún 1	UGAMS 10451	IPUN ind 2	surface	1590 ± 25	-9.3	Bone (human)	1534–1411
Isla Victoria 2	UGAMS 10452	VIC 2 ind 1	surface	1820 ± 25	-10.6	Bone (human)	1824–1698

Isla Victoria 2	UGAMS 10453	VIC 2 ind 2	surface	2330 ± 25	-11.2	Bone (human)	2431-2214
Nahuelquín 1	UGAMS 04949 **	NAH 1 ind 1	75-90	430 ± 25	-21	Bone (human)	525-342
Isla Acuao 1	UGAMS 8117 *	ACUAO ind 1	surface	1630 ± 25	-10.8	Bone (human)	1601-1416
Isla Elena 1	UGAMS 8119 *	ELE 1 ind 1	surface	1880 ± 25	-10.6	Bone (human)	1880-1735
Isla Elena 1	UGAMS 8120 *	ELE 1 ind 2	surface	1880 ± 25	-10.6	Bone (human)	1880-1735
Isla Elena 1	UGAMS 8121 *	ELE 1 ind 3	surface	1750 ± 30	-11.2	Bone (human)	1734-1561
Isla Elena 1	UGAMS 8122 *	ELE 1 ind 4	surface	1820 ± 30	-10.4	Bone (human)	1860-1633
Isla Benjamín 01	UGAMS 8286 *	BEN ind 1	surface	700 ± 30	-10.6	Bone (human)	690-563
Isla Benjamín 01	UGAMS 8287 *	BEN ind 2	surface	770± 30	-10.5	Bone (human)	734-669
Seno Canalad	UGAMS 8288 *	CAN ind 1	surface	740 ± 30	-12	Bone (human)	727-660
Isla Harris	UGAMS 8289 *	HAR ind 1	surface	650 ± 25	-12.5	Bone (human)	668-558
Isla Sin Nombre	UGAMS 8290 *	ISN ind 1	surface	870 ± 30	-10.4	Bone (human)	905-699
Puqueldón	UGAMS 8291 *	PUQUEL ind 1	burial feature	210 ± 25	-20.1	Bone (human)	304-0
Puqueldón	UGAMS 8292*	PUQUEL ind 2	burial feature	210 ± 30	-19.7	Bone (human)	305-0
Puquitín	UGAMS 8293 *	PUQUIT ind 1	indetermined	1050 ± 30	-10.1	Bone (human)	1053-924
Repollal 02	UGAMS 8294 *	REP ind 1	20	830 ± 30	-13.9	Bone (human)	791-686
Repollal Caverna	UGAMS 8295 *	REP ind 2	surface	730 ± 25	-11.7	Bone (human)	723-655

BETA: Beta Analytic Inc.; UGAMS: Center for Applied Isotope Studies, University of Georgia; ind: individual; *Reyes et al. 2013; **Reyes et al. 2011; ***Reyes et al. 2007.

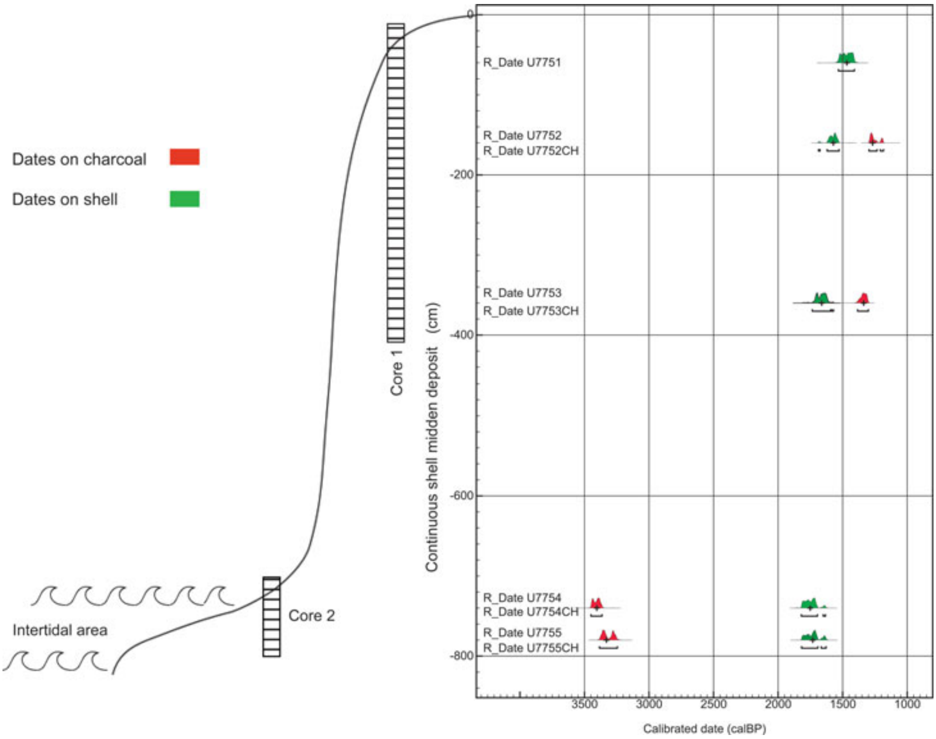

Figure 4. *Depth/age model for Posa Las Conchillas, Traiguén Island, and the intertidal effects on the basal deposits.*

The direct chronology obtained from human remains demonstrates that the deposition of bodies in rockshelters occurred from 2330 ± 25 BP (2430–2210 cal BP) until 650 ± 25 BP (670–560 cal BP). No human remains recorded within rockshelters yield dates younger than ~450 cal BP (~1500 AD), when the first contact with Western populations occurred (Cárdenas et al. 1991). However, the incidence of a reservoir effect in human beings with a marine diet remains unevaluated. Certain sites, such as the Isla Elena ossuary, indicate that all of the individuals ($N = 4$) were deposited simultaneously or within a short time period (Reyes et al. 2013). However, other sites, such as Isla Victoria 2 ($N = 2$) and Isla Ipún 1 ($N = 2$), show they were reused for funerary purposes over long periods, which indicates a continuity of this practice during which individual depositions generated diachronic collective bone assemblages.

Burials at the shell middens have been recorded since 1630 ± 25 BP (1600–1420 cal BP; Acuao-1, $N = 1$) until 210 ± 25 BP (300 cal BP-modern; Puqueldón, $N = 2$), and they are both multiple (Repollal 01, $N = 3$) or individual. Only on the Puqueldón site was it possible to document an extended burial deposition, which was a foreseeable pattern for Western populations (Sáez 2008). The remaining bioanthropological evidence is highly incomplete and corresponds to fragmented remains obtained from profiles degraded by tidal erosion (Reyes et al. 2011). No funerary goods associated with these contexts have been obtained.

Stable Isotopes

Of the 20 samples studied for stable isotopes, all C:N ratios fall within the normal range (Ambrose 1990; De Niro 1985) indicating that the isotopic signals are primary

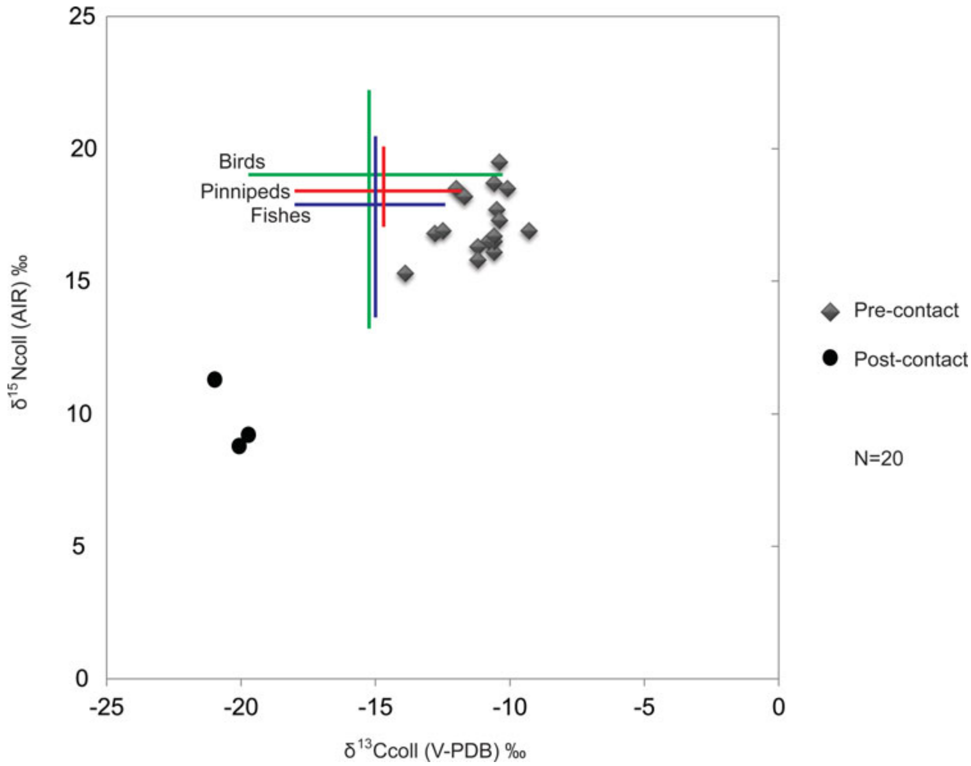

Figure 5. *$\delta^{13}C$ and $\delta^{15}N$ collagen values of human samples from Chonos Archipelago; data from marine resources after Panarello et al. (2006) and references therein.*

(Table 3). Seventeen samples (all dated pre-contact) presented high values of δ^{15}N, between 15.3‰ and 19.5‰ (average: 17.2‰, sd: 1.2) and values of δ^{13}C between −9.3‰ and −13.9‰ (average: −11.1‰, *SD* = 1.1) (Figure 5). The samples constitute a highly homogenous group, with values that are characteristic of a protein-rich diet based on marine resources (Schoeninger et al. 1982; Yesner et al. 2003) as seen in light of the available isotopic ecology of the southernmost Patagonian Archipelago, ~1300 km south (Panarello et al. 2006). However, the three remaining samples, with post-contact dates, present substantially different values for δ^{13}C (average: −20.3‰, *SD* = 0.7) and δ^{15}N (average: 9.8‰, *SD* = 1.3). The comparison of pre- and post-contact groups for δ^{13}C and δ^{15}N displays significant differences (Wilcoxon matched-pairs signed-ranks test δ^{13}C and δ^{15}N: W = 51, p = .001754; Shapiro-Wilk normality test δ^{13}C W = 0.6944, p = 3.333e-05; δ^{15}N W = 0.7872, p = .0005606). The differences observed between the groups may be explained by the incorporation of terrestrial resources (e.g., domesticated animals, tubers, such as the potato, and other vegetables of the C3 photosynthetic pathway) in the diet as a result of the deep cultural changes that occurred after western contact (Álvarez et al. 2008; Cárdenas et al. 1991).

Even though the pre-contact group was highly homogenous, we evaluated whether there were differences related to geographical distribution, funerary practices or chronology: 1) When dividing the samples from the Pacific margin (Isla Ipún, Isla Benjamín, and Isla Sin Nombre) and the interior channels (all other) no significant

Table 3. **Stable isotope data from human bone remains mentioned in this study.**

Site	Lab #	Sample	Collagen yield, %	C content, %	N content, %	C:N	δ^{13}C ‰	δ^{15}N ‰	Skeletal element
Isla Ipún 1	UGAMS 10450	IPUN ind 1	12.3	45.16	17.24	3.06	-12.8	+16.8	Metacarpal
Isla Ipún 1	UGAMS 10451	IPUN ind 2	8.1	45.40	16.36	3.23	-9.3	+16.9	Ulna
Isla Victoria 2	UGAMS 10452	VIC 2 ind 1	7.1	43.36	16.60	3.05	-10.6	+16.1	Skull
Isla Victoria 2	UGAMS 10453	VIC 2 ind 2	5.8	44.59	16.82	3.09	-11.2	+16.3	Skull
Nahuelquín 1	UGAMS 04949**	NAH 1 ind 1	12.1	n/a	n/a	n/a	-21	+11.3	Scapulae
Isla Acuao 1	UGAMS 8117*	ACUAO ind 1	8.0	36.15	13.04	3.23	-10.8	+16.5	Parietal
Isla Elena 1	UGAMS 8119*	ELE 1 ind 1	6.7	40.30	14.08	3.33	-10.6	+16.5	Clavicle
Isla Elena 1	UGAMS 8120*	ELE 1 ind 2	7.2	44.89	16.74	3.12	-10.6	+16.7	Clavicle
Isla Elena 1	UGAMS 8121*	ELE 1 ind 3	6.1	38.20	14.25	3.13	-11.2	+15.8	Clavicle
Isla Elena 1	UGAMS 8122*	ELE 1 ind 4	6.6	41.14	14.51	3.30	-10.4	+19.5	Clavicle
Isla Benjamín 01	UGAMS 8286*	BEN ind 1	12.9	44.28	15.38	3.36	-10.6	+18.7	Rib
Isla Benjamín 01	UGAMS 8287*	BEN ind 2	13.2	39.43	13.55	3.39	-10.5	+17.7	Rib
Seno Canalad	UGAMS 8288*	CAN ind 1	14.1	45.59	15.92	3.35	-12	+18.5	Rib
Isla Harris	UGAMS 8289*	HAR ind 1	14.0	4.27	13.98	3.36	-12.5	+16.9	Rib
Isla Sin Nombre	UGAMS 8290*	ISN ind 1	12.7	43.69	14.71	3.46	-10.4	+17.3	Rib
Puqueldón	UGAMS 8291*	PUQUEL ind 1	15.6	37.64	12.82	3.42	-20.1	+8.8	Rib
Puqueldón	UGAMS 8292*	PUQUEL ind 2	16.3	45.02	15.25	3.44	-19.7	+9.3	Rib
Puquitín	UGAMS 8293*	PUQUIT ind 1	11.2	43.25	15.04	3.35	-10.1	+18.5	Rib
Repollal 02	UGAMS 8294*	REP ind 1	12.6	36.56	12.49	3.42	-13.9	+15.3	Rib
Repollal Caverna	UGAMS 8295*	REP ind 2	12.1	42.80	15.03	3.32	-11.7	+18.2	Tibia

UGAMS: Center for Applied Isotope Studies, University of Georgia; ind: individual; n/a not available; *Reyes et al. 2013; **Reyes et al. 2011; ***Reyes et al. 2007.

Figure 6. *Axes/wedges from Chonos Archipelago, Curry's collection, Instituto de la Patagonia, Universidad de Magallanes, (a–c) preforms with percussion flaking; (d–g) axes/wedges with polished (d–e) or ground surfaces (f–g).*

differences were observed between the two groups (δ^{13}C: $t = 0.8921$, $p = .404$; δ^{15}N: $t = 0.8145$, $p = .4305$; normal distribution according to Shapiro-Wilk). 2) When the samples were divided between burials in rockshelters and in shell middens, again, no significant differences were observed (δ^{13}C: $t = 0.8817$, $p = .5343$; δ^{15}N: $t = 2.2004$, $p = .2006$; normal distribution according to Shapiro-Wilk). 3) Finally, when the sample was arbitrarily segregated into two chronological groups (660–960 cal BP and 1470–2350 cal BP) their δ^{13}C and δ^{15}N values showed no significant differences, even when for δ^{13}C the p value was quite low (δ^{13}C: $t = 2.1185$, $p = .0567$; δ^{15}N: $t = -1.3837$, $p = .1873$; normal distribution according to Shapiro-Wilk). The results demonstrate that before western contact and for a period of at least 1,700 years, the isotopic values remained constant across the entire Chonos Archipelago, which implies that the dietary reliance on marine proteins did not vary significantly.

Lithic Material

The studied lithic assemblage corresponds to selective collections from the surface of different sites in the Chonos Archipelago and, as such, its only purpose is to illustrate general characteristics of the material culture without any statistical representation. However, valuable information at the regional level may be obtained from its study. In general, signs of abrasion on scar ridges, differential erosion in surfaces, and natural wear on thin edges are frequent because the pieces were recovered from the intertidal zone, where the action of sediment particles suspended in the water promotes the abrasion of the exposed surfaces (Petraglia and Potts 1994). These characteristics

Table 4. **Lithic assemblage of Curry's collection, Instituto de la Patagonia, Universidad de Magallanes.**

Site	Axe/ wedge	Hammer/ anvil	Core	Weight	Bifacial artifacts	Grinding tools	Sidescraper	Other non diagnostic artifacts	Debitage	Total
Isla Goñi Spear site			4	1	5		1	1	27	39
Posa Las Conchillas 1	6	4	1			1	1	4	4	21
Corrientes de Yates	1	4	1			2				8
Backside Bay	1	2	1	1		1		1	1	8
Darwin 0008					1				7	8
Cemetery site	6								1	7
Isla Rojas	4									4
South Point Island Achao	4									4
Poor Point	2			1				1		4
Darwin 0004				3					1	4
Canal Vicuña 2	2							1		3
Gypsy Bay					1				2	3
East site Isla Roja	2									2
Botany Bay	1					1				2
Cholguero site	1									1
Nueva Esperanza	1									1
La Cruz		1								1
Posa Las Conchillas 5		1								1
Punta Tai		1								1
Canal Vicuña 1			1							1
Posa Las Conchillas 3			1							1
Canal Vicuña 3				1						1
Skinny Bay				1						1
Bahía San Ramón						1				1
Zaphod island						1				1
Total	31	13	9	8	7	7	2	8	43	128

make it difficult to identify the cultural traces and technical attributes of the pieces.

Given the selectivity of the recollection, the assemblage yields a high variety of tool types (Table 4). For example, one of the most frequent lithic classes consists of axes/wedges (24% of the total sample and 36% of all of the lithic tools), which were recorded either as finished or pieces discarded in different stages of their use-life (Figure 6). Considering minor variations, these tools were manufactured on selected flat pebbles through hard hammer percussion on one or both faces and later smoothed with pecking. This process created biconvex sections and a double-beveled active edge in the thicker portion of the tool. Only a few pieces exhibit a concentrated polish on the active edge, a feature that prolongs use-life.

The anvil is another lithic tool class represented in this assemblage. For these tools, flat pebbles were selected and used for bipolar percussion, as suggested by pecking traces located primarily at the center of the active surfaces. Ovoid pebbles were flaked at both ends, and either on one or both faces, producing grabbing notches for their use as fish net weights (Figure 7 d–e). Alternatively, some weights exhibit a circumferential groove.

Bifacial artifacts are less frequent (Figure 7 a–c), and their manufacture involves large quantities of thinning and edge-shaping flakes, which are occasionally recorded in the intertidal zone. Generally, bifacial points are large (>12 cm) with a lanceolate morphology, which is a widespread type along the northern and southern Patagonian channels (Morello et al. 2002; Porter 1993; Reyes et al. 2007). Obsidian was used in a significant number of these pieces. Macroscopic criteria (crystal inclusions, color, and texture) and geochemical analyses ($N = 4$) suggest that this toolstone was procured at the area of the Chaitén volcano (Stern and Curry 1995; Stern and Porter 1991; Méndez et al. 2008–2009), located between 130 and 360 km distant from the extremes of Chonos Archipelago.

Because these cases are isolated, only detailed studies of lithic assemblages at different sites would enable us to understand fully the technology involved in the manufacture of tools and the economic decisions made when using and discarding them. However, preliminarily we suggest that the majority of rocks selected correspond to pebbles recovered near or immediate to the sites, which were manufactured into expedient tools. Only the axes and the bifacial tools exhibit more specific designs and were conceived for longer use-lives. Of these, only the latter required good-quality raw material.

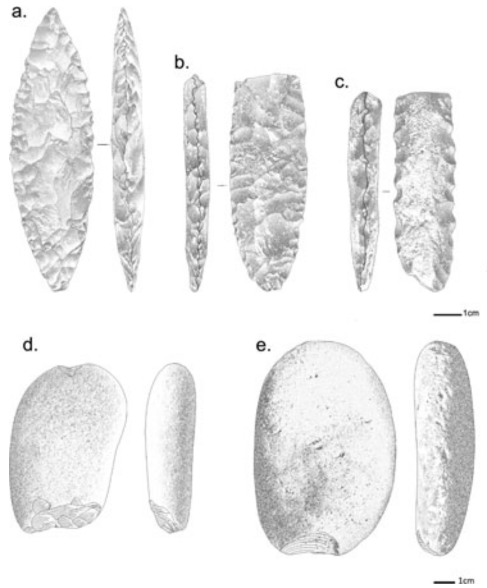

Figure 7. *Lithic material from intertidal sites in the Chonos Archipelago, (a–c) lanceolate bifacial points: (a and c) Seno Gala 1, (b) Nahuelquín 1, (d–e) weights, Darwin 1.*

DISCUSSION AND CONCLUSIONS

The coastal survey of the Chonos Archipelago demonstrates the relevance of incorporating new extensive areas in the discussion of marine adaptations. Only in this way can the cultural and temporal variability of this process in the Western Patagonia Channels be properly evaluated. Among the main challenges, we can emphasize the effects of sea-level change

(Fairbanks 1989), isostatic rebound (Reed et al. 1988), and local tectonics (Diaz and Naveas 2010) on the archaeological sites located in the coastlines. Inland sites have not been recorded yet, whether because of the abrupt topography, the dense vegetation cover, or undetermined behavioral patterns. The location of the sites directly affects their conservation. Eroded stratigraphic deposits, human remains, and lithic material recovered in the intertidal zone and emerged intertidal management features reflect the coastline dynamics and underscore the difficulty of recording settlements in this archipelagic space. We believe that the significant and permanent regional tectonic activity can be signaled as the primary factor that prevents modeling paleocoasts in accordance with global Holocene sea levels. For example, the largest contemporary subduction event ever recorded (the 1960 earthquake in Chile between 37° and 48° S (Mw 9.5), SHOA 2000) caused a rise of more than 5.7 m on the Guafo, Guamblin, and Ipún Islands, and a subsidence of 1 to 2 m in the interior of the Chonos Archipelago (Plafker and Savage 1970).

The earliest anthropogenic deposit recorded in the Chonos Archipelago corresponds to GUA 10, an open-air site, located 6 masl which yielded a 5020 ± 90 BP age (5730 cal BP; Porter 1993). The rest of the archeological settlements recorded do not exceed 3360 ± 25 BP or ~3600 cal BP. We propose three non-mutually exclusive explanatory scenarios for this trend: 1) the evolution of the coastline and its permanent reshaping may have hidden or destroyed the evidence located on the coastline; 2) surveys are yet limited; only 250 km of the coastline have been covered, thus there remains potential for greater variability of occupation. In the future, other types of localities should be studied, such as offshore islands or higher terraces, which have not been affected by the sea erosion. In fact, reliable sea-level reconstructions, performed 1100 km south in the Magellan Straight, suggest a mid-Holocene marine ingression that produced a 6–10 masl terrace between 9000 and 4000 cal BP (McCulloch and Morello 2009). These data may be used to suggest probable new areas for searching, as has been the case with GUA 10 (Porter 1993). 3) The evidence obtained in the Chonos Archipelago corresponds to a late occupation originated in other areas. That is, no base of any dated deposits is as old as the occupations detected 400 km to the north in Chiloé (Legoupil 2005) where radiocarbon dates reach 5950 ± 80 BP (6730 cal BP). Furthermore, in the Beagle Channel, 1300 km to the south, the earliest coastal occupation dates to 7842 ± 53 BP (8580 cal BP; Piana et al. 2012) and a full maritime adaptation has been proposed by approximately 6400 BP (7300 cal BP; Orquera et al. 2011).

Site characteristics, locations, the isotopic results, and the lithic technology of the Chonos Archipelago testify to a marine and pericoastal specialization. The faunal assemblages and deposition rates suggest a strong tendency towards the use of marine resources through reiterated recollection episodes on the same sites. The insular location of these contexts and the geographical distribution of the obsidian from the Chaitén volcano can only be explained in a scenario of navigation as a means of residential mobility and access to resources. The isotopic values of δ^{15}N on the human remains also support that the diets of the pre-contact populations were predominantly marine, in further agreement with the faunal assemblages of the sites. Additionally, the location of burials (primarily in caves) along the coast indicates that the environments that provided the resources correspond to the same areas in which the individuals died. Finally, the lanceolate lithic points and net weights constitute tools that may have been designed for marine hunting and fishing. The axes/wedges could have been used for the permanent provision of the necessary wood for the production and maintenance of canoes and for handling the dense vegetation of the woodlands surrounding camp-sites.

The magnitude of coastal reshaping documented throughout the last 500 years (Lomnitz 1970), must be regarded as an important factor when searching for evidence of occupation in this territory. However, the evidence of populations adapted to the sea and inhabiting insular locations of the Chonos Archipelago towards 3360 BP (3600 cal BP) suggests that there should be older antecedents in the region or at least evidence that could confirm traces suggestive that this adaptation originated in the geographical extremes of the Western Patagonian Channels. The study of unexplored areas with changing coasts offers the opportunity to record a greater variability of adaptation of hunter-gatherers to marine environments and the role of archipelagic systems in the specialization of human groups (Boomert and Bright 2007; Keegan et al. 2008).

ACKNOWLEDGEMENTS

We acknowledge the help of Francisco Mena, Mauricio Osorio, Flavia Morello, Manuel San Román, Eugenio Aspillaga, Patricia Curry, Constanza de la Fuente, Kurt Rademaker, Ramiro Barberena, and the Nahuelquín Indigenous community.

FUNDING

This research was funded by FONDECYT, grant 1130151.

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